

General Specification for Building

2022 Edition



Architectural Services Department
The Government of the Hong Kong Special Administrative Region

INTRODUCTION

The 2022 edition of the General Specification for Building was reviewed by the Technical Information Committee of the Architectural Services Department (ArchSD). Major amendments and additions in this 2022 edition include the following aspects:

1. Adopted a new numbering system for the whole General Specification
2. Added a new Section 27 on Modular Integrated Construction (MiC)
3. Enhanced the supervisory checks on materials submissions
4. Tightened the thermal performance on building envelopes and energy efficiency requirements under climate change concerns
5. Incorporated more mandatory requirements in green specifications based on the Environment Bureau Circular Memorandum no. 1/2021
6. Reviewed the technical requirements of various Sections
7. Updated international standards and statutory requirements
8. Deleted Index 3 and 4 (Index 1 and 2 had been deleted in 2012 edition and 2017 edition incorporating Corrigendum No. GS 2017-02 respectively)

Updating of specification is a continuous process. The electronic version of this 2022 edition of the General Specification for Building will be kept up-to-date and may be viewed on the ArchSD Homepage.

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SECTION 1

PRELIMINARIES

Applicability **1.1** This General Specification for Building is applicable to all building works in connection with the construction, alteration and maintenance of buildings unless overridden by other part(s) of the Contract or the instructions of the Supervising Officer.

Terminology **1.2** If **NEC3 Engineering and Construction Contract** (NEC3 ECC) or **NEC4 Engineering and Construction Contract** (NEC4 ECC) or **NEC Engineering and Construction Contract Hong Kong Edition** (NEC HK Edition) published by Thomas Telford Limited is specified as the form of contract, the following terms under column heading "Specifications" whenever appear in the General Specifications and Particular Specifications as stated in the Contract shall be construed as references to the corresponding terms listed under the column heading NEC3 ECC or NEC4 ECC or NEC HK Edition where appropriate, which may further be amended or supplemented by the Schedule of the Articles of Agreement as the context requires:

Specifications	NEC3 ECC	NEC4 ECC	NEC HK Edition
approval / satisfaction	acceptance		
approved / satisfied	accepted		
Supervising Officer's instruction	*Project Manager*'s instruction		
Bills of Quantities / BQ / Schedule of Rates	*bill of quantities* / breakdown of the Prices of the *activity schedule*		
ascertained / determined / valued by the Surveyor	assessed by the *Cost Manager*		
claim for extension of time and/or additional payment	notification of compensation event		
Contract / BQ rate(s)	rate(s) or price(s) in the *bill of quantities* / *activity schedule*		
Contract Sum	tendered total of the Prices		
Final Contract Sum	final total of the Prices		
Contractor	*Contractor*		
date of the letter of acceptance / date of award of the Contract / date of the acceptance of the Tender / date for commencement of the Contract	Contract Date		
date for commencement of the Works	*starting date*		
date for possession of the Site	*access date*		
defect	Defect		
Drawings	drawings		
Employer	*Employer*	*Client*	

Specifications	NEC3 ECC	NEC4 ECC	NEC HK Edition
equipment (those items intended to be included in the permanent works)	Plant		
expiry of the Maintenance Period	*defects date*		
extension of time	change to the Completion Date		
He / he	He / he	It / it	
him	him	it	
himself	himself	itself	
liquidated damages	delay damages		
maintenance certificate	Defects Certificate		
Maintenance Period / Period of Maintenance / Defects Liability Period	the period between Completion and the *defects date*		
materials (those items intended to be included in the permanent works)	Materials		
plant / construction plant (those items used by the Contractor to Provide the Works and which the Works Information does not require him to include in the permanent works)	Equipment		
Portion	part of the Site		
Price Fluctuation Factor	Price Adjustment Factor		
Retention Money	amount retained		
Section	*section*		
Specialist Sub-contractor	Specialist Subcontractor		
Specialist Contractor	other contractors employed by the *Employer* for works connected with or ancillary to the *works*	other contractors employed by the *Client* for works connected with or ancillary to the *works*	
Specialist Works	works provided by other contractors employed by the *Employer* connected with or ancillary to the *works*	works provided by other contractors employed by the *Client* connected with or ancillary to the *works*	
sub-contractor / subcontractor (of first tier)	Subcontractor		
substantial completion / completion	Completion		
Supervising Officer	*Project Manager / Supervisor*		
Supervising Officer's Representative	*Project Manager*'s delegate / *Supervisor*'s delegate		

Specifications	NEC3 ECC	NEC4 ECC	NEC HK Edition
Surveyor	*Cost Manager*		
Surveyor's Representative	*Cost Manager*'s delegate		
the Contract	this contract		
the date for completion of the Works	*completion date*		
the extended date for completion of the Works	Completion Date		
certified date of completion	date of Completion		
variation	change to the Works Information	change to the Scope	
Works	*works*		

Abbreviations **1.3** Abbreviations used shall have the following meanings:

(a) Common terms:

BS	British Standard
BS EN	European Standard
CP	Code of Practice
CS	Construction Standard
GS	General Specification for Building
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization Publication
PS	Particular Specification
PW	Public Works
SO	Supervising Officer
DEVB List	Development Bureau current enforced List of Approved Suppliers of Materials and Specialist Contractors for Public Works

(b) Units:

°	degree
°C	degrees Celsius
cm	centimetre
cm^2	square centimetre
g	gram
g/m^2	gram(s) per square metre
ha	hectare
hr	hour
kg	kilogram
kg/m^2	kilogram(s) per square metre
kg/m^3	kilogram(s) per cubic metre
km	kilometre
km/hr	kilometre(s) per hour
kN	kiloNewton
kN/m	kiloNewton(s) per metre
kN/m^2	kiloNewton(s) per square metre
kPa	kiloPascal
L	litre
L/min	litre(s) per minute
$L/min/m^2$	litre(s) per minute per square metre
L/m^2	litre(s) per square metre
$L/m^2/s$	litre(s) per square metre per second
m	metre
m^2	square metre
m^3	cubic metre

m/s	metre(s) per second
m^2/kg	square metre(s) per kilogram
m^2/L	square metre(s) per litre
$m^3/hr/m$	cubic metre(s) per hour per metre
$m^3/hr/m^2$	cubic metre(s) per hour per square metre
Mg	megagram
Mg/L	megagram(s) per litre
min	minute
mL	millilitre
mm	millimetre
mm^2	square millimetre
mm^3	cubic millimetre
mm/hr	millimetre(s) per hour
mm/s	millimetre(s) per second
MPa	megaPascal
N	Newton
Nm	Newton metre
N/cm^2	Newton(s) per square centimetre
N/mm	Newton(s) per millimetre
N/mm^2	Newton(s) per square millimetre
No.	number
RH	relative humidity
s	second
t	tonne
µm	micrometre (micron)
µW	microwatt(s)
$\mu W/cm^2$	microwatt(s) per square centimetre
w/m °C	watt(s) per metre per degree Celsius
%	percentage
% m/m	percentage by mass

Applications of specification **1.4** Materials and workmanship specified in one Section of this GS shall apply to the same items in other Sections.

Form of Contract **1.5** The form of contract is the conditions of contract as defined in the Contract, hereinafter referred to as the "Conditions".

The Conditions include Clauses dealing specifically with the provision of plant, equipment, labour and the quality of workmanship and samples and testing. This GS is written for use in conjunction with the Conditions and the Contractor shall be deemed to have knowledge of all relevant Clauses in the Conditions. All definitions in the Conditions shall be deemed to apply also to this GS.

Government of Hong Kong **1.6** The term "Government of Hong Kong" mentioned in this GS shall mean the Government of the Hong Kong Special Administrative Region.

Supervising Officer **1.7** "Supervising Officer" is the "Architect" or the "Maintenance Surveyor" or the "Supervising Officer" as respectively defined in the Conditions.

British Standards, European Standards and Codes of Practice **1.8** "British Standards", "European Standards" and "Codes of Practice" shall be deemed to include all amendments, revisions and standards superseding the standards listed herein, current and published before the date of first tender invitation for the Contract unless otherwise specified. In the case of Sections 1, 3, 5, 6, 7, 8, 15, 25 and 26, the stated editions of BS, BS EN, CP and similar standards are to take preference over any later amendments, revisions or standards superseding the standard. For the Codes of Practice and Construction Standards issued by the Government of Hong Kong, the latest editions shall apply unless otherwise specified. Equivalent International Standards may be used if approved by the SO.

Guidelines, Practice Notes, Manuals and Standard Drawings **1.9** Relevant "Guidelines", "Practice Notes", "Manuals" and "Standard Drawings" referred in this GS shall be deemed to include all amendments, revisions and standards superseding the standards listed herein, current and published before the date of first tender invitation for the Contract unless otherwise specified.

Specification in Manufacturer's recommendations **1.10** "Manufacturer's recommendations" mean those recommendations or instructions printed or in writing and produced by the manufacturer of any specified product current and published before the date of first tender invitation for the Contract.

Approval **1.11** "Approval" or "approved" means the approval in writing by the SO but this shall not relieve the Contractor from responsibilities imposed by the Contract.

Proprietary brand name products or materials **1.12** The phrase "or alternative products or materials having equivalent functions or performance" shall be deemed to be included wherever products or materials are specified by proprietary brand names. Alternative products or materials of different brands or manufacture having equivalent functions or performance may substitute for the specified proprietary brand name products or materials if prior approval from the SO has been obtained. If the Contractor intends to use the intellectual property rights of another party in performing his obligations under the Contract, appropriate licences shall be obtained from the relevant rights owners.

Specified **1.13** The term "specified" means the incorporation of a particular clause or alternative by specific reference in the Drawings, Particular Specification, Bills of Quantities or Schedule of Rates prepared by the Employer.

Where alternatives are given in the GS, the required alternative may be "specified". If it is not so specified the Contractor is at liberty to make his own choice from the stated list, or the Contractor may propose alternatives subject to the agreement and acceptance of the SO.

Regulations **1.14** "Regulations" mean any Ordinance or Regulation published by Government of Hong Kong, byelaws of any local or duly constituted authority and rules or regulations of public bodies and companies which may be applicable to the Works.

Equivalent standards and imperial sizes **1.15** When products or materials to the appropriate standards are not available, products or materials conforming with equivalent standards (or performance) shall be acceptable subject to approval.

When a material is available in metric size, an imperial size equivalent shall not be acceptable.

If a material is unobtainable in metric size, a material of the nearest equivalent imperial size which will fully meet the specification may be substituted if prior approval has been obtained, but the rates will not be changed from those submitted for the materials specified.

GENERAL OBLIGATIONS

Use of the Site **1.16** Do not use the Site or permit the Site to be used by others for any purpose other than for the execution of the Works or Specialist Works.

Advertising **1.17** Do not display, or permit advertisements to be displayed on the Site.

Fire precautions **1.18** Comply with all Regulations to prevent loss or damage from fire.

Safety **1.19** Comply with all Regulations concerning safety on the Site. Obtain posters and display prominently on all structures or temporary huts on the Site throughout the construction period and remove on completion. These posters, both in English and Chinese, drawing attention to safety on site are obtainable from the Labour Department, Government of Hong Kong and Occupational Safety and Health Council.

Provide sufficient personal protective equipment such as safety helmets with suitable chin straps, rubber boots, safety shoes, umbrella, protective and waterproof clothing, ear mufflers, face masks, protective glasses, etc. where appropriate for the use of the SO, the SO's representatives, and other authorized persons visiting the Site.

Nuisance **1.20**

Comply with all Regulations concerning the prevention of nuisance arising from vibration, noise, water, smoke, dust, accumulation of rubbish, mosquito breeding and all other causes of nuisance.

Provide throughout the whole period of the Contract and extended period, if any, mufflers or other suitable noise suppressors on all pneumatic drills, compressors and other plant which may create a noise nuisance to the general public.

Obtain posters and display prominently on all structures or temporary huts on the Site throughout the construction period and remove on completion. These posters, both in English and Chinese, drawing attention to the dangers of allowing the breeding of mosquitoes on site are obtainable free of charge from the Health Education Exhibition and Resource Centre of the Food and Environmental Hygiene Department, Government of Hong Kong.

Treat any standing water on the Site with an approved insecticidal oil at least once per week.

Store, cover or treat all items on the Site including Constructional Plant, capable of retaining water to prevent the collection of water in them.

Provide throughout the construction period an approved central collection point on the Site for depositing of all empty cans, oil drums, packaging and other receptacles capable of holding water and for the regular collection and removal of such articles from the Site.

Do not burn debris, or any other matter on the Site.

Traffic control **1.21**

Comply with all regulations concerning traffic control, signing, lighting and barriers including the **"Code of Practice for the Lighting, Signing and Guarding of Road Works"** issued by the Highways Department, Government of Hong Kong.

Maintenance of roads **1.22**

Make good, or accept responsibility for the cost of making good, any damage caused by site traffic or site operations to public or other roads, footpaths, bridges and the like. Keep the aforementioned and the approaches to the Site, borrow site or dump site clear of dust, mud, debris and all obstructions. Avoid contamination and blockage of all Government drains and sewers, as well as associated private drains & sewers.

In particular take the following precautions to prevent dusty materials such as cement, earth, pulverized fuel ash, silt, stone fines, sand, debris, saw dust and wooden chips, etc. or rock and recycled rock filling material from falling into roads, footpaths or bridges during haulage:

(a) Fit vehicles having an open load compartment with tightly fitting and adequately secured side and tail boards.

(b) Rock or recycled rock filling material shall be carefully stacked to prevent dislodging during haulage.

(c) All materials shall not be loaded to a level higher than the side and tail boards, and shall be covered by a suitable tarpaulin (or any other impervious covering material as approved by the SO) in good condition before leaving the Site. The tarpaulin shall be properly secured and extended at least 300 mm over the edges of the side and tail boards and maintained in a secured position throughout the journey to the off-loading destination.

(d) Provide and employ at the Site, borrow site and dump site, such labour and washing facilities as necessary or as directed by the SO to clean the wheels and undersides of lorries free of earth prior to leaving the Site, borrow site or dump site and, after dumping, for sweeping out all loose material remaining in all vehicles. At the discretion of the SO such labour and washing facilities may also be employed in keeping clean the approach road

to the Site, borrow site or dump site.

Restriction on occupancy and rental of private land of ecological values **1.23** The Contractor shall not rent or occupy any private land falling within the designated areas listed below for any purposes arising out of or in connection with the Contract unless prior approval is obtained from the SO:

(a) Existing country parks designated under the **Country Parks Ordinance (Cap 208)**;

(b) Areas designated as Coastal Protection Area, Site of Special Scientific Interest, Green Belt, Conservation Area and Other Specified Uses (River Park) on statutory plans (i.e. Outline Zoning Plans and Development Permission Area Plans) under the **Town Planning Ordinance (Cap 131)**;

(c) Restricted areas under the **Wild Animals Protection Ordinance (Cap 170)**; and

(d) Areas designated under the **Marine Parks Ordinance (Cap 476)**.

Existing features **1.24** Provide written proposals for the protection of existing buildings, gates, walls and all other features of the Site which shall be retained for the acceptance of the SO. Verify by dimensional confirmation all features which form physical constraints to site development.

Existing utility services **1.25** Check and confirm the position of all existing utility services within the Site at the commencement of the Works, including locating these services by means of hand-dug trial holes.

Protect and maintain existing electric or telecommunication service cables including overhead wires, gas or water mains, sewers, live drains and the like. Make all necessary arrangements for the temporary diversion or alteration of such services to the satisfaction of the relevant authority and utility undertakings.

Do not commence work adjacent to existing utility services until the necessary diversions or alterations have been completed.

Adjoining properties **1.26** Protect, shore up and in all ways support all adjacent lands, buildings and services which are liable to be disturbed or damaged during the execution of the Works. Take adequate precautions to prevent excavated materials encroaching onto adjoining properties. Set up monitor points for controlling noise, vibration, settlement and lateral movement imposed on adjoining properties as directed by the SO.

TEMPORARY WORKS AND SERVICES

Location of temporary works **1.27** Obtain approval from the SO and utility undertakings where necessary for the location of spoil heaps, temporary roads, services, temporary buildings, latrines and the like.

Access and roads **1.28** Provide and maintain temporary access to the Site and working areas and provide and maintain temporary roads, tracks, crossings and hardstandings required for use by those engaged upon or in connection with the Works.

Comply with all the requirements of the relevant government departments and authorities and relevant utility undertakings. Obtain authorization to cross pavements and similar areas.

When using public roads for access purposes, co-operate with the relevant government departments and authorities and others using such roads to ensure that they are kept free from obstruction at all times and comply with any restriction on access.

Drainage **1.29**

Provide and maintain temporary channels, catchpits and drainage work to keep the Site clear of water, silt or mud and prevent nuisance due to run-off onto adjacent land.
Protect the Works and/or adjoining properties from being washed out by rain, ensure effective diversion of stormwater and provide earth bunds or sandbag barriers and/or any other temporary measure if necessary.

Before site water is directed into any public drain, obtain the approval of the relevant government departments and authorities and comply with all instructions. Provide temporary silt traps or other measures as may be required and keep from blocking.

Watchmen **1.30**

Keep efficient watchmen about the Site and on the Works, day and night. Watch dogs shall be confined to the Site, be kept under control and properly inoculated and licensed in compliance with the following requirements.

(a) No dog shall be kept by the Contractor or his employees, his agents or sub-contractors or their employees, on the Site unless the dog is acceptable for licensing by the Agriculture, Fisheries and Conservation Department (AFCD), and is licensed under the **Rabies Ordinance (Cap. 421)**, implanted with a microchip and vaccinated against rabies. In addition, the keeper of the dog under the licence shall either be:

(i) an employee of the Contractor who shall be of a rank not lower than deputy site agent or equivalent as agreed by the SO, or
(ii) a security firm in its own name or an employee of the firm who shall not be of a rank lower than assistant manager level, where the security firm is engaged by the Contractor solely for the purpose of Site security.

(b) All licensed dogs kept on the Site must be neutered. The Contractor shall keep or cause the aforesaid security firm to keep on the Site a copy of the licence, together with a copy of the certificate issued by a registered veterinary surgeon confirming that the dogs kept on the Site have been neutered, for inspection by the SO upon request. All licensed dogs on the Site shall be identified by suitable markings on their collars as agreed by the SO, and shall be removed by the Contractor from the Site upon completion of the Works under the Contract.

(c) The Contractor shall alert the AFCD and facilitate access, where appropriate, to the Site for removal of any unlicensed dogs from the Site.

(d) The Contractor shall observe and undertake, or cause his employees, his agents or sub-contractors or their employees to observe and undertake, the licensing and control measures as set out in the current edition of the **Code of Practice for Keeping Dogs on Construction Sites** issued by AFCD for any dogs kept on the Site. The SO or the SO's Representative shall have the power to order the removal of any person who fails to comply with the requirements from the Site.

Site accommodation for contractor **1.31**

Provide all necessary offices, mess rooms, drinking water, latrines and washing facilities and the like for all workmen engaged upon the Works including lighting, power, telephones, maintenance and cleaning.

On multi-storey buildings, provide one male and one female temporary latrine accommodation on every third floor in approved locations and maintain in a sanitary condition at all times.

Adopt Modular Integrated Construction (MiC) for site accommodation if the overall construction floor area of the site accommodation for Contractor and the site accommodation for SO is greater than 300 m^2. The MiC modules adopted shall be provided by those suppliers of the MiC systems on the List of Pre-accepted MiC Systems / Components of the Buildings Department.

Storage sheds **1.32** Provide temporary storage sheds. Partially completed buildings may be used for storage with the permission of the SO.

Accommodation for workmen **1.33** Workmen shall not be permitted to live on the Site except in particular and stated circumstances.

When workmen are permitted to live on the Site, provide accommodation to comply with the following minimum requirements:

(a) Habitable floor area of 3.5 m^2 per workman, with 3 m floor to ceiling height. Window area to be 10% of floor area, with 33% to open for ventilation.

(b) Kitchen constructed of fire resisting materials, located 6 m minimum from any structure not of fire resisting materials. Provide cooking slab with hood and chimney, or brick built cooking stoves with flues. Floor to fall to drainage outlet.

(c) Ground floors of concrete or other approved material.

(d) Drinking water and ablution facilities.

(e) Sufficient garbage bins, to be emptied daily.

(f) Provide all necessary fire fighting equipment and means of escape.

Office for SO **1.34** When specified, provide weatherproof office accommodation for the SO and the SO's representatives, of sufficient strength and adequately braced and anchored to resist typhoon conditions. Provide all facilities as specified and separate toilet accommodation for the exclusive use of the SO and the SO's representatives including all necessary lighting, power and water services and maintain and keep in a clean condition.

When specified, provide a separate direct line telephone for the use of the SO.

When specified, provide and install a room cooler heating unit or units of a suitable capacity complete with all necessary wiring and switchgear and the like and maintain in efficient working order.

The site accommodation shall be of low-cost design. The Contractor shall design, supply, install, service and maintain site accommodation with sustainable provisions in accordance with the requirements as stated in the latest edition of **Code of Practice for Energy Efficiency of Building Services Installation** issued by the Electrical and Mechanical Services Department.

Used materials and products which are in reasonable and serviceable conditions shall be allowed. If used materials and products are not available, the materials and products shall be supplied from regional manufacturers to minimize transportation cost and carbon footprint.

Adopt MiC for site accommodation if the overall construction floor area of the site accommodation for SO and the site accommodation for Contractor is greater than 300 m^2. The MiC modules adopted shall be provided by those suppliers of the MiC systems on the List of Pre-accepted MiC Systems / Components of the Buildings Department.

Screens **1.35** Where work is carried out in, or adjacent to existing buildings, provide protection against the spread of dust and other nuisances by means of dust sheets, tarpaulins, boards and the like.

When specified, provide specially constructed dust-proof or sound deadening screens or such other means as required by the relevant government departments and authorities.

Hoardings and gantries **1.36** Provide temporary fencing, barriers, guard rails, gangways, walkways, fans and the like for protecting the public and others during the proper execution of the Works.

When specified, provide hoardings or covered walkways with lighting as required. All materials for hoardings, gantries and covers shall be submitted for approval by the SO.

Scaffolding etc. **1.37** Provide all scaffolding including bamboo poles, fir poles, suitable brackets, wooden planks, metal foil, tarpaulin sheets and other framing and covering materials.

Ensure that all scaffolding, screens, coverings, screen framings and the like are properly constructed, wedged, braced, secured and maintained in accordance with best local practice. All materials shall be of good quality and of adequate strength and stability to carry the loads to be sustained.

Signboards **1.38** When specified, provide a project signboard or boards including sign writing in multi-coloured gloss finish over the completed board including English letter and Chinese characters, artist's impressions or diagrammatic plans and logos. Submit draft drawings for approval before painting.

Water **1.39** Provide an adequate temporary water supply for the Works and all Specialist Works and for testing of installations where specified, obtained by metered supply from Government mains where possible. If taken from a source other than Government main supply, it shall be tested in accordance with **BS EN 1008** when required by the SO. Make arrangements for storage, pumping and distributing about the Site.

Lighting and power **1.40** Provide an adequate temporary electricity supply and equipment for lighting and power for the Works and all Specialist Works where and when specified. Where a permanent supply is available, it may be used with the permission of the SO subject to the cost being met by the Contractor.

Temporary passenger lifts **1.41** When specified, provide temporary passenger lifts complying with all current Regulations for the use of persons engaged in the execution of the Works and all Specialist Works. Install the lifts in an approved location, which shall not be in any permanent lift shaft and shall be ready for use in all respects immediately the structural work is completed up to the 3rd floor level.

Provide all power and maintenance and one full time operator to each lift.

Do not use passenger lifts for the movement of materials.

Maintenance of Temporary Works **1.42** Maintain, alter, adapt and move Temporary Works as necessary. Clear away when no longer required and make good.

TEMPORARY WORKS (SCAFFOLD SYSTEM)

General **1.43**

(a) Temporary double layer scaffold (hereinafter referred to as the "Scaffold System") against the facade or perimeter of a structure or building shall be constructed, as required, with working platforms supported by two framed layers of vertical members (standards) tied by cross members (bracings, transoms) and longitudinal members (ledgers), and other ancillary members such as guard rails, toe boards, access ladders, sloping catch-fans, safety screens, anchors, support brackets, foundations and the like.

(b) Metal Scaffold System shall be a Scaffold System constructed, as required, with working platform adequately supported and other ancillary members including guard-rails, toe boards, access ladders, sloping catch-fans, safety screens, anchors, support brackets, foundation and the like; and all the structural members of the scaffolding system shall be of metal construction.

(c) The Scaffold System shall provide a suitable and sufficient safe means of access and workplace for carrying out work which cannot be conveniently executed from the ground or from a floor in a building, or from a ladder, etc.

(d) The Scaffold System shall be used for all construction, alteration, repair and maintenance works. Unless otherwise specified and subject to approval by the SO, other alternative scaffolding may be used for screening purposes.

(e) The Contractor shall be responsible for the design, planning and co-ordination, transportation, fabrication, erection, maintenance, alteration and dismantling of the Scaffold System.

Codes and standards 1.44

The design, planning and co-ordination, transportation, fabrication, erection, maintenance, alteration and dismantling of the Scaffold System shall comply with:

(a) **Factories and Industrial Undertakings Ordinance, Cap. 59;**

(b) **Occupational Safety and Health Ordinance, Cap. 509;**

(c) **Construction Sites (Safety) Regulations, Cap. 59I;**

(d) **Code of Practice for Bamboo Scaffolding Safety**, issued by the Labour Department (CPFBSS);

(e) **Code of Practice for Metal Scaffolding Safety**, issued by the Labour Department (CPFMSS);

(f) **Guidance Notes on Safety at Work (Falsework - Prevention of Collapse)**, issued by the Labour Department;

(g) **Guidance Notes on Classification and Use of Safety Belts and their Anchorage Systems**, issued by the Labour Department;

(h) **Code of Practice for the Structural Use of Steel**, issued by the Buildings Department;

(i) **Code of Practice on Wind Effects in Hong Kong**, issued by the Buildings Department;

(j) **BS EN 12811-1** Temporary works equipment – Part 1: Scaffolds – Performance requirements and general design together with the latest scaffolding Technical Guidance **TG 20** issued by the National Access & Scaffolding Confederation (NASC), and

(k) **BS 5975** Code of practice for temporary works procedures and the permissible stress design of falsework.

The **Guidelines on the Design and Construction of Bamboo Scaffolds**, issued by the Buildings Department, shall also be complied with while the **CPFBSS** takes preference.

Materials for metal Scaffold System shall comply with the following standards or other equivalent national / international standards approved by the SO :

(a) **BS 1139-1.2**, Metal Scaffolding - Part 1: Tubes - Section 1.2: Specification for aluminium tube

BS 1139-2.2+A1, Metal Scaffolding - Part 2: Couplers and fittings - Section 2.2: Couplers and fittings outside the scope of **BS EN 74** - Requirements and test methods

BS 1139-4, Metal Scaffolding - Part 4: Specification for prefabricated steel splitheads and trestles

BS 1139-6, Metal Scaffolding - Part 6: Prefabricated tower scaffolds outside the scope of **BS EN 1004**, but utilizing components from such systems - Specification

(b) **BS EN 39**, Loose steel tubes for tube and coupler scaffolds. Technical delivery conditions.

(c) **BS EN 74-1**, Couplers, spigot pins and baseplates for use in falsework and scaffolds – Part 1: Couplers for tubes – Requirements and test procedures.

(d) **BS EN 74-2**, Couplers, spigot pins and baseplates for use in falsework and scaffolds – Part 2: Special couplers – Requirements and test procedures.

(e) **BS EN 74-3**, Couplers, spigot pins and baseplates for use in falsework and scaffolds – Part 3: Plain base plates and spigot pins – Requirements and test procedures.

(f) **BS EN 1004**, Mobile access and working towers made of prefabricated elements – Materials, dimensions, design loads safety and performance requirements.

(g) **BS EN 12810-1**, Façade scaffolds made of prefabricated components – Part 1: Products specifications.

Submissions **1.45**

(a) The Contractor shall submit for the consent of the SO the following information in accordance with the **CPFBSS** and **CPFMSS** and **Guidelines on the Design and Construction of Bamboo Scaffolds**, issued by the Buildings Department, taking into account site and project conditions 10 days prior to commencing the erection, alteration or dismantling of the Scaffold System:

(i) The material specifications, test certificates, place of the origin, and instructions and procedures supplied by the manufacturers of the metal Scaffold System;

(ii) The intended or current use of the Scaffold System and a method statement for the erection, alteration or dismantling of the same. Working drawings for the Scaffold System as per Clause 1.46 of this Section shall be submitted with the method statement;

(iii) For any portion of the Scaffold System which cantilevers up from the top floor under construction, the method statement shall include adequate tie and strut arrangement for the cantilevered portion; and

(iv) The names, "substantial training" and "practical experience" of the "competent person", the "trained workmen" and the "professional engineer" as referred to in **CPFBSS** and **CPFMSS**.

(b) The consent of the SO shall not relieve the Contractor of any duty or responsibility under the Contract.

Design requirements **1.46**

(a) The design and construction of the Scaffold System shall withstand a combination of the following loading situations at all stages of construction without causing overstressing, instability, bulging, distortion, overturning, collapse, settlement or damage to any portion of the Scaffold System or the supporting structure:

(i) Total weight of all members of the Scaffold System including all the associated provisions e.g. working platforms, safety nets, catch-fans etc.;
(ii) Construction and working loads including all traffic using the Scaffold System; and
(iii) Wind loads.

(b) For any segment of the Scaffold System exceeding 15 m in height or if the bamboo Scaffold System does not conform with the prescribed types of

scaffolding in the **CPFBSS** or the **Guidelines on the Design and Construction of Bamboo Scaffolds** issued by the Buildings Department, the whole Scaffold System shall be designed and approved by a Registered Professional Engineer who shall have adequate relevant experience. Working drawings for the Scaffold System shall be prepared, checked and endorsed by the Registered Professional Engineer for submission to the SO.

Construction **1.47** (a) The Scaffold System shall be constructed and maintained in accordance with the following criteria:

(i) Provide firm and adequate supports to the Scaffold System at appropriate locations. If steel brackets are used as scaffold supports, their vertical spacing shall not exceed 15 m;

(ii) Provide firm and adequate ties and struts for fastening the Scaffold System securely onto the structure or building. All temporary ties, fixing bolts and the like shall not be allowed to remain within the specified concrete cover and shall be cut back more than 40 mm (concrete cover for external elements) from the surface of structural concrete;

(iii) Provide firm and adequate longitudinal, transverse and diagonal bracings to ensure the stability of the Scaffold System;

(iv) Keep the space or clearance between working platforms and the structure or building as small as possible but it shall not exceed 300 mm wide;

(v) Where scaffolding is provided for structure or building exceeding 15 m in height, provide a protective canopy of nominal width 3600 mm at a maximum height of 6 m above ground along the edges of the structure or building at locations as directed by the SO;

(vi) Where scaffolding is provided for structure or building which is under 30 m in height or is set back from the site boundary such that an inclined projection plane from the top outer edge of the structure or building at 10 degree from the vertical does not go beyond the site boundary at ground level, provide safety nets comprising nylon mesh of minimum 15 core threads with grids not more than 12 mm or of similar approved type covering the entire face of the structure or building. The safety nets shall be tautly fixed with minimum lap of 450 mm in any direction to the outer face of the scaffold;

(vii) Where scaffolding is provided for structure or building except those specified in sub-clause (a)(vi) of this Clause, provide safety nets consisting of two layers in accordance with Buildings Department Practice Note **APP-102**;

(viii) Use fire retardant material for safety nets;

(ix) Provide a sloping catch-fan at not more than 15 m vertical intervals to give a minimum horizontal projection coverage of 1500 mm. The sloping catch-fan shall consist of timber boarding covered by a layer of galvanised metal sheeting, both of adequate thickness to capture and retain falling debris;

(x) Provide access/egress to and from the walkway at appropriate locations;

(xi) Ensure that the sloping catch-fans and safety nets remain in place until all works are completed;

(xii) Ensure that the Scaffold System will not be overloaded at any time.

The Scaffold System including the sloping catch-fans, safety nets, walkways, protective canopies and the like shall be kept clear of debris; and

(xiii) When plastic sheet is used to cover the Scaffold System, the Scaffold System shall be reinforced to withstand strong winds. Flame retardant sheeting shall be used at locations as specified by the SO. Obstruction of natural ventilation and lighting by sheeting should be avoided as far as possible.

(b) During any inspection of the works, if the SO is of the opinion that part or whole of the Scaffold System is unstable, insufficient or requires modification in the interests of safety, the SO may, by notice in writing require the Contractor to modify the Scaffold System and the Contractor shall comply within a reasonable time.

(c) On completion of the Works, the Contractor shall clean and make good the structure or building disturbed or damaged by the Scaffold System.

Management **1.48** The management and procedures for safety and health on scaffolding work including safe erection / maintenance / alteration / dismantling of the Scaffold System shall comply with Section 4 and 6 of **CPFBSS** and **CPFMSS** unless otherwise approved by the SO.

Technical requirements for safety in bamboo scaffolding **1.49**

(a) When bamboo scaffolding is used for the Scaffold System, the Contractor's attention is drawn to Section 5 of **CPFBSS**.

(b) Unless otherwise approved by the SO, all bamboo scaffolding shall be in accordance with the following drawings:

(i) For a structure or building not exceeding 15 m in height, the Scaffold System shall be in accordance with Drawing No. SCAFFOLD/3 at Annex A.

(ii) For a structure or building exceeding 15 m in height, the Scaffold System shall be in accordance with Drawing No. SCAFFOLD/1 and SCAFFOLD/2 at Annex A.

(c) Walkways shall be constructed as follows:

(i) 400 mm (minimum) wide continuous walkway formed by 200 mm (minimum) x 25 mm thick close timber boarding as referred in Figure 2 of **CPFBSS**, and

(ii) 200 mm (minimum) high toe boards made of suitable and sound material of sufficient strength at each side of walkways from which a person or any object may fall more than a height of 2 m.

(d) No bamboo scaffolding shall be stood for use over 24 months in a construction site. All the overdue bamboo scaffolding deemed by the SO shall be dismantled and removed off site. Erect a new bamboo scaffolding if deemed necessary.

Technical requirements for safety in metal scaffolding **1.50**

(a) When metal scaffolding is used for the Scaffold System, the materials, foundations and erection / maintenance / alteration / dismantling for the Scaffold System shall comply with the technical requirements for safety in metal scaffolding in Section 5 of **CPFMSS**.

(b) If the Scaffold System is constructed of metal, proper equipotential bonding and lightning protection must be provided.

ADMINISTRATION AND ATTENDANCE

Site meetings **1.51** Attend site meetings when required by the SO. Inform Nominated Sub-contractors, Specialist Contractors and utilities undertaking when their presence is required.

General attendance **1.52** Provide attendance of one trade upon another.

Attendance on Sub-contractors and Specialists **1.53** Provide the following attendances to all Nominated Sub-contractors, Specialist Contractors, Government Departments and utilities undertaking:

(a) Every facility to move about the Site in the legitimate pursuit of their work;

(b) The use of such plant, ladders, scaffolding or staging as may have been provided or erected by the Contractor, provided that there is no obligation to retain any such plant, ladders, scaffolding or staging longer than is necessary for the Contractor's own use;

(c) Having regard to the nature of the Site and the Works, sufficient space as required within the Site or within the Works under construction for work areas and storage sheds for the storage of materials and plant brought onto the Site. Such sheds shall be provided, erected and cleared away by the Nominated Sub-contractors, Specialist Contractors, Government Departments and utility undertakings;

(d) Adequate temporary water and electrical supplies at convenient positions throughout the Works under construction and to work and storage areas and surroundings within the Site for lighting, security lighting, operation of power tools and testing and commissioning up to and including final acceptance of the installations by the SO;

(e) The use of the telephone, mess rooms, latrines and the usual conveniences of a building site;

(f) Such assistance as is necessary in the unloading of plant, goods and materials brought onto the Site;

(g) Such watchmen guards as are reasonably necessary to safeguard the Site and particularly storage areas. In this connection Specialist Contractors will be required to provide reasonable access to, or knowledge of, their materials stored on the Site in order that an adequate service can be provided for the safe custody of such materials;

(h) Such service as is necessary for the clearing away of rubbish as it accumulates; and

(i) Any making good on completion of work disturbed by the use or removal of the above facilities.

Make arrangements with Nominated Sub-contractors, Specialist Contractors, Government Departments and utilities undertaking as regards the following:

(a) The time and manner of the execution of their work or delivery of their materials;

(b) Full particulars of their requirements for chases, recesses, openings, holes, cuttings on formwork and the like and execute the same including providing and fixing or obtaining from others and fixing all slots, sleeves and the like required;

(c) The obtaining of approval for any cutting to structural work; and

(d) The supplying of all dimensions and other information necessary to ensure that their work is correctly executed or that correct goods or materials are supplied.

Carry out all work necessitated by any failure in the above arrangements or pay the Employer all expenses properly incurred as a result of such failure.

When specified, provide temporary electricity supply for testing for Nominated Sub-contractors and Specialist Contractors. Where permanent supply is available, it may be approved for use for such testing, subject to the cost being met by the Contractor.

When specified, provide special attendance on Nominated Sub-contractors and Specialist Contractors.

When specified, co-ordinate the programme to suit any advance completion requirements to suit work by Specialist Contractors.

Co-ordination of services **1.54** Generally the Drawings for services are schematic and only indicate the approximate location of the various services. Plan the sequence of the programme and co-ordinate the physical deployment of all services included in the Works and the Specialist Works, if any, in accordance with the Drawings and good practice. All services shall be installed in the correct sequence and position. All cleaning, adjustment and control points shall be readily accessible and that loops, cross-overs and the like shall be kept to a minimum.

Attendance on materials supplied by the Employer **1.55** Where items are to be obtained from the Employer:

(a) Take delivery from Government Logistics Department;

(b) Load, transport to the Site, unload, check, examine, take to store and protect;

(c) Take from store, distribute, hoist and fix in position;

(d) Return surplus items to Government Logistics Department;

(e) Return all crates and other packings as required to Government Logistics Department.

MATERIALS AND WORKMANSHIP

Material **1.56** Materials for inclusion in the permanent works shall be new unless otherwise specified. Random on-site sample tests and performance tests shall be carried out when specified or when requested by the SO.

Quality generally **1.57** Materials and workmanship shall generally be consistent with good building practice in Hong Kong and shall comply with the Regulations and the relevant BS, BS EN or CP unless otherwise specified and/or approved.

Manufacturer's recommendations **1.58** Handle, store and fix each material in accordance with manufacturer's recommendations. Submit copies of these recommendations to the SO when requested before work is commenced.

Compliance with standards **1.59** When specified or when requested by the SO, provide test certificates obtain from the manufacturer's guarantees that materials specified are to a BS or other internationally recognized standard.

Specialist work **1.60** When specified, specialist work shall be carried out by a firm whose name is included on the appropriate DEVB List or the list of approved specialist contractors included in the Contract.

Specialist materials **1.61** When specified, specialist materials shall be obtained from a firm whose name is included on the appropriate DEVB List or the list of approved specialist suppliers included in the Contract.

Single source **1.62** When a choice of manufacturer is permitted for any material, either obtain the entire quantity required to complete the work from one manufacturer or, if a change in the source of supply is contemplated after deliveries of the material has begun, obtain approval for such a change in the source of supply.

Choice of material **1.63** When a choice of type or size of material is allowed (e.g. glazed wall tiles, mosaic tiles), the same type and size selected by the Contractor shall be used throughout for all work in like locations.

Sample of materials **1.64** Submit samples of all materials required for the Works as the SO may reasonably direct and do not confirm orders until approval has been obtained. Keep approved samples on the Site for comparison with materials used in the Works. When there is a choice of material, colour or texture, samples shall be submitted for approval.

Samples of finished work **1.65** Make samples of finished work as specified or as required by the SO and obtain approval before proceeding with the work. Retain samples on the Site for comparison with the completed work.

Mix proportions **1.66** Unless otherwise specified, mix proportions shall be by volume.

Tests **1.67** Make tests on materials and workmanship as specified or as instructed by the SO.

Provide test samples under the supervision of the SO and carry out tests by the Public Works Laboratories (PWL) or when required, by an independent body accredited by the Hong Kong Laboratory Accreditation Scheme (HOKLAS) (hereinafter referred to as the "Accredited Laboratory").

Submit sampling and analysis methodology, including name of the laboratory to be appointed and procedures from collection of test samples to submission of test results, for the SO's approval prior to conducting any tests. Declare in writing that the Accredited Laboratory appointed has no affiliation as a legal entity to the Contractor and its sub-contractors.

Appropriately label, mark and keep selected samples under the charge of the SO securely under lock before delivery to the laboratory.

With the approval of the SO or the SO's Representative either to:

(a) appoint representative(s) from the Accredited Laboratory or through collection service operated by the Public Works Laboratories (PWL) to collect test samples on site; or
(b) arrange the Contractor's representative(s) to collect test samples on site under the close supervision of the SO or the SO's Representative.

Ensure that the agreed representative(s) has strictly followed all the procedures stated in the approved methodology. Test samples collected shall be kept in sealed container inaccessible to unauthorized persons at all times.

Test results shall be submitted directly from the laboratory to the SO in sealed envelopes, not via the Contractor. For the Accredited Laboratory, the test results shall be reported in a HOKLAS endorsed test report.

Submit samples of materials, carry out tests and obtain approval before the materials are used in the Works.

Test cube security cages **1.68** Provide sufficient concrete test cube security cages size 1.25 x 1.00 x 0.70 m high constructed of mild steel framing with mesh sides, hinged and lockable top, plywood bottom and shelves.

Protection from weather **1.69** Cover up, protect and secure the Works and the Specialist Works from damage by inclement weather, including providing sufficient staff, adequate plant and any other requirements necessary to ensure protection during typhoon and heavy rainstorm conditions.

Removal of water **1.70** Keep the Site and all trenches and excavations thereon free from all water arising from rain, springs, drains, percolating water and the like by pumping or otherwise. Ensure that such removal of water has no detrimental effect on adjacent property.

Cleanliness **1.71** Store materials and plant neatly, remove rubbish and debris as they accumulate, and keep the Site and the Works clean and tidy.

Protection from overloading **1.72** Protect the Works from damage due to overloading. Obtain details of design loads from the SO.

Drying the Works **1.73** When specified, provide temporary equipment, fuel and attendance for drying and controlling the humidity of the Works.

Work at completion **1.74** Clean the Works thoroughly inside and outside and leave the Works without damage and ready for occupation on completion, including polishing floors, windows and similar finishes.

Security at completion **1.75** Leave the Works secure, with all accesses locked. Account for all keys, which should be appropriately tagged, and transfer these to the SO.

Tolerances **1.76** Unless otherwise specified, the maximum permitted tolerances in construction shall be in accordance with **BS 5606.**

The structural limits for lift shafts at any level shall be in accordance with **BS 5655-6**, where applicable.

Restrictions on the use of hardwood **1.77** The use of hardwood shall not be permitted for the construction of site accommodation, storage sheds, screens, hoardings, covered walkways, signboards, side supports to excavation, propping to formwork, etc. in Clauses 1.31, 1.32, 1.33, 1.34, 1.35, 1.36, 1.38, 3.8(a) and 6.1. The Contractor is free to submit for SO's approval proposed alternatives to hardwood which will meet the same protection and aesthetic standards. If the proposals are subsequently not approved, the Contractor shall be directed by the SO to use other acceptable alternatives.

Conducting of compliance tests and surveys on site **1.78** Compliance tests conducted on site on structural works shall be carried out by the Public Works Laboratories (PWL) or when required, by an Accredited Laboratory.

Surveys conducted on site shall be carried out by a surveyor with recognized expertise subject to the prior approval of the SO.

The Accredited Laboratory / surveyor shall not be a holding company, an associated company, a subsidiary company or a related party of the Contractor and / or the piling Specialist Sub-contractor and shall not have any financial stake in the Works to be tested or surveyed.

Test and survey reports shall be submitted directly from the laboratory / surveyor to the SO in sealed envelopes, not via the Contractor. For the Accredited Laboratory, the test results shall be reported in a HOKLAS endorsed test report.

SUNDRY REQUIREMENTS

Records of Inspection **1.79** All inspections as required under the Contract or by the SO should be completed with records of inspections. These records including but not limited to the following should be kept on site :

(a) for quality compliance control.
(b) for temporary works checking.
(c) for examination of work before covering up.

(d) for SO's approval before further construction.

Red Imported Fire Ants **1.80** Collect, control and monitor Red Imported Fire Ants ("RIFA") in compliance with the following requirements:

(a) Scope of works

(i) The Contractor shall employ a pest control specialist in controlling Red Imported Fire Ants ("RIFA") to provide treatment services for the RIFA including their mound(s).

(ii) The treatment services shall include collection services of the suspected RIFA; controlling services against the confirmed RIFA; and surveillance monitoring on the RIFA.

(iii) The Contractor shall maintain and protect all the existing planting in the controlling area where treatment services are carried out. Whenever such maintenance or protection is not possible, the Contractor shall report to the SO with alternative proposal and resume the original condition at his own cost, such as re-planting to the satisfaction of the SO.

(b) Collection Services of suspected RIFA

(i) The Contractor shall report immediately to the SO upon discovery of mound(s) of suspected RIFA. Collection services of the suspected RIFA including collection of specimens of suspected RIFA to the Plant and Pesticides Regulatory Division of AFCD, and handling and transportation of samples as required by AFCD shall be provided. The collected specimens shall be stored in 70% alcohol. AFCD will examine, identify and confirm whether the specimens are RIFA.

(ii) Where suspected RIFA or mound(s) of suspected RIFA have been found, circular segment region, namely, possible infested zone, shall be marked with radial distance of 1 m measured from the edge of the circular mound where pesticide shall be applied therein. The Contractor shall cordon off and isolate the possible infested zone with clear bilingual warning sign to alert any workers or public about the presence of suspected RIFA and the relevant pest control situation. In case of multiple mounds, the possible infested zone shall be defined as the union of all the circular segment regions of each mound, if the circles overlap.

(iii) The Contractor shall liaise with the SO to complete the necessary information in the forms required to be submitted to the relevant departments, such as AFCD, DEVB etc., for reporting.

(iv) Upon confirmation of the suspected RIFA being regarded as RIFA by AFCD, the Contractor shall provide controlling services and surveillance monitoring for the confirmed RIFA.

(c) Controlling Services of the confirmed RIFA

(i) The Contractor shall provide pest-controlling services, namely, controlling services, for the confirmed RIFA in accordance with the approved proposal of controlling RIFA.

(ii) The Contractor shall submit a proposal of controlling RIFA to the SO for approval prior to carrying out the controlling services on site. The proposal shall include, but not limited to the followings:

(1) Pest control methodology, e.g. Individual Mound Treatment and / or 'Slow-release Granule' over large infested area;

(2) Working programme including pest control schedule and surveillance programme schedule;

(3) Layout plan(s) showing the location(s) of pest control to be provided; and

(4) Details of the pesticides to be applied, including Material Safety Data Sheet, application procedures with precaution measures, ecological information, etc. The Contractor shall refer to the updated list of registered pesticides available from AFCD's website.

(iii) The Contractor shall submit written formal reporting after each controlling service and surveillance monitoring to conclude the final effectiveness of each individual pest control or any new findings of RIFA mound(s).

(d) Surveillance Monitoring of the confirmed RIFA

(i) The Contractor shall provide surveillance monitoring for the whole site area if there is any discovery of RIFA.

(ii) Where controlling services for the confirmed RIFA have been carried out, surveillance monitoring shall be conducted every 14 days from the last day of provision of controlling services for the RIFA in the first month; and then thereafter monthly from the second month to the sixth month inclusive subject to no new mound(s) has been found at the subject location; and then thereafter quarterly from the seventh month to the twelfth month inclusive subject to no new mound(s) has been found at the subject location.

(iii) If new mound(s) of the confirmed RIFA is identified after each surveillance monitoring, the Contractor shall provide new treatment services for the newly identified area again.

(iv) Unless the surveillance area has been handed over to the recipient department after the Maintenance Period or to the satisfaction of the SO on the whole treatment services provided by the Contractor that surveillance monitoring is considered to be no longer required, the surveillance monitoring shall continuously be provided by the Contractor.

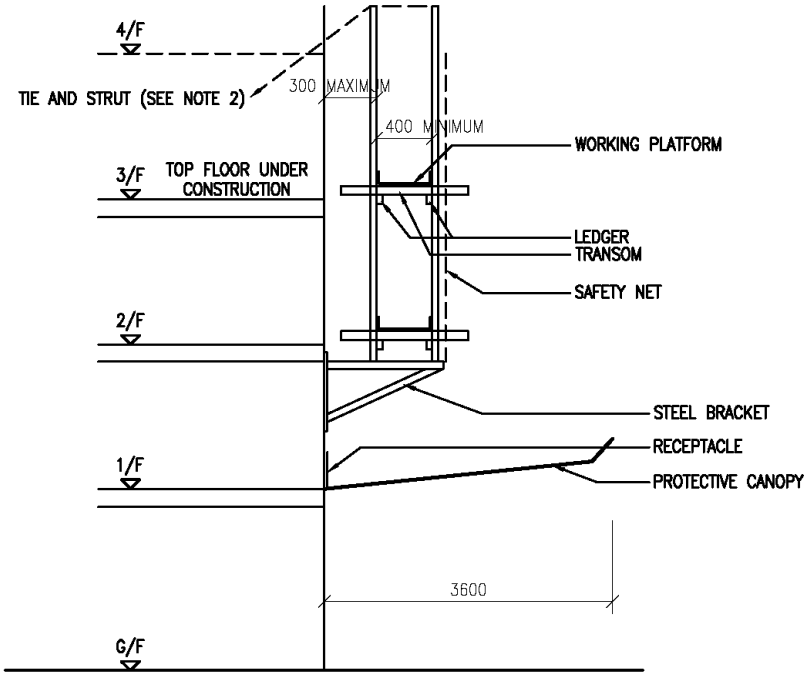
Site Uniform **1.81** Ensure that all workers involved in site works, except workers who are engaged for the execution of the Works on the Site for an aggregated period of 7 days or shorter, wear a set of site uniform when they are on the Site in accordance with this Clause.

For works contract other than maintenance term contracts, the site uniform, in the form of polo shirt (short-sleeve or long-sleeve to suit the weather conditions) and trousers, shall adopt the design of the anti-heat stress uniform of the Hong Kong Polytechnic University or a similar design submitted to and not disapproved by the SO within 5 working days after the date of delivery of the design to the SO.

For maintenance term contracts, the site uniform shall be in the form of polo shirt (short-sleeve or long-sleeve to suit the weather conditions) or vest / reflective vest / reflective jacket as specified. The design of the polo shirt shall adopt the relevant design of the anti-heat stress uniform of the Hong Kong Polytechnic University or a similar design submitted to and not disapproved by the SO within 5 working days after the date of delivery of the design to the SO.

The Contractor may show the Contractor's logo or a sub-contractor's logo on the site uniform.

ANNEX A



Stage 1

1. Erect protective canopy at 1st floor level.
2. Fix steel brackets as scaffold support at 2nd floor.
3. Erect outer and inner scaffold layers one floor above the top floor under construction.
4. Fix the safety nets to outer scaffold layer up to 2m above the top floor level under construction.
5. Provide working platform up to the top floor level under construction. No person is allowed to carry out any work on the scaffold if the working platform is not provided.

For structure or building exceeding 15m in height

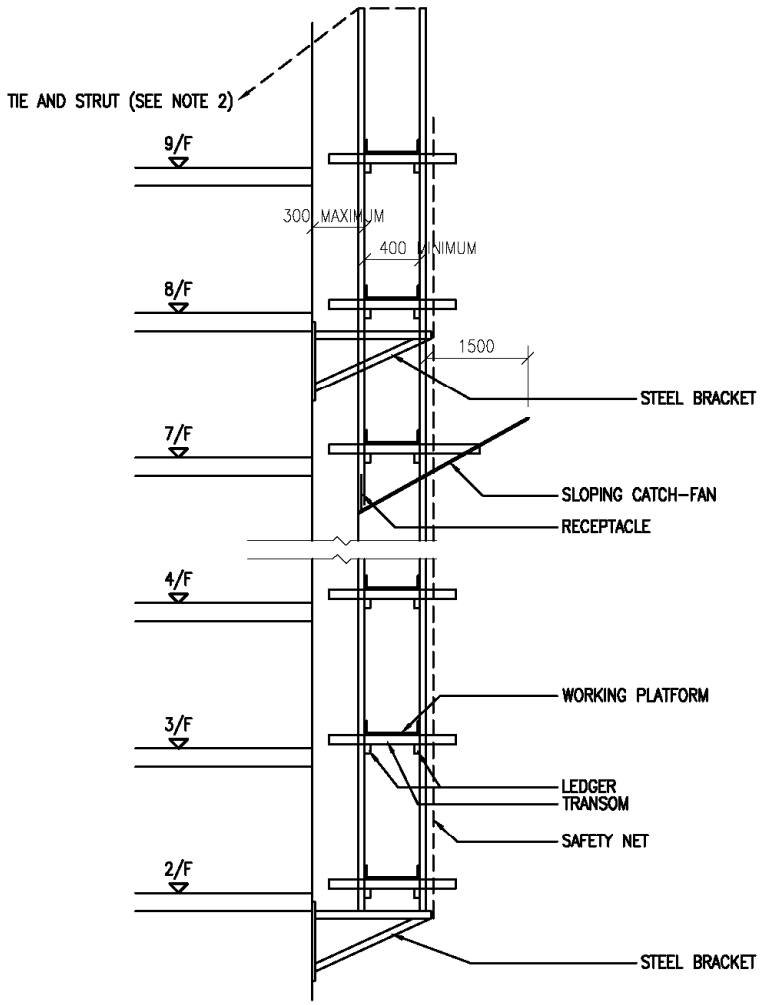
NOTE : 1. THE ABOVE SKETCH IS INDICATIVE ONLY. FOR SIMPLICITY, TIE/STRUTS, BRACING/LEDGES, GUARD-RAILS AND OTHER CONSTRUCTION DETAILS OF THE SCAFFOLD SYSTEM ARE NOT SHOWN.
2. ADEQUATE TIE AND STRUT ARRANGEMENT SHALL BE PROVIDED AT ALL TIMES TO THE CANTILEVERED SCAFFOLD ABOVE THE TOP FLOOR UNDER CONSTRUCTION.

title	date	drawing no.	scale
DOUBLE LAYER SCAFFOLD SYSTEM	FEB 2017	SCAFFOLD/1	N.T.S.
	office: STRUCTURAL ENGINEERING BRANCH	ARCHITECTURAL SERVICES DEPARTMENT	

0 50 100 0 500 1000 1500 2000 2500 mm

A4 210 x 297

ANNEX A



Stage 2

1. Install sloping catch-fan at every 15m vertical interval.
2. Install steel brackets at every 15m vertical interval.
3. Repeat Stage 1 item 3, 4 & 5.
4. Repeat Stage 2 as construction work progress for upper floors.

For structure or building exceeding 15m in height

NOTE : 1. THE ABOVE SKETCH IS INDICATIVE ONLY. FOR SIMPLICITY, TIE/STRUTS, BRACING/LEDGES, GUARD-RAILS AND OTHER CONSTRUCTION DETAILS OF THE SCAFFOLD SYSTEM ARE NOT SHOWN.

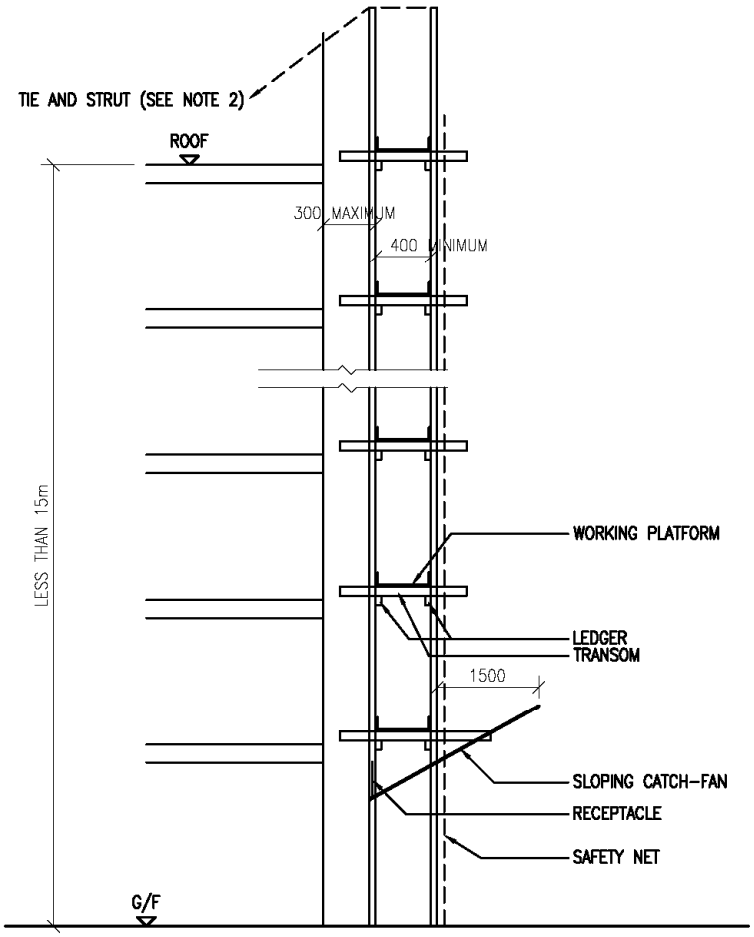
2. ADEQUATE TIE AND STRUT ARRANGEMENT SHALL BE PROVIDED AT ALL TIMES TO THE CANTILEVERED SCAFFOLD ABOVE THE TOP FLOOR UNDER CONSTRUCTION.

title	date	drawing no.	scale
DOUBLE LAYER SCAFFOLD SYSTEM	FEB 2017	SCAFFOLD/2	N.T.S.
	office: STRUCTURAL ENGINEERING BRANCH	ARCHITECTURAL SERVICES DEPARTMENT	

0 50 0 500 1000 1500 2000 2500 mm

A4 210 x 297

ANNEX A



For structure or building not exceeding 15m in height

NOTE : 1. THE ABOVE SKETCH IS INDICATIVE ONLY.
FOR SIMPLICITY, TIE/STRUTS, BRACING/LEDGES, GUARD-RAILS AND OTHER CONSTRUCTION DETAILS OF THE SCAFFOLD SYSTEM ARE NOT SHOWN.
2. ADEQUATE TIE AND STRUT ARRANGEMENT SHALL BE PROVIDED AT ALL TIMES TO THE CANTILEVERED SCAFFOLD ABOVE THE TOP FLOOR UNDER CONSTRUCTION.

title	date	drawing no.	scale
DOUBLE LAYER SCAFFOLD SYSTEM	FEB 2017	SCAFFOLD/3	N.T.S.
	office: STRUCTURAL ENGINEERING BRANCH	ARCHITECTURAL SERVICES DEPARTMENT	

0 500 1000 1500 2000 2500 mm

A4 210 x 297

SECTION 2

DEMOLITION, SITE CLEARANCE AND ALTERATIONS

Regulations, Ordinances, Codes of Practice & Practice Notes

2.1 Comply with all relevant legislation, Codes of Practice and Practice Notes. Particular attention is drawn to the following:

(a) **Code of Practice for Demolition of Buildings** issued by the Buildings Department.

(b) **Code of Practice for Site Supervision** and **Technical Memorandum for Supervision Plans** issued by the Buildings Department.

(c) **Guidelines for Selective Demolition and On Site Sorting** issued by the Civil Engineering and Development Department.

(d) **Building (Demolition Works) Regulations**.

(e) **Building (Administration) Regulations**.

(f) **Construction Sites (Safety) Regulations**.

(g) **Noise Control Ordinance**.

(h) **Air Pollution Control Ordinance**.

(i) **Water Pollution Control Ordinance**.

(j) **Factories and Industrial Undertakings Ordinance**.

(k) **Factories and Industrial Undertakings (Lifting Appliances and Lifting Gear) Regulations**.

(l) **Factories and Industrial Undertakings (Noise at Work) Regulations**.

(m) **Factories and Industrial Undertakings (Safety Officers and Safety Supervisors) Regulations**.

(n) **Air Pollution Control (Construction Dust) Regulation**.

(o) **Noise Control (Construction Work) Regulation**.

(p) The prevailing Buildings Department's **Practice Notes for Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers**.

(q) The prevailing Buildings Department's **Practice Notes for Registered Contractors**.

GENERAL REQUIREMENTS FOR DEMOLITION

Specialist Contractor for Demolition

2.2 The demolition works shall be carried out by a Registered Specialist Contractor for Demolition (RSC) on the Specialist Contractor's list maintained by the Buildings Department.

Registered Structural Engineer

2.3 The Contractor shall appoint a Registered Structural Engineer (RSE) registered under the Buildings Ordinance for the preparation and endorsement of the method statements, with drawings and design calculations, Supervision Plan for the

Contractor's Stream and any other submissions as required by the SO. The duties and roles of the RSE should include but not limited to:

(a) Take up the full design responsibility for method statements and all related drawings and calculations.

(b) Assume the role of Authorized Signatory's Representative in the Contractor's Stream under the Supervision Plan.

(c) Check that assumptions made in the design of temporary works and method statements are validated on the Site.

(d) Prepare a risk assessment report with the Safety Officer including an inspection schedule for all staff such as RSE, site engineer, Safety Officer, site agent, site supervisor / foreman, etc. on all critical activities in demolition works.

(e) Carry out such periodical supervision and make such inspections as may be necessary for proper control of the works and submit reports after each visit to certify the work is safe.

(f) Carry out inspections on other activities which, in his/her professional judgement, are critical and require close supervision.

(g) Should there be any formation and/or alteration to any slopes, retaining walls and other geotechnical features as a result of the demolition works in the vicinity of the works sites which require geotechnical submissions under current statutory requirements, the RSE shall be responsible to arrange a Registered Geotechnical Engineer (RGE) for all necessary geotechnical submissions to the Geotechnical Engineering Office (GEO) as stipulated in DEVB Technical Circular and other relevant authorities for comments and approval prior to demolition of any structure in the vicinity of the affected slopes, retaining walls and other geotechnical features. All geotechnical submissions shall be prepared by the RGE who shall be under direct supervision of the RSE. The RGE shall also be required to update the slope registrations and Maintenance Manuals to all affected slopes, retaining walls and other geotechnical features with GEO where necessary. The RSE shall ensure that all geotechnical submissions and site supervisions are made in accordance with all current statutory requirements of GEO and are acceptable to the relevant checking divisions of GEO.

(h) Change of the RSE shall not be permitted without prior written consent of the SO. In case of change of RSE, the new RSE shall review and resubmit the method statements prepared by the former RSE and assume the role of Authorized Signatory's Representative in the Contractor's Stream under Supervision Plan.

SUBMISSION REQUIREMENTS FOR DEMOLITION

Submission of Documents **2.4** Submission of documents for the SO's approval shall be two months before commencement of demolition works or other specified period. The documents shall include, inter alia, the following:

(a) Demolition Plans and Stability Report including calculation, and Method Statements.

(b) Project Safety Plan and the associated Risk Assessment Report.

(c) Supervision Plan.

(d) Environmental Management Plan.

(e) Details of hoardings, covered walkways, catch platforms, catchfans and all necessary precautionary measures in accordance with the **Code of Practice for Demolition of Buildings**.

(f) Mechanical plant and equipment list.

(g) Details of supervisory staff.

All the above plans and reports shall be prepared in accordance with the requirements of the **Code of Practice for Demolition of Buildings**. Items (a) to (e) shall be prepared and certified by the RSE.

Proposals for Specific Items and Critical Areas **2.4A**

Pay particular attention to detailed proposals for the demolition of the specific items and critical areas that may impact on the general safety of the public and on site personnel, including but not limited to:

(a) Cantilevered canopies and balconies.

(b) External wall, parapet and features.

(c) Scaffolding systems with more than 1.5 m projection.

(d) Any other structures as stated in the drawings or directed by the SO.

Demolition Plan and Method Statement **2.5**

Prepare a Demolition Plan and Stability Report including calculation in accordance with the requirements of the Buildings Ordinance, Building (Administration) Regulations, **Code of Practice for Demolition of Buildings** and the relevant Practice Notes issued by the Buildings Department, and a comprehensive Method Statement prepared and certified by the RSE. The comprehensive Method Statement of the demolition works shall include but not limited to the following details:

(a) A scaled plan showing the locations of the structures to be demolished and their distances to the adjacent buildings, structures, streets and significant street furniture. The plan should also show the location of the site video cameras as stipulated in Clause 2.11. The plan should be fully dimensioned with levels and provide sections where appropriate. If possible, site photographs should be included as much as possible.

(b) An appraisal of the structures to be demolished including an assessment on the structural condition of the part of the structures that are relevant to the demolition works, site condition and adjacent properties. Any potential hazard that may be associated with the proposed demolition works should be included.

(c) A description of the proposed methods used to demolish the different parts of the structure. This should include descriptions of the equipment used, the schedule, sequence and proposed procedures for the demolition. Detailed instructions for demolishing special features and critical areas that may affect the safety of the public and on-site personnel should be included. Specific precautionary steps for identifying these features should also be included. The use of graphics could be particularly useful to convey the message.

(d) The method statement shall include the specification and details for precautionary measures, which are essential to safety. The type of precautionary features should meet the requirement of the demolition method selected and the site conditions. These features should include scaffolds, catch platform, temporary supporting systems to the part of the structure to be demolished and bracing for weakened structural elements.

(e) A proposed plan for conveyance of debris, on-site management and off-site transportation of the debris. Anticipated traffic condition should also be discussed to allow better planning for off-site transportation. On-site

storage of debris shall be specified.

(f) The method statement shall include detailed plan for removal and disposal of on-site hazardous materials, if any, and disposal in compliance with the environmental protection regulations.

(g) Access route for handling emergency situations, such as accident, should be provided.

(h) Inspection and maintenance frequency for the precautionary measures and on site equipment should be included.

(i) The method statement shall also include the storage and handling of flammable materials that would be used in the demolition process.

(j) A suggested scheme of on-site supervision and technical support for ensuring all works are carried out safely.

(k) Means to reduce dust, noise and vibration impacts.

(l) Stability checking calculations for the building to be demolished, its supports, if any, the adjoining properties and the loading due to powered mechanical plants, or equipment.

(m) Detailed design for temporary supporting systems to support machines working on the building and protection of any structure that may be affected by the demolition.

(n) Periodic inspection schedule on adjacent structures that would potentially be affected by the demolition to evaluate their structural conditions.

(o) If the project required temporary closure of traffic, a traffic plan with detailed locations of the temporary traffic sign.

STAFF REQUIREMENTS FOR DEMOLITION

Technically Competent Persons **2.6** Employ such number of technically competent persons (TCP) for the demolition works as required. The TCP should have obtained the required qualification (a relevant certificate, diploma, degree or registered professional engineer) and experience in the structural, civil or building discipline and have at least the number of years of relevant site experience in accordance with the **Technical Memorandum for Supervision Plans** and **Code of Practice for Site Supervision**.

The TCP(s) shall prepare daily site supervision reports to be endorsed by the RSE.

Site Engineer **2.7** Employ a site engineer, who shall be a Registered Professional Engineer in the structural, civil or building discipline with at least 5 years relevant experience. Submit the particulars of the site engineer, including name, qualification and previous experience, to the SO for approval within 7 days after commencement of the contract.

The site engineer shall conduct full time site supervision, oversee the entire process of the demolition works and prepare site supervision reports at each of the following stages. Such report should be submitted to the SO after completion of each stage of demolition works and before the commencement of the next stage of demolition works. These stages shall include:

(a) When all site preparation works, including hoardings, covered walkway, scaffolding, catchfans, protective screens and safety nets, dust screens, catch platforms, safety barriers have been erected;

(b) When all temporary works for demolition of a particular structure have been erected prior to actual demolition; and

(c) At any stages identified by the SO as critical stage from the Demolition Plan submitted by the Contractor.

Registered Electrical Worker **2.8** Appoint a relevant registered electrical worker of appropriate trade to certify that the structures have been appropriately electrically disconnected from all electricity supplies and the supply company's incoming supply connected to the structures has been de-energized. The appointed Registered Electrical Worker shall supervise and certify all electrical works to meet the relevant regulations during the contract.

Operator of Powered Mechanical Plant or Equipment **2.9** Operator of powered mechanical plant or equipment used in demolition works shall be in compliance with Regulation 9(3) of the **Building (Demolition Works) Regulations**; and shall have at least 3 years experience in operating the particular plant or equipment. The operator shall also have completed a training course in "Demolition of Building Course for Plant Operators" organized by the Hong Kong Institute of Construction (HKIC) and obtained the relevant certificate or other equivalent training and certificate issued by a recognized examining body; and operate under the immediate supervision of a TCP of the demolition works.

Submit the personal particulars, qualifications and experience of the operators of powered mechanical plant or equipment proposed to be used in the demolition works in accordance with Regulation 31 of the **Building (Administration) Regulations**, to the SO before the commencement of the demolition works. The Contractor shall notify the SO within 7 days of any change in the appointment of the operator and provide personal particulars, qualifications and experience of the new operator.

Demolition Workers **2.10** Employ workmen who shall be registered demolition workers or registered worker of appropriate trades and under supervision of a TCP. These demolition workers shall have attended the Safety Training Course for Construction Workers of Specified Trades (the "Silver Card" course) organized by HKIC for demolition works, and possessed the relevant valid silver card issued by HKIC. All workers involved in the demolition works should also have received other relevant safety trainings such as proper procedure for the use of PPE, working at height safety, etc.

VIDEO RECORDING SYSTEM FOR DEMOLITION

Video Recording System **2.11** Provide and maintain two colour video cameras for each building with resolution not less than 1920 x 1080 and with appropriate view angle coverage, light sensitivity and automatic focus and aperture, TV monitors and video recording systems, and with all necessary accessories including the recording media for transmitting and recording, to capture the entire demolition process. The video recording systems and video records shall be kept in a secured place to be agreed with the SO. The video signals from the cameras shall also be real-time connected or transmitted to the site office of the SO and be viewed and inspected by the SO with a TV monitor, equipped with switching system to each camera. The video cameras shall be installed at strategic locations as directed by the SO and be securely protected so that the entire demolition process including the movement of debris and the overall sequence of demolition can be captured. The video records shall be kept for inspection for at least 14 days. Post sufficient notices at conspicuous positions to notify the affected persons including the workers, the staff and the general public about the purpose of video recording system in accordance with Data Protection Principles set out in the **Personal Data (Privacy) Ordinance**.

ENVIRONMENTAL CONTROL DURING DEMOLITION

Noise Level Control **2.12** The noise level generated from the works site and measured at the nearby noise sensitive receivers shall not exceed the limits as specified.

Provide all necessary equipment and labour to monitor and to record the noise levels measured at the nearby premises and any other locations to be agreed by the SO at least twice daily and any other time when required by the SO. The

monitoring records of the noise measurements shall be kept on site for the SO's inspection.

Water Pollution Control **2.13** Provide, operate and maintain all necessary water pollution control system on site and plan the works such that discharge and deposit of effluents generated from the demolition operations shall be controlled as specified.

Air Pollution Control **2.14** Provide, operate and maintain all necessary air pollution control system on site and plan the works to minimize generation of dust and to minimize the spread of dust to beyond the Site.

Coordination with neighbour **2.15** Adopt demolition operation that produces the least loud noise or dust nuisance to occupants of the surrounding buildings. Co-ordinate with the management of the neighbouring premises and all other concerned parties with report to the SO, and schedule the works to suit those hours that will cause the least disturbance.

PROTECTION OF ADJACENT PROPERTIES DURING DEMOLITION

Protection to adjacent buildings and structures **2.16** Provide adequate support and protection to adjacent buildings and structures, pedestrian subways, building services installations including all underground cables and pipe works within or in the vicinity of the Site.

Any area, if unduly damaged, shall be restored and made good to its original conditions at the expense of the Contractor.

METHODS OF DEMOLITION

Top Down Method **2.17** Top down method shall be adopted unless specified otherwise.

Hydraulic Concrete Crusher and Concrete Breaker **2.18** Hydraulic Concrete Crusher shall be used for demolition of reinforced concrete structures unless otherwise approved by the SO.

Unless specified otherwise, the use of percussive type of concrete breaker is allowed during part of the demolition process. Submit proposal on limiting the noise generation for the SO's approval. Subject to the approval by the Environmental Protection Department on noise permit, the time allowed for using any percussive type of concrete breaker shall be agreed by the SO.

Wrecking Ball **2.19** The use of swinging ball, drop ball and blasting shall not be permitted for demolition works.

Saw Cut Method **2.20** To isolate the vibration and noise generated during demolition being transmitted to the adjacent premises adjacent to the Site, the Contractor can use Saw-Cut method or other approved methods to separate the structures to be demolished from the structures to be retained before demolition. Submit method statement for forming such separation joints, including temporary support and shoring, for the SO's approval.

DISPOSAL OF DEMOLITION WASTE DURING DEMOLITION

Removal of Demolition Waste **2.21** Except otherwise directed, all salvage materials become the property of the Contractor and shall be removed from the Site expeditiously as the works proceed. The storage, segregation and disposal of demolition waste shall be in accordance with the guidelines stipulated in the "**Guidelines for Selective Demolition and On-Site Sorting**" and the contract requirements. The handling of demolition waste shall follow the Environmental Management Plan prepared by the Contractor.

A complete record is required to be kept on site and regularly updated on the disposal, reuse and recycling of all demolition waste with respect to their dates of disposal and the quantities involved.

All hazardous waste discovered shall be handled by licensed contractor registered in the Environmental Protection Department listing and approved by the SO.

Environmental Management Plan **2.22** Environmental Management Plan shall, in conjunction with the Demolition Plan, provide all necessary details including but not limited to the following:

(a) Method of handling demolished building debris.

(b) Routing and movement of debris from each floor to on grade holding area prior to leaving the Site.

(c) Means of transportation of debris off the Site.

(d) Time and frequency of debris disposal off site.

(e) Record scheme on the tonnage of each truck load, truck licence plate, driver's name, trip tickets and location of dump site.

(f) The site supervisory personnel responsible for the debris disposal and management system.

Disposal of Construction & Demolition (C&D) Materials **2.23** Disposal of C&D materials shall comply with the "Particular Specification on Environmental Management" and the "**Waste Disposal (Charges for Disposal of Construction Waste) Regulation**" currently enforced.

CERTIFICATION AND SUBMISSION UPON COMPLETION OF DEMOLITION

Certification **2.24** Upon completion of the demolition works, the Contractor shall certify the completion of the demolition works in accordance with the Buildings Ordinance, Regulations and the Demolition Plan. The certification shall be endorsed by the RSE.

As-built Records **2.25** Provide a complete list of as-built drawings with drawing number / reference and brief description stored in computer diskettes. The drawings shall show the final boundary of the Site with fencing, ground features, levels and as-built external storm water drains, where the surface water is connected to the storm water drainage system outside the Site.

PRELIMINARY WORKS AND PRECAUTIONARY MEASURES FOR DEMOLITION, SITE CLEARANCE AND ALTERATIONS

Survey **2.26** Carry out detailed survey including existing services, drainage systems and building services installations.

Building Services and Drainage System **2.27** The Contractor shall appoint a Building Services Coordinator to liaise and coordinate decommissioning of existing building services installations. The Building Services Coordinator shall have a diploma or higher certificate in building services, electrical or mechanical engineering from a recognized tertiary in Hong Kong or equivalent and have at least 5 years experience in building services installations of which at least 2 years experience shall be in building services co-ordination.

Ensure all existing water supplies, drainage and building services provisions of adjacent buildings and areas will not be affected.

Report to the SO for directions upon discovery of any previously hidden or unidentified services/cables. Any unknown cables / pipes so discovered shall be carefully exposed by hand tools or as directed by the SO.

Provide all temporary water supplies and drainage connections to any adjacent buildings affected prior to disconnecting the existing supplies in the buildings.

Coordinate all utility companies and organizations such as power supply companies, telecommunications network services operators, town gas supply company, liquefied petroleum gas supply company and Water Supplies Department and other parties appointed by the SO to carry out disconnection, diversion, relocation or removal of their equipment and installations.

Preliminary Works **2.28**

Seal all abandoned sewer and drainage connections of the existing manholes and associated underground drain pipes as directed by the SO.

Remove all glazed sashes and doors from the relevant parts of the structures.

Remove all hazardous materials including asbestos.

Displace the trapped gas within all town gas systems and liquefied petroleum gas systems and certify that they are free of combustible gas in accordance with the Regulation and requirements specified by the authorities.

Precautionary Measures **2.29**

The necessary precautionary measures shall comply with the requirements in Clause 2.1 including but not limited to the following:

(a) Erection of hoarding, covered walkway and catch platform including temporary lighting according to drawings.

(b) Design and erection of scaffoldings, screen covers and catchfans.

(c) Design and erection of temporary supports to the elements of structure to be demolished, in particular, the cantilevered canopies and covered walkway and the external parapet wall and features and other elements as specified by the SO.

(d) Protection of adjacent properties, structures and services.

(e) Use of tarpaulin material as specified by the SO.

(f) Provide precautionary measures for disused manholes and underground voids.

Certification of Precautionary Measures **2.30**

Upon completion of the precautionary works, including hoarding, covered walkway, scaffolding, catchfans, protective screens and safety nets, dust screens, catch platform, safety barrier, and the like, the Contractor shall certify the completion of the precautionary works in accordance with the provisions of the Buildings Ordinance, Regulations and Demolition Plan. The certification shall be endorsed by the RSE.

Post-Demolition Precautions **2.31**

After completion of demolition, reinstate the Site to the conditions as shown in drawings. Unless specified otherwise, the following precautionary measures shall be adopted:

(a) The Site shall be levelled and cleared of any debris. Adequate drainage shall be provided.

(b) If the new development is not immediately commenced, the Site shall be completely enclosed as shown in drawings.

(c) Provide supports to adjacent building structures, weather-proofing and stabilization of exposed party walls shall be completed. A final inspection by RSE on the supports of adjacent structures shall be conducted to ensure satisfactory and safe conditions. If temporary shoring remains on site, inspection and maintenance shall be continued until the temporary shoring is removed or replaced by permanent supports.

(d) Any excavation shall be braced and stabilized.

(e) For sloping sites, and/or sites with retaining wall supporting ground, the following additional precautionary measures shall be included:

(i) The ground surface shall be sealed up to prevent water infiltration.

(ii) Any unstable structures and ground shall be stabilized.

SAFETY MEASURES FOR DEMOLITION, SITE CLEARANCE AND ALTERATIONS

Hoarding and Covered Walkway **2.32** Provide and maintain the hoardings and covered walkways as shown on the drawings.

Safety Protection **2.33** Provide and erect necessary and sufficient safety protection such as scaffolding, catchfans, protective screens and safety nets, dust screens, catch platforms, safety barriers, additional hoardings and covered walkways etc. for the safety and convenience of traffic, passers-by, users of adjacent premises, or workmen employed on the Works. All safety protection shall be erected prior to the commencement of the demolition operation and shall be maintained in good conditions until the completion of the demolition works. Regular inspection and clearance of debris shall be carried out.

Fire or Explosion **2.34** Take precautions to prevent fire or explosion caused by gas, vapour, electricity or any other source. Take appropriate precautions when removing tanks or pipes which may have contained flammable liquids or gases.

Disused drain **2.35** Take care to allow disused drains to vent built-up gas before allowing workmen to carry out works below ground level.

Underground voids **2.36** Provide vent pipes to underground tanks to vent built-up gases and vapours.

TREE PRESERVATION AND PROTECTION FOR DEMOLITION, SITE CLEARANCE AND ALTERATIONS

Precautions generally **2.37** The Contractor shall comply with the requirements in Clauses 25.201 to 25.257 on tree preservation and protection to ensure that the demolition, site clearance and alteration works will not damage the preserved trees. Regular cleansing to keep off dust accumulation on foliage; and works to the satisfaction of the SO.

Precautions prior to demolition, site clearance and alteration **2.38** The Contractor shall commence demolition, site clearance and alteration works only after the Contractor's compliance with the requirements stipulated to be completed prior to commencing site clearance, demolition, construction of permanent or temporary works, and any other site operations which may affect the trees. These requirements include but are not limited to:

(a) Installation of tree identification labelling or marking system pursuant to Clause 25.217 (c);

(b) Agreement of the SO to the limits of site clearance pursuant to Clause 25.218;

(c) Erection of temporary protective fencing pursuant to Clause 25.233; and

(d) Erection of temporary protective armouring and application of temporary protective mulching pursuant to Clause 25.238.

Precautions during demolition, site clearance and alteration **2.39** During demolition, site clearance and alteration works, the Contractor shall comply with the requirements on the restrictive use of the preserved trees and their Tree Protection Zones (TPZs) and the control measures for works within the TPZs. These requirements include but are not limited to:

(a) Restrictive use of the preserved trees and their TPZs pursuant to Clauses

25.223, 25.225, 25.226 and 25.228; and

(b) Control measures for changes in ground levels, excavation including trenching, and drilling within the TPZs pursuant to Clauses 25.240 to 25.244.

CLEARING WEEDS FOR DEMOLITION, SITE CLEARANCE AND ALTERATIONS

Clearing weeds generally **2.40** When instructed by the SO, the Contractor shall identify any *Mikania micrantha* as well as any other unwanted plants specified as noxious weeds by the SO and remove these plants from the Site as part of the site clearance work. The Contractor shall comply with the requirements in Clause 25.53 when clearing these unwanted plants.

Clearing *Mikania micrantha* **2.41** When clearing *Mikania micrantha*, the Contractor shall follow the technical guidance in the latest version of **Nature Conservation Practice Note No. 01 "Clearing Mikania"** promulgated by the Agriculture, Fisheries and Conservation Department.

ASBESTOS INVESTIGATION, REMOVAL FOR DEMOLITION, SITE CLEARANCE AND ALTERATIONS

Asbestos containing materials **2.42** Before any demolition or alteration work commences, a registered asbestos consultant shall be appointed to conduct a thorough investigation of the building for the presence of asbestos containing material at the premises and submit an Asbestos Investigation Report and, if asbestos containing material is found, an Asbestos Abatement Plan to the Environmental Protection Department at least 28 days before the asbestos abatement work commences.

When appropriate, a registered asbestos laboratory shall be appointed to carry out sampling, measurement or analysis of any suspected asbestos containing material.

Asbestos removal works shall be carried out by a registered asbestos contractor under the supervision of a registered asbestos consultant in compliance with relevant legislation and codes of practice.

If during the course of the general demolition works, hidden suspected asbestos containing material is found, stop works immediately and report to the SO.

Asbestos removal **2.43** The removal of asbestos-containing materials shall be carried out by an approved registered asbestos contractor prior to commencement of general demolition works to avoid contamination of debris arising from the demolition.

Specified notification forms about the commencement of the asbestos abatement works shall be submitted to the Environmental Protection Department and the Labour Department 28 days in advance.

Sampling and analysis **2.44** Bulk samples of suspected asbestos-containing materials shall be taken on the advice and under the supervision of a registered asbestos consultant and analysed by an approved laboratory to verify the presence of asbestos, and to determine the content and the type of asbestos.

Full depth of the insulation material from its outer surface to the base structure shall be taken for sampling.

When specified, two additional side by side quality control samples shall be taken and analysed by another approved laboratory.

Asbestos abatement plan and method statement **2.45** Where an asbestos abatement plan has been prepared as per Clause 2.42, the registered asbestos consultant appointed shall supervise the implementation of the plan. Where the submission of an asbestos abatement plan is not required, the Contractor shall submit, before commencement of the removal work, a detailed method statement to the SO for approval, which shall include a detailed works programme, sketches showing the containments, air locks, air movers and scaffolding as required. Contingency measures of safety and escape access shall be maintained in case of an emergency (fire, accident, etc.).

Glove bag method **2.46** The use of glove bag method for the removal of asbestos-containing materials shall be included in the asbestos abatement plan with prior approval by the Environmental Protection Department and the SO.

Supervisor **2.47** A full time Registered Asbestos Supervisor shall be stationed at the works site.

Warning signs **2.48** Proper and publicly visible warning signs in compliance with relevant legislation and codes of practice shall be provided.

Floor tile adhesive remover **2.49** The floor tile adhesive remover used in the asbestos vinyl floor removal works shall be the type of low volatile organic compound (VOC) content and shall comply with the following requirements:

(a) biobased
(b) VOC content of less than 5%

Mastic removers made from petroleum-based chemistry are prohibited. The tile adhesive remover shall be acceptable by the Environmental Protection Department of proven safe formula in accordance with the **Code of Practice on Asbestos Control**. The application of the tile adhesive remover shall strictly follow the manufacturer's instructions and recommendations.

After removal of tile adhesive, the surface shall be cleaned with an approved degreaser. Only those degreasers recommended by the manufacturer of the tile adhesive remover shall be used for removing the residue remaining on the floor substrate, before laying the new floor tiles.

Minimisation of fibre release **2.50** Full containment method shall be applied to the removal works of friable asbestos materials. Smoke test shall be conducted by a registered asbestos consultant before the commencement of asbestos removal works to ensure the integrity of the full containment. Sufficient negative pressure shall be maintained during the removal works.

No power tools shall be used directly on asbestos containing materials.

Asbestos material shall be wetted prior to stripping / removal and shall be mist-sprayed with amended water during stripping.

Breakage of asbestos material should be minimized during removal works.

Asbestos waste shall be collected in approved waste containers as soon as it is produced.

Debris / dust generated shall be removed with high efficiency particulate absolute vacuum cleaner which shall be positioned next to the source of fibre generation.

When entering or leaving the contaminated work area, a strict changing and decontamination routine must be followed by all personnel.

Waste disposal **2.51** Asbestos-containing waste generated from the removal works shall be properly disposed of in accordance with the requirements of the **Code of Practice on the Handling, Transportation and Disposal of Asbestos Waste** published by the Environmental Protection Department.

Notification shall be given to the Environmental Protection Department at least ten

days before the scheduled disposal of asbestos waste and a duly stamped trip ticket shall be submitted to the SO for confirmation of disposal.

Water contaminated with asbestos shall be filtered first before being discharged into soil drains.

Air monitoring **2.52** Asbestos removal shall be closely monitored by air sampling and an analysis of the air-borne fibres in conjunction with the removal work undertaken by an approved laboratory.

Personal air samples shall be taken for the worker carrying out asbestos removal work. A reading of less than 0.2 fibre/mL shall be required for the removal works of amosite / crocidolite. For removal works of other types of asbestos materials, the reading shall not exceed 0.5 fibre/mL.

A reading of less than 0.01 fibre/mL will be required in the penultimate / final clearance / reassurance air sample analysis to ensure the site cleanliness after asbestos removal works.

Storage of waste **2.53** Double-bagged asbestos waste shall be clearly marked with indelible ink and labelled, and stored either in a designated weatherproof holding area within the Site or in a secured lockable area outside the contaminated works area, with either location to be agreed on site. Conspicuous warning sign in compliance with relevant legislation and codes of practice shall be provided at the storage area.

Regulations, Ordinances and Codes of Practice (Asbestos) **2.54** Comply with all relevant legislation and codes of practice in connection with asbestos removal works. Particular attention shall be drawn to the following:

(a) **Factories and Industrial Undertakings (Asbestos) Regulations**.

(b) **Air Pollution Control Ordinance**.

(c) **Air Pollution Control (Asbestos) (Administration) Regulations**.

(d) **Code of Practice on the Handling, Transportation and Disposal of Asbestos Waste**, the Environmental Protection Department.

(e) **Code of Practice on Asbestos Work using Full Containment or Mini Containment Method**, the Environment Bureau.

(f) **Code of Practice on Safe Handling of Low Risk Asbestos Containing Material**, the Environment Bureau.

(g) **Code of Practice on Asbestos Work using Glove Bag Method**, the Environment Bureau.

(h) **Code of Practice - Safety and Health at Work with Asbestos**, the Labour Department.

(i) The prevailing Codes of Practice on asbestos control issued by the Environmental Bureau.

SECTION 3

EXCAVATION AND EARTHWORK

GENERAL

Definitions **3.1**

(a) (i) "Top soil" is soil capable of supporting vegetative growth.

(ii) "Inert construction and demolition material" shall mean rock, rubble, earth, soil, concrete, asphalt, brick, tile and masonry generated from construction and demolition works.

(b) "Suitable material" shall consist of naturally occurring or processed material, or inert construction and demolition material, which at the time of deposition is capable of being compacted in accordance with the specified requirements to form stable areas of fill. The soluble sulphate content of the suitable material placed within 500 mm of concrete, cement bound material or cementitious material shall not exceed 1.9 g of sulphate, expressed as SO_3, per litre. The total sulphate content, expressed as SO_3, of the suitable material placed within 500 mm of metal work shall not exceed 0.5% by mass.

The method of testing of the total sulphate content shall be in accordance with **Geospec 3** - Model Specification for Soil Testing issued by the Geotechnical Engineering Office.

(c) "Unsuitable material" is material other than suitable material or containing any of the following:

(i) Material susceptible to volume change, including marine mud, soil with a liquid limit exceeding 65% or a plasticity index exceeding 35%, swelling clays and collapsible soils.

(ii) Peat, vegetation, timber, organic, soluble or perishable material.

(iii) Dangerous or toxic material or material susceptible to combustion.

(iv) Metal, rubber, plastic or synthetic material.

(d) "Rock" is hard material which in the opinion of the SO can only be removed by the use of blasting, wedges or pneumatic drills and shall include individual boulders or other masses exceeding 0.20 m^3 in size.

(e) (i) "Rock filling material" shall consist of pieces of concrete or hard and durable rock of which the maximum size shall not be greater than three times the minimum dimension of individual pieces and in the opinion of the SO not more than 30% by mass is discoloured or shows other evidence of decomposition.

(ii) "Recycled rock filling material (Grade 200)" shall be recycled rock or inert construction and demolition material which is hard and durable, and free from cracks, veins, and other evidence of decomposition.

(f) Not used.

(g) "General filling material" shall be "suitable material". It may contain up to 25% rock distributed evenly throughout the whole mass of the material. General filling material shall contain no material exceeding 200 mm in size.

(h) "Fine filling material" shall be "suitable material" capable of passing through a 75 mm BS sieve.

(i) "Special filling material" shall be "suitable material" capable of passing through a 75 mm BS sieve. The special filling material shall be sampled and tested according to **Geospec 3**. The special filling material shall have the following characteristics:

(i) Liquid limit shall not exceed 45%.

(ii) Plasticity index shall not exceed 20%.

(iii) Coefficient of uniformity shall be greater than 50.

(iv) The percentage passing a 63 μm BS sieve shall be less than 45% by mass.

(j) "Embankment", "filling area" or "area of fill" means an area on the Site other than a foreshore or sea-bed where the ground level shall be raised by filling in layers as part of the Works.

(k) "Trench excavation" means excavating from ground level not exceeding 5000 mm in width at surface.

(l) "Bulk excavation" means excavation in the open other than trench excavation.

(m) Well-graded material shall consist of material that has a coefficient of uniformity exceeding 10.

(n) Uniform-graded material shall consist of material that has a coefficient of uniformity of 10 or less.

(o) The coefficient of uniformity (C_u) shall be calculated as $C_u = D_{60}/D_{10}$ where D_{60} and D_{10} are the equivalent sieve sizes in millimetres, interpolated from the particle size distribution curve, through which 60% and 10% of the filling material would pass respectively.

(p) The different types of filling material shall have the particle size distributions within the ranges stated in Table 3.1.

TABLE 3.1
Particle size distributions of filling material

Type of filling material	Percentage by mass passing					
	Size		BS test sieve			
	400 mm	200 mm	75 mm	20 mm	600 μm	63 μm
Fine filling material	-	-	100	-	-	-
General filling material	-	100	75-100	-	-	-
Special filling material	-	-	100	-	-	0-45
Rock filling material / Recycled rock filling material (Grade 200)	-	100	20-75	0-50	-	-

Note: The definitions of trench excavation and bulk excavation stated in sub-clauses (k) and (l) are for the purposes of the GS only and do not apply to the measurement of excavation in Bills of Quantities which are measured in accordance with the current edition of the **Hong Kong Standard Method of Measurement of Building Works**.

Ground investigation **3.2** Ground investigation reports, where these have been prepared, will be made available for inspection at the office of the SO. This information is given in good faith and no warranty whatsoever is given as to its accuracy.

Record survey **3.3** Spot levels and contours shown on drawings are, unless otherwise stated, reduced to principal datum.

Check the accuracy of site levels shown on drawings. Where levels are found to be inaccurate, notify the SO in writing before commencing excavation or earthwork. No claim in respect of inaccuracy of levels will be entertained after the relevant site levels have been altered by the Works.

Where specified, make an oversite topographical survey by an approved independent firm included in the current List of Approved Suppliers of Materials and Specialist Contractors for Public Works – Land, Engineering and Hydrographic Survey Services before any work is carried out under the Contract and again, after all excavation and filling work has been completed. If an independent firm is not employed, agree with the SO that plans or sections prepared from the above truly represent the original ground levels and the final levels required by the Contract and ensure that both parties sign the drawings. These endorsed drawings shall become the record surveys for the measurement of earthwork quantities.

Temporary works for earthworks **3.4** Design the temporary works associated with earthworks, including temporary slopes, stockpiles and drainage, such that the risk of failure is not more than that which would be adopted if the temporary works were to be permanent. Allowance may be made in the design of the temporary works for the shorter design life and for the risk to persons and property and the surface water and groundwater conditions which may occur during construction.

The Contractor shall provide details to the SO to demonstrate that the design of temporary works has been considered and incorporated measures, which minimise excavation of materials.

Earthwork **3.5**

(a) Carry out excavation and earthwork in such a manner as to prevent erosion or slips. Limit working faces to safe slopes and height. Do not stockpile material where it might cause a landslide or failure of excavation face.

(b) Provide and maintain necessary temporary access roads and temporary drainage, and divert and subsequently reinstate permanent drainage systems. Submit proposed alignments and levels of temporary access roads for

approval prior to their construction. Provide temporary roads with sufficient drainage ditches over their full length.

(c) Monitor weather forecasts to ensure awareness of impending heavy rain and inspect the site frequently during periods of sustained rainfall.

(d) Seal, cover with impermeable sheeting or protect by other methods approved by the SO, all excavation and earthwork at the cessation of the day's work and when heavy rain is expected.

(e) Material handling and storage areas shall be levelled and well drained. Stockpiles of material shall be sprayed with water or a dust suppression chemical to minimize dust generation.

(f) Carry out excavation and earthwork in the dry unless otherwise authorised by the SO. Carry out the formation of cuttings and filling in such a manner that the surfaces have at all times a sufficient minimum cross fall and, where practicable, a sufficient longitudinal gradient to enable them to shed water and prevent ponding. Adopt a method of working which exposes the minimum area of bare soil across the Site. Follow up earthwork immediately with either approved temporary protection or the permanent surface protection and drainage work.

(g) Rapidly disperse water, whether shed on to the excavation and earthwork, or arising from any other source including flowing into the Site from elsewhere. Provide temporary watercourses, ditches, catch pits, drains, pumping or other means of maintaining excavation and earthwork free from water. Approval shall be sought from the Drainage Services Department and the Environmental Protection Department for the discharge of site effluent into permanent drainage system. Ensure temporary and permanent drainage systems are adequately maintained and clear of rubbish and debris.

(h) Excavations for structures, pits and trenches shall not be carried out on or near slopes unless measures are taken to prevent water collecting in the excavation and running down the slope.

(i) Install permanent drainage systems when practicable and proceed upwards from the low point.

Rock crushing plants **3.6** Do not use rock crushing plant on the Site unless specifically permitted to do so under the Contract.

Topsoil **3.7** Remove topsoil when required before starting excavation or filling and, unless otherwise specified, deposit on site in temporary heaps for reuse. Ensure the soil is kept free from contamination and undue compaction.

EXCAVATION

Generally **3.8**

(a) Adequate support shall be used to maintain excavations in a stable condition and to prevent settlement of structures or utilities due to excavation or dewatering. Construction plant or other vehicles shall not be operated or parked adjacent to excavations and earthworks materials or other materials shall not be placed adjacent to excavations unless this has been allowed for in the design of the temporary works for the support of the excavation.

(b) Keep excavation free of water in accordance with Clause 3.5.

(c) Neatly trim the face of excavation.

(d) Carry out excavation to the lines, levels, dimensions and slopes specified.

(e) Carefully level the bottom of excavation and step or bench horizontally as specified. Remove any pockets of soft material or loose rock in the bottoms of pits and trenches and fill the resulting cavities and any large fissures with Grade 10 or higher grade concrete. Do not trim the side faces of excavations for at least 24 hr after placing any blinding concrete required by the Contract.

(f) Backfill in accordance with the GS and at no extra cost "over-excavated" areas where the Contractor's proposed method of excavation, if approved, involves excavation in excess of that specified in certain areas.

(g) Maintain excavated surfaces to be used for construction traffic at a level of 300 mm minimum above formation level unless in rock. Make good any damage to the surface arising from such use with material having the same characteristics as the material which has been damaged.

(h) Ensure that no construction traffic uses an area once trimming to final formation level has commenced, with the exception of plant necessary for such trimming, and ensure that no damage is caused to the surface by this plant.

(i) Make good, at no extra cost, surfaces which, after excavation, have deteriorated to a condition that makes compaction of backfilling impracticable, either by carrying out additional excavation and filling in accordance with this GS or, by waiting until the condition of the exposed material is, in the opinion of the SO, fit to receive the approved backfill.

(j) Excavate in such a manner that suitable material is kept separate and store in temporary spoil heaps to the satisfaction of the SO, where required for use in the Works without contamination by unsuitable material or deterioration. Where, in the opinion of the SO, suitable material has become contaminated by unsuitable material or has deteriorated, this material shall be removed from the Site and replaced with suitable imported material at the Contractor's expense.

(k) Take necessary precautions to prevent damage to existing drains and services encountered in and around the excavation. Should any damage occur, notify the SO and the relevant authorities concerned immediately and make good at no extra cost. Temporarily divert ditches, land drains or other waterways encountered in the excavation and subsequently reinstate at the Contractor's expense.

(l) Take necessary precautions to prevent damage to tops of piles during excavation.

(m) Bottoms of excavation shall be approved before any new work is laid. Inform the SO when excavation is ready for inspection. Do not trim and blind the bottom of excavation without approval.

Obstructions **3.9** Notify the SO of the location and nature of any buried obstruction encountered during excavation. Take up disused drains encountered in the excavation and clear away. Remove any contaminated earth. Disinfect as necessary and seal off ends with concrete. Break up and remove disused manholes and backfill where required with approved material properly compacted.

Break out and remove old walls, foundations, piles and other underground structures encountered in the excavation and backfill where required with approved material in accordance with the GS.

Removal of excavated material **3.10** Remove unsuitable material from the Site. Do not remove suitable material from the Site without the permission of the SO, unless surplus to requirements of the

Contract. Unsuitable material and surplus materials shall become the property of the Contractor unless otherwise provided for in the Contract. Inform the SO of the proposed dumping areas and take responsibility for making arrangements for disposal of these materials. Notwithstanding the foregoing the SO retains the right to direct the manner in which dumping is to be carried out.

Tolerance for excavation **3.11** Excavation shall be within the tolerances stated in Table 3.2 of the specified design profile.

TABLE 3.2
Tolerances for excavation final surfaces

Type of surface	Tolerance for excavation except in rock (mm)		Tolerance for excavation in rock (mm)	
	+	-	+	-
Formations for foundation and utilities	0	25	0	150
Formations for pavements	0	50	0	150
Note: A positive tolerance refers to under excavation and a negative tolerance refers to over excavation.				

In case of cut slopes, the tolerance shall not exceed 75 mm measured at right angles to the batter.

Surfaces of cutting **3.12** Remove from the side of rock cuttings any inferior stone or soft material intervening between layers of compact rock, or rock which, in the opinion of the SO, will not withstand the weather satisfactorily after exposure. Remove from sides of cuttings rock fragments which move when prized with a crow-bar. The depth from the face of cuttings to which material is to be removed will be determined by the SO. Build up the resulting space to the required profile with Grade 10 or higher grade concrete or masonry in cement mortar to the required profile using rock similar to the adjoining natural rock as instructed by the SO.

Foundation pits and trenches **3.13** Do not excavate trenches and pits wider than is necessary for the construction of the foundation or execution of other works specified therein.

Do not open any greater length of trench at any one time than that has been approved. Remove all surplus spoil as soon as possible after excavation. Keep stacked spoil for filling tidy and free from contamination at all times.

Nullahs **3.14** Stack excavated materials away from nullahs, stream courses and covered culverts at a point convenient for direct loading on to transport in such a manner as to cause the minimum nuisance to the public.

Blasting **3.15** Do not use explosives except when specifically permitted by the Contract, or with prior approval of the SO.

Blasting operations, including the supply, transport and storage of explosives, on site manufacture of explosives, and the use of explosives including preparing, placing and firing a charge, handle misfires, and destroying or disposing surplus/unused explosives, as well as related preventive, protective, monitoring and contingency measures, shall be in accordance with conditions and restrictions imposed by the Commissioner of Mines. The Contractor shall make all arrangements with and obtain all licences and permits from the Commissioner of Mines in connection with blasting operations.

Give the SO a minimum of 24 hours' notice of a proposal to use blasting and give any details he may request concerning the charges, their positions, methods of monitoring the effects of blasting and protective measures. The SO may regulate, restrict or prohibit blasting if, in his opinion, it is necessary to do so for the safety of persons or property, to limit noise or to safeguard the Works. The approval of the SO shall be obtained for each location, or series of locations, where the Contractor wishes to use more than 10 kg of explosive in one blast.

Carry out pre-splitting trials well in advance of excavation to the final face where explosives shall be used to form a cut rock face required as part of the permanent works. Submit to the SO the following information before commencing the pre-splitting trials:

(a) Proposed blast-hole depth, diameter, spacing and orientation.

(b) Proposed type of explosive, charge weight and delay for each blast hole.

Adopt an approved pre-splitting technique for forming the final cut rock face.

Take responsibility for any delays arising from blasting operations.

FILLING AND COMPACTION

Surface preparation for filling material **3.16**

Clear all soft spots, loose boulders, grass, top soil, bushes, trees, roots and other vegetation or rubbish in natural ground or surface over which filling is to be placed. Do not place filling material until watercourses have been diverted or under drained. Do not place filling material on sloping ground until benches or trenches as described in Clause 3.17 have been completed.

Filling **3.17**

(a) Unless otherwise specified, filling material shall consist of general filling material obtained from excavation on Site, borrow areas or other approved sources.

(b) Provide for the SO's approval a method statement showing the sources of fill for each fill area, the construction plant to be used for placing filling material and the method of compaction.

(c) Commence filling works only when sufficient compaction plant is in operation at the place of deposition to ensure compliance with the requirements of Clause 3.19 or 3.20.

(d) Filling material shall be deposited in layers of a thickness appropriate to the compaction method to be used. In deposition of filling material, ensure that a good bond is achieved between layers of fill, and unless otherwise directed by the SO, no material shall be placed on previously compacted layers unless the surface has been scarified or otherwise broken up and, if necessary, watered.

(e) Blind the top surface of recycled rock filling material and rock filling material with fine filling material.

(f) Cut benches or trenches as shown on the drawings and as directed by the SO where filling shall be formed on sloping ground and provide any necessary under-draining of the affected part of the Site.

(g) Keep the fill area free of water in accordance with Clause 3.5.

(h) Obtain approval from the SO before commencing filling and before any fill layer is covered.

(i) Do not use “end tipping” in filling.

(j) Leave surfaces with no area that can retain water at the end of each day's work and, if necessary, cut ditches to achieve this.

(k) Stop work when the state of the weather is such that, in the opinion of the SO, it will adversely affect the placing of compacted fill.

(l) Adopt one of the following procedures when material placed and compacted, or awaiting compaction, reaches a condition which, in the opinion of the SO, does not comply with the GS or has been damaged either by weather or in any other way:

(i) Remove the material from Site, replacing it with equivalent suitable material.

(ii) Remove the material to stockpile until it is in a suitable condition for reuse.

(iii) Make good the material by mechanical or chemical means.

(iv) Cease work on the material until it is in a suitable physical condition for reuse.

Obtain approval from the SO before any of these options are adopted.

Remove, and adopt option (i) or (ii) above for any material not complying with the GS that has been overlaid by more recently placed material.

(m) Make good to the satisfaction of the SO settlement in filling and backfilling and any consequential damage that may occur up to the end of the Maintenance Period.

Tolerance for filling **3.18** Filling shall be within the tolerances stated in Table 3.3 of the specified design profile.

TABLE 3.3
Tolerances for filling

Design profile	Tolerance (mm)	
	+	-
Formations for foundation and utilities	0	25
Formations for pavements	0	50
Fill platforms	0	50
Fill slopes	50	50
Note: A positive tolerance refers to excess filling material and a negative tolerance refers to insufficient filling material.		

Compaction by performance specification **3.19** (a) Agree with the SO the thickness of each layer which shall be compatible with the particular filling material and the specific compaction plant to be used. Carry out carefully control tests to determine the optimum placing thickness for the particular filling material and the number of passes to achieve the required density with the specific compaction plant to be provided. No permanent fill shall be placed until such compaction procedure and control tests results have been agreed with the SO. Earth moving plant will not be accepted as compaction equipment under this clause. Spread

material in layers of uniform thickness and compact as soon as practicable after deposition.

(b) Test the material to be compacted in accordance with Clause 3.21 to determine its maximum dry density and moisture content.

(c) Not used.

(d) Carry out in-situ field density tests to determine the relative compaction in accordance with Clause 3.21 after compaction with the following arrangement:

(i) Test each layer and obtain approval from the SO prior to placing of the next layer, or

(ii) Subject to the approval from the SO, tests for each layer may be performed after filling material in not more than 2 layers above have been deposited and compacted. If the results of any tests at lower layers do not comply with the specified requirements for relative compaction, the soil layer and all the layers above shall be re-compacted and tested with additional tests for relative compaction. The number of additional tests shall refer to Table 3.6. Further deposition of filling shall not be allowed unless all the underlying soil layer(s) have satisfied all the test requirements. No claim in respect of re-compaction and additional tests of the soil layer due to non-compliance of the soil underneath will be entertained.

(e) The relative compaction (RC) of filling material shall be determined in accordance with the following equation:

RC = IDD/MDD x 100%

where:

- IDD is the in-situ dry density determined in accordance with Clause 3.21

- MDD is the maximum dry density determined in accordance with Clause 3.21

(f) Unless otherwise specified, filling material shall be compacted to obtain the following relative compaction (RC):

(i) Fill within the 1.5 m thick top surface zone of the platforms and fill within the 2.5 m thick top surface zone of the peripheral slopes measured at right angles to the batter - RC of at least 95%.

(ii) Interior of large fill platforms which do not or will not support structures - RC of at least 90%.

(iii) Interior of large fill platforms supporting structures - RC of at least 95%.

(iv) Fill immediately below road formation level - RC of at least 98% for a depth of 200 mm.

(v) Backfill to foundation pits or underneath suspended ground slab - RC of at least 90% or as agreed by the SO.

Compaction by method specification **3.20**

Compaction by method specification shall only be adopted for rock filling material or general filling material with a large portion of coarse material. Submit to the SO for approval a method statement covering particulars of the filling material, compaction layer thickness, specific compaction plant to be used, compaction procedure and the site control measures. Allow for control tests on the proposed method statement as required by the SO. Inspect and record compaction procedures and details carried out on site.

Carry out sieve analysis to determine the particle size distribution for each source of filling material. The number of tests required for each source of material shall be as stated in Table 3.5. If the results do not comply with the specified requirements, additional samples shall be provided from the same batch and additional tests shall be carried out. The number of additional samples shall be as stated in Table 3.5. If the results of the additional tests do not comply with the specified requirements, the material of the source shall not be allowed for compaction by method specification.

The size of samples of filling material other than rock filling material shall be in accordance with **Geospec 3**. Each sample of rock filling material of Grade size not exceeding 200 shall have a mass of at least 250 kg and each sample of rock filling material of Grade size exceeding 200 shall have a mass of at least 1000 kg.

(a) Compaction of rock filling material

(i) Spread and level each layer of rock filling material and systematically compact by at least 8 passes of a vibratory roller with a minimum static load per 100 mm width of roller of 2 kN or other equivalent plant approved by the SO. Each layer of rock filling material for compaction shall not exceed 400 mm. The final surface of rock filling material shall be compacted by at least two additional passes of a vibratory roller or by other equivalent plant approved by the SO.

(ii) The surface voids of each layer of rock filling material shall be filled with fragments of rock before the next layer is deposited. The final surface of rock filling material shall also be blinded with fine filling material.

(b) Compaction of general filling material with a large portion of coarse material

General filling material with a large portion of coarse material shall consist of material of which less than 90% passes a 20 mm BS test sieve. It shall be compacted to the following requirements:

(i) Spread and level each layer of general filling material with a thickness not less than 1.5 times of the maximum size of the general filling material and not exceeding the maximum depth of compacted layer in accordance with Table 3.4. If there is a presence of over-sized coarse material in the filling material, the over-sized coarse material shall be removed or broken down to sizes acceptable to the SO. Each layer shall be systematically compacted by an approved vibratory roller with the stipulated minimum number of passes corresponding to the minimum static load per 100 mm width of the roller.

(ii) The number of passes of the roller shall only be counted when the roller is travelled on the material to be compacted at a speed of not more than 2 km/hr with full vibration. Plant with addition of external load to increase the static load of the vibratory roller shall be disregarded in counting the number of passes.

TABLE 3.4
Compaction requirement for general filling material with a large portion of coarse material

Static Load per 100 mm width roller (kN)	Well-graded material		Uniform-graded material	
	Maximum depth of compacted layer (mm)	Minimum no. of passes	Maximum depth of compacted layer (mm)	Minimum no. of passes
0.25 – 0.45			150	16
0.46 – 0.70			150	12
0.71 – 1.25	125	12	150	10
1.26 – 1.75	150	8	200	10
1.76 – 2.30	150	4	225	10
2.31 – 2.80	175	4	250	10
2.81 – 3.50	200	4	275	8
3.51 – 4.20	225	4	300	8
4.21 – 4.90	250	4	300	8

Test for determining the degree of compaction of compacted fill

3.21 Arrange for tests specified below to be carried out by the Public Works Laboratories (PWL).

(a) Compaction tests shall be carried out on Site unless approved otherwise.

(b) Determine the maximum dry density and optimum moisture content in accordance with **Geospec 3**.

Test each soil type when first used and thereafter at the same time as every set of field density tests is carried out or whenever the SO may direct. Unless otherwise specified, the number of tests required shall be as stated in Table 3.5. Keep the records identifying the soil type and the location within the Works.

TABLE 3.5
Number of samples for testing of optimum moisture content and maximum dry density of filling material and sieve analysis of the same source of filling material

Description	Size of batch	No. of samples per batch
Special filling material	0 - 3000 m^3	3
	more than 3000 m^3	1 for each 1000 m^3 or part thereof
Filling material other than special filling material	0 – 15000 m^3	3
	more than 15000 m^3	1 for each 5000 m^3 or part thereof
Note: A batch is any quantity of filling material which is of the same type and which has similar properties, as determined by the SO.		

(c) Determine the in-situ field density and moisture content in accordance with **Geospec 3** as directed by the SO to determine the relative compaction achieved.

Unless otherwise stated in the Contract, the number of tests required shall be as stated in Table 3.6. Keep records identifying the soil type and location in the Works and showing the following information for each series of tests:

(i) Dry density of soil tested.

(ii) Moisture content.

(iii) Relative compaction achieved (%).

(d) Determine moisture content in accordance with moisture content tests under **Geospec 3** by means of a drying oven.

TABLE 3.6
Number of samples for testing of moisture content and relative compaction

Description	Size of area of fill in batch	No. of samples / No. of tests per batch = (a) + (b)	
		(a)	(b)
Areas of fill in excavations for structures, pits and trenches and on formations	0 – 100 m^2	3	-
	exceeding 100 – 500 m^2	1	2 for each 100 m^2 or part thereof
	exceeding 500 m^2	6	1 for each 100 m^2 or part thereof
Other areas of fill	0 - 1 ha	-	4 for each 1000 m^2 or part thereof
	exceeding 1 – 10 ha	10	3 for each 1000 m^2 or part thereof
	exceeding 10 ha	110	2 for each 1000 m^2 or part thereof

Note: For the purpose of testing moisture content and relative compaction, a batch is any quantity of filling material which is of the same type and which is deposited in a single layer in any one location of fill presented by the Contractor for testing on one occasion.

Formation is that part of the earthworks final surface on which a pavement, structure or utility, is constructed, or on which the blinding or bedding for a pavement, structure or utility is placed.

Filling of foundation pits and trenches **3.22** Deposit and compact suitable filling material to achieve the compaction specified in Clause 3.19 (f) unless otherwise shown on the Drawings or directed by the SO. Carefully remove planking and strutting and other excavation supports as the filling proceeds except where they are specified or required by the SO to be left in position.

Embankments **3.23**

(a) Form embankments of special filling material unless otherwise specified.

(b) Deposit and compact all earthwork material for filling as soon as practicable after excavation. Build up embankments evenly over the full width. Control and direct construction traffic during the construction of embankments uniformly over their full width. Form sloping faces of embankments and other fill areas by l m overfilling unless otherwise directed by the SO and cutting back to the desired profile. Make good damage to compacted layers caused by construction traffic.

(c) Compact embankments in accordance with Clause 3.19 or 3.20.

(d) Adopt one of the following procedures at no extra cost when material deposited as fill subsequently reaches a condition such that it cannot be compacted in accordance with the GS.

(i) Make good by removing the material from the embankment to tip or elsewhere until it is in a suitable physical condition for reuse and replace it with suitable material.

(ii) Make good the material by approved mechanical or chemical means to improve its stability.

(iii) Cease work on the material until its physical condition is suitable such that it can be compacted in accordance with the GS.

(e) Rock used in rock fill embankments shall, except for any specified external cover to slopes or near formation level, be of a size such that it can be deposited in horizontal layers each not exceeding 450 mm thick before compaction, extending over the full width of the embankment. Spread and level the material by a crawler tractor weighing not less than 15 t and compact in accordance with Clause 3.20(a). Each layer shall consist of reasonably graded rock and all surface voids shall be filled with broken fragments before the next layer is placed. Blind the top surface and side slopes of embankments so formed with approved fine filling material to seal the surface. On side slopes and verges, such material may be topsoil as defined in Clause 3.1.

(f) Isolated boulders each within the range 0.015 m^3 to 0.10 m^3 in size may be incorporated in embankments not of rock fill at the discretion of the SO provided that the specified compaction requirements are met. Boulders exceeding 0.015 m^3 shall be placed a minimum of 2 m below formation level of carriageways or hard-shoulders.

(g) Form embankments equally on both sides of culverts or drain pipes and the like.

(h) Where surfaces of embankment are required for use by construction traffic, build up and maintain at minimum 300 mm above formation level the area between the extremities of carriageways, including any central reserve and hard shoulders before subsequently trimming to formation level. Make good surface damage at no extra cost. Ensure that no construction traffic uses an area once trimming to final formation level has commenced, with the exception of plant necessary for such trimming and ensure that no damage is caused to the surface by such plant.

Filling existing watercourses **3.24** Divert existing watercourses and channels as required and clear the same of all vegetable growth and soft deposits and carefully fill in with suitable material deposited and compacted as specified.

Backfilling behind retaining walls **3.25** Backfill behind retaining walls with the graded filter drain specified. The grading of filter material shall be such so as to prevent the filling material from being washed through the filter.

Place graded filter with care to avoid contamination and in layers simultaneously with the filling material and compact in the same manner as the filling material.

Place general filling material or special filling material as specified on the drawings as backfilling to the sections shown on the drawings and thoroughly compact to achieve RC of at least 90% unless otherwise stated on the drawings or directed by the SO. Avoid excessive compaction to filling material behind retaining walls.

PREPARATION AND SURFACE TREATMENT OF ROAD FORMATION

Generally **3.26** Carry out preparation and surface treatment of the road formation after completion of any specified subgrade drainage and, unless otherwise agreed by the SO, immediately prior to laying the sub-base or the road-base where no sub-base is required. Follow the following sequence of operations :

(a) Formations other than rock fill

(i) Remove all mud and slurry from surfaces below carriageways, lay-bys, cycle tracks, footpaths and hard-shoulders after general reinstatement of any soft areas.

(ii) Compact surface by 4 passes of a smooth-wheeled roller having a load per 100 mm width of roller of 4.35 kN - 6.10 kN.

(iii) Trim the formation.

(iv) Roll the trimmed formation by 1 pass of a smooth-wheeled roller having a minimum load per 100 mm width of roller of 2.1 kN, or a vibratory roller having a minimum static load per 100 mm width of vibratory roller of 0.7 kN or a vibratory plate compactor having a minimum static pressure under the base plate of 13.8 kPa. Where the completed formation is not immediately covered with sub-base material, protect it with a membrane of 65 to 80 μm impermeable plastic sheeting with 300 mm laps or other approved means to prevent ingress of moisture. If the moisture content of the accepted compacted material is allowed to reach a value above the maximum permitted for the material, allow the material to revert to an acceptable moisture content and, if directed by the SO, make good the surface at no extra cost by recompaction before laying the sub-base or road-base.

(b) Formations of rock fill:

(i) Trim and blind the formation in accordance with the requirements of Clause 3.23.

(ii) Roll the trimmed formation as specified in Clause 3.26 (a) (iv) above.

(c) Formations of rock cuttings :

Make good with lean concrete any surface irregularities under the formation which remain after trimming of rock excavation.

SOIL-CEMENT FILL

Soil-cement **3.27**

(a) Soil-cement shall consist of Portland Cement (PC), sand and inorganic soil in the proportions 1:3:12 by mass.

(b) PC shall comply with Clause 6.27.

(c) Sand shall be natural sand or crushed natural stone complying with **BS 1200:2019**.

(d) Inorganic soil shall be free from organic matter and shall contain no more than 30% of soil particles passing a 63 μm BS test sieve.

Mixing soil-cement	**3.28**	Mix thoroughly soil-cement in a concrete mixer; hand-mixing of small quantities of soil-cement may be permitted by the SO.
Deposition of soil-cement fill	**3.29**	(a) Place soil-cement fill in its final position and compact within 30 min of the cement being added to the mix. (b) Submit to the SO for prior approval a method statement covering the soil-cement filling material, method of mixing, specific compaction plant to be used, compaction procedure and site control measures.
Regulations, Ordinances, etc.	**3.30**	Comply with all relevant legislation, Codes of Practice and Practice Notes listed in Clause 2.1.

SECTION 4

STEEL SHEET PILING WORK

MATERIALS

Steel sheet pile sections **4.1** Steel sheet piles shall be weldable structural steel to **BS EN 10248-1** Grade S270GP unless otherwise agreed by the SO.

Steelwork and accessories for use in the system of lateral support shall be as Section 15 - Structural Steel Work**.**

Testing of steel sections and accessories shall be as Section 15 - Structural Steel Work.

Fabricate special and non-standard sheet piles including corner piles and junction piles from sheet pile sections approved for use in the Works.

Provide sheet piles in single continuous lengths unless otherwise specified.

INFORMATION TO BE PROVIDED

Submission of Documents **4.2** Submit the following information:

(a) Type of sheet pile proposed including proprietary name, grade of steel, sectional modulus and qualities.

(b) Proposed sequence for installation of sheet piles.

(c) Details of special or non-standard piles.

(d) Details of initial trenching and guide frames.

(e) Details of pile driving equipment selected including proprietary names.

(f) Proposed method of pitching and driving piles to the tolerances given in Clause 4.10.

(g) Contingency proposals for the remedy of piles installed outside the tolerances.

(h) Detailed calculations of the proposed sheet piles and the system of lateral support of sheet piles prepared by a Registered Structural Engineer when specified**.**

(i) Proposed sequence of excavation and installation of system of lateral support if applicable.

(j) Proposed system to monitor the effect of excavation and dewatering on adjacent buildings, pavements, public or private services and any other structures or permanent features as Clause 4.6.

(k) Undertaking that the noise caused by the sheet piling works shall satisfy the legislation currently in force.

Provision of details before commencement of works

4.3 Submit detailed drawings with the method statements showing:

(a) The setting out arrangement for construction of the pile wall in relation to the Site and to adjoining structures. Each pile shall be annotated with a reference number and length.

(b) The sub-division of the pile wall into panels for the purposes of driving.

(c) The location of corner and closure piles.

(d) Proposed work on standard piles, e.g. holes for lifting.

(e) Design for the fabrication of corner, closure, taper and other non-standard piles.

(f) The proposed sequence of driving by panel and by individual pile.

(g) Design of the guide frames required at all locations in the Works to support piles for pitching and driving within required tolerances.

(h) Design of lateral support if applicable, including details of connections of walings, strutting, bracing, posts and splicing of members and sequence of construction and sequence of subsequent removal if applicable.

Do not change the method of installing sheet piles without approval.

WORKMANSHIP

4.4 Not used.

Existing services

4.5 Comply with the following when it is necessary to carry out any work in the vicinity of utility services:

(a) Advise the relevant utility undertaking at least 7 days before commencement of the Works.

(b) Excavate by hand to a depth sufficient to ascertain the position of service pipes etc. to ensure that these services are not damaged.

Monitoring system and ground settlement

4.6 Provide a system to monitor the effects of sheet piling work, subsequent excavation and dewatering on adjacent buildings, pavements, public or private services and any other structures or permanent features. The monitoring system must be adequate to effectively monitor ground movement.

Do not lower the ground water table level beyond the boundary of the Site unless otherwise specified, and adopt the approved measures to control and monitor ground water table levels.

Pre-load struts or braces and carry out grout injection if required by the Site conditions to minimise ground settlement.

Lateral support

4.7 Design by a Registered Structural Engineer when specified, the system of lateral support to the sheet piles to resist horizontal soil and water pressure arising from sub-soil conditions.
Construct the system of lateral support as Section 15 - Structural Steel Work when detailed design is provided.

Install members of the system of lateral support as excavation proceeds in stages in accordance with the approved construction sequence in the method statement as Clause 4.3 (h) or the designed sequence provided, whichever is applicable.

Marking **4.8**

Identify sheet piles on the Site by marking with the relevant number in accordance with the approved drawings of the sheet pile arrangement.

Mark the length on each pile and calibrate the pile at 1 m intervals along the length to permit checking by the SO.

Welding and splicing **4.9**

Welding shall be in accordance with Section 15 - Structural Steel Work.

Sheet piles not exceeding 12 m long shall be in single lengths. Piles in excess of 12 m may be spliced with approval. Splice sheet piles by full strength butt welding and maintain the true vertical alignment.

Form special and non-standard sheet piles by full strength butt welding.

Tolerance **4.10**

Install sheet piles within the following tolerances:

(a) Deviation from the correct line at ground level: Not exceeding 15 mm.

(b) Deviation from verticality of individual piles in any direction:

(i) Generally: Less than 1 : 400.

(ii) For end piles in panels and for guide piles: Less than 1 : 500.

Notwithstanding these specified tolerances, piles shall always be driven to ensure that the stated dimensions of any permanent structural elements are not reduced.

Pitching **4.11**

Provide rigid guide frames at upper and lower levels on both sides of the sheet piles. Accurately set out and interlock piles within the guide frames. Guide frames shall be designed to maintain piles in their true positions within tolerance during driving.

Driving **4.12**

Keep noise and vibration to a minimum when driving sheet piles. Comply with the legislation currently in force in connection with noise control. Drive piles to the specified penetration with high frequency vibration pile drivers. For hard driving only, other methods could be adopted if approved.

Extract and re-drive sheet piles installed outside tolerance. Replace any extracted piles that the SO considers as unfit for re-driving. Alternatively, the SO may approve the insertion of taper or other non-standard piles or other methods of correcting the plumb of piles.

Drive sheet piles in any length or panel progressively, with the top of no individual pile exceeding 600 mm below the top of the adjacent piles.

Obstructions **4.13**

Advise the SO immediately when obstructions are encountered that prevent the installation of any sheet piles to the specified penetration.

Adopt an approved method for overcoming the obstruction which, depending on actual circumstances, may include:

(a) Withdrawing the sheet piles, excavating for and removing the obstruction, backfilling and subsequently re-driving the sheet piles.

(b) Leaving the sheet piles at the depth of penetration achieved, excavating for and removing the obstruction, backfilling and subsequently completing the installation of the sheet piles.

(c) Driving the sheet piles on either side of the piles obstructed to the full penetration specified, removing the obstruction during general excavation work and subsequently completing the driving of the piles obstructed. This

method of removing obstructions may only be adopted with the express permission of the SO.

(d) Driving through the obstruction under controlled conditions. Replace any sheet piles damaged through the adoption of this method.

(e) Withdrawing and temporarily removing sheet piles, boring through the obstruction from ground level with approved drilling equipment and subsequently replacing and re-driving the piles.

Provide temporary propping / bracing to obstructed sheet piles when a significant length of pile remains above the general top level of adjacent piles.

Extraction **4.14** Do not extract sheet piles unless otherwise specified.

Burning off **4.15** Burn off the tops of sheet piles driven to full penetration to the level required when specified.

Burn off the tops of sheet piles damaged by hard driving when so directed.

Sheet pile record **4.16** Provide the SO with a record, in duplicate, for sheet piles driven the previous day giving for each pile its identity number and the reference of the rig used. The following data shall also be included:

(a) Date sheet pile pitched.

(b) Length of completed sheet pile and whether spliced.

(c) Type of pile drivers used at all stages to achieve specified penetration.

(d) Depth of penetration below an agreed datum level.

(e) Details of any driving damage.

(f) Alignment of completed sheet pile.

(g) Details of any obstructions encountered and measures adopted for overcoming the same if applicable.

Re-use of steel sheet pile from other site **4.17** Re-use of steel sheet piles from other site is permissible if they are used as temporary works and their physical conditions are considered satisfactory by the SO.

For steel sheet piles re-used as temporary works with design prepared by the Contractor that require checking and certification by independent checking engineer or structural design checker, mill certificate and testing requirements of steel sheet piles may be exempted by the independent checking engineer or structural design checker who shall provide justifications to the SO for prior agreement.

For other steel sheet piles re-used as temporary works, steel sheet piles may be re-used without testing, subject to the Contractor's provision of adequate proof evidence, e.g. mill certificate or testing certificate of structural steel materials, etc., showing that the steel sheet piles are in compliance with the specification.

SECTION 5

PILING WORK

GENERAL

Generally **5.1**

(a) Piles shall be designed by the Contractor unless otherwise specified.

(b) The approved types of piles that may be adopted by the Contractor unless otherwise specified are:

(i) Precast concrete piles.

(ii) Precast prestressed tubular piles.

(iii) Percussion cast in-situ concrete piles.

(iv) Steel 'H' piles.

(v) Non-percussion cast in-situ concrete piles.

(vi) Large diameter bored piles.

(vii) Large diameter bored piles with bell-outs.

(viii) Mini-piles.

(ix) Rock-socketed Steel H-piles (RSSHP).

(x) Barrette piles.

(xi) Any other piling systems approved by the Development Bureau.

(c) Support all loadings as specified with piles. Unless otherwise stated, all loads are acting at the geometric centres of columns and walls.

(d) In addition to the loads given in the loading schedule, the weight of pile caps or backfill over the pile caps and the imposed load over the plan area of the pile caps, which shall be taken as 7.5 kN/m^2 unless specified otherwise, shall be included in the pile loading.

(e) Design piles for the most critical loading generally produced from the following combinations:

(i) Dead load + imposed load + adverse soil and water load.

(ii) Dead load + imposed load + adverse soil and water load + wind load.

NOTE: The allowable load capacity of piles in the load case with wind load may be increased to 1.25 times the appropriate values as given in Clause 5.4.

The following criteria shall also be satisfied for the design:

(iii) Minimum dead load – 2.0 x adverse imposed load including soil load – 1.5 x uplift due to the highest anticipated groundwater table (or 1.1 x uplift due to the highest possible groundwater table) – 1.5 x adverse wind load ≥ 0

(f) Piles shall not be positioned directly under any wall opening as indicated on the drawing.

(g) No piles or portions of pile caps outside the Site boundary shall be permitted.

(h) The use of tension piles shall not be permitted unless otherwise stated.

(i) Carry out piling work in accordance with **Code of Practice for Foundations** published by the Buildings Department.

(j) The piling work shall be executed by a Contractor on the List of Approved Suppliers of Materials and Specialist Contractors for Public Works – Land Piling.

(k) The following works specified in the Contract shall be carried out by an independent Ground Investigation Contractor from the List of Approved Suppliers of Materials and Specialist Contractors for Public Works – Ground Investigation Field Work Category, who is required to make a declaration that it is not a holding company, a subsidiary company, an associated company or a related party of the Contractor, and that it has no financial interest in the piling work to be tested:

(i) pre-drilling to establish bedrock level and quality;

(ii) core drilling;

(iii) proof drilling;

(iv) other works as instructed by the SO.

(l) The point load test to determine the uniaxial compressive strength (UCS) of rock core samples in association with Clause 5.1 (k)(i) and (ii) shall be executed by an Accredited Laboratory, who shall submit the HOKLAS endorsed test reports directly to the SO in sealed envelopes.

INFORMATION TO BE PROVIDED

Design submission **5.2** (a) Submit two copies of the following information:

(i) A full specification of the piles proposed. Piles of the same size and material shall be designed and constructed to the same allowable load capacities irrespective of the actual design load sustained by each pile. Should the Contractor design the pile by adopting a smaller allowable load capacity of pile, the adopted allowable load capacity shall be used for calculating the test load for the static loading test.

(ii) A complete set of design calculations for the piles.

(iii) A drawing showing the number, position and size of the piles, the estimated maximum and minimum gross lengths of the piles (i.e. distance from ground level to tip of piles) and the proposed pile cap layout.

(iv) A method of installation including equipment to be used, sequence of operations, quality supervision and site control measures.

(v) Details of grout mix and pressure grouting, where applicable.

The submissions in items (i), (ii) and (iii) above shall be certified by a Registered Structural Engineer.

(b) Obtain the agreement of the SO in writing to the matters referred to in item (a) above before the Works commences. No piling works shall commence on the Site unless the design submissions are approved by the SO in writing.

(c) Submit as specified two copies of the following information certified by a Registered Structural Engineer when the Contractor is required to carry out design of pile caps and/or strap and tie beams:

(i) Complete set of calculation on the design of pile caps and/or strap and tie beams, in compliance with **Code of Practice for the Structural Use of Concrete** issued by the Buildings Department.

(ii) Drawings showing the proposed layout of pile caps and/or strap and tie beams with levels, sizes and typical details and detail drawings showing the reinforced concrete details of pile caps and/or strap and tie beams. The drawing presentation shall comply with the Drafting Manual for Reinforced Concrete Structures for the Architectural Services Department.

(d) Each load element (column or wall) shall be supported on individual pile cap. Combination of loads from individual elements supported by one large cap shall not be allowed unless otherwise noted.

(e) If hydraulic hammer is used, the following shall apply:

In addition to those stated in Clause 5.2 (a) above, submit two copies each of the following:

(i) Details of piling equipment to be used which shall include the model number, hammer weight, drop height, and theoretical energy output etc.

(ii) Unless approved otherwise by the SO, Hiley Formula shall be used in assessing the allowable load capacity of the piles proposed.

(iii) The efficiency of drop of the hydraulic hammer used in the Hiley Formula shall be taken as 90% unless a higher value can be verified in accordance with Clause 5.14 (d). Under no circumstances shall the efficiency of drop be greater than 98%.

(iv) The coefficient of restitution shall not be taken as greater than 0.8.

Provision of drawings and calculations **5.3** (a) Submit the following to the SO:

(i) One complete set of the agreed calculations referred to in Clause 5.2;

(ii) Three copies of the agreed drawings provided in accordance with Clause 5.2; and

(iii) One complete set of revised calculations and three copies of revised drawings pursuant to a variation order.

Record survey and drawings (b) Arrange for a survey to enable preparation of the piling record plans to show the positions, cut-off levels, gross and nett lengths of the piles, and the record survey drawings to show the as-built works included in the Contract.

The survey shall be carried out jointly by the Contractor and an approved independent firm included in the current List of Approved Suppliers of Materials and Specialist Contractors for Public Works – Land, Engineering and Hydrographic Survey Services employed by the Contractor at his own cost. These as-built piling record drawings shall be certified by both the Contractor and the independent firm.

Submit to the SO within 14 days after the completion of the piling works, two copies each of the following:

(i) piling record plan showing the position, cut-off level, gross and nett lengths of the piles.

(ii) record survey drawings showing the as-built works included in the Contract.

(c) For cases where construction of pile caps and/or strap and tie beams are included in the contract, the independent firm shall also set out and mark on the surface of the pile caps or ground/strap beams the outline of all columns and walls for checking by the SO.

Allowable load capacity of piles **5.4**

(a) The allowable load capacity of piles for loads along the vertical axis must be such that the average compressive stress imposed by this loading does not exceed 25% (20% only for precast concrete piles) of the design grade strength of the concrete or 7.5 MPa whichever is smaller, of the nominal cross-sectional area of piles. The effect of reinforcement shall not be included in the calculation of the allowable load capacity.

(b) The allowable load capacity of precast prestressed tubular piles for loads along the vertical axis must be such that the average compressive stress imposed by this loading does not exceed 25% of the design grade strength of the concrete less the pre-stress after losses.

(c) The allowable load capacity of steel 'H' piles (for a driving resistance of 2) for loads along the vertical axis must be such that the average compressive stress imposed by this loading does not exceed 30% of the yield stress appropriate to the type of steel and thickness given in Table 5.1 below:

TABLE 5.1
Minimum yield stress with thickness

Steel Specification	Up to and including 16 mm	Over 16 mm Up to and including 40 mm
BS EN 10025-2:2004 - Grade S275	275 MPa	265 MPa
BS EN 10025-2:2004 - Grade S355JR	355 MPa	345 MPa
BS EN 10025-2:2004 - Grade S450J0	450 MPa	430 MPa

Unless specified otherwise by the SO, no corrosion protection to the steel 'H' pile is required. However, when the steel 'H' pile is subjected to combine axial and bending under working load, the combined extreme fibre stress shall not exceed 0.33 f_y, where f_y is the minimum yield stress of the steel 'H' pile as stated in Table 5.1. When the calculation of stress is based on loadings including wind load, the permissible combined stress can be up to 0.42 f_y.

Settlement characteristics of piles **5.5**

Design piles such that the relative settlement between piles or pile groups under working load does not affect the performance of the superstructure. Except where otherwise specified, the settlement criterion is deemed to be satisfied if the pile under test load does not exhibit a total settlement in excess of that calculated in accordance with the formula in Clause 5.29 (d).

Negative skin friction **5.6**

(a) The pile design calculations shall include for the effect of the negative skin friction (NSF), when appropriate, in accordance with the following formula:

$$NSF = 0.25 \times \text{Perimeter} \times \int_0^L Pv \times dL$$

Where:

L = Depth from ground level to top of dense alluvial sand or top of in-situ CDV or CDG, which should make reference to the ground investigation information of the adjacent borehole(s). The Contractor must satisfy himself on the values of L adopted in his design.

Perimeter = Perimeter of the pile, e.g. π x diameter for circular sections or 2 x (breadth + depth) for rectangular and H sections.

Pv = Effective vertical pressure (total pressure minus the hydrostatic pressure) taking the water table at the level stated on the Drawings.

dL = Elemental length.

(b) The above formula is provided as a minimum assessment. If this formula is not considered adequate, submit an alternative method of calculating the negative skin friction for the SO's approval.

(c) For piles claimed to be non-negative friction (NF) pipe piles, the Contractor may adopt such methods of calculation in assessing the magnitude of the NSF approved when the system was registered by the Development Bureau.

(d) A pile group reduction factor of 0.85 may be applied to the evaluation of NSF under a pile group condition as defined in Clause 5.7.

Pile group reduction factor **5.7**

Where five or more piles are placed under a structural element and in such proximity that the capacity of the piles to sustain the loading may be affected by other piles, a pile group shall be deemed to exist. A pile group reduction factor of 0.85 shall be applied to the calculated allowable load capacity of piles unless:

(a) The centre-to-centre spacings are of more than 3 times the perimeter of the piles or the circumscribed rectangles in the case of H-piles; or

(b) The allowable load capacity of the piles is derived from end-bearing; or

(c) The piles are rock-socketed piles; or

(d) The piles are driven to refusal to rest on rock with final penetration not more than 1.0 mm per blow.

Minimum spacing / nos. of piles **5.8**

(a) Unless otherwise stated, the centre to centre spacing of piles shall normally be not less than the perimeter of the larger pile or 1 m, whichever is the greater.

(b) For piles bearing on bedrock as defined in Clause 5.19 (d) and not deriving their capacities from bond strength of grout or concrete in rock sockets, the minimum clear spacing between the shaft surfaces of adjacent piles or edge of bell-outs shall be 1000 mm. For piles deriving their capacities from bearing on bedrock and bond strength of grout or concrete in rock sockets (such as large diameter bored piles socketed into bedrock), the centre to centre spacing shall not be less than 2 m or 2 times the diameter of the pile shaft, whichever is the greater.

(c) The minimum centre to centre spacing of piles shall be the greater of 750 mm and 2 times the outer diameter of external steel casing for mini-piles or the perimeter of the drill hole formed in bedrock for RSSHP.

(d) Minimum spacing requirement specified shall apply to spacing between newly installed and existing piles.

(e) The centres of all driven piles and of all piles deriving their resistance mainly from friction shall be placed not less than half the length of the perimeter of the pile or 500 mm, whichever is the greater, from the site boundary.

(f) Except for large diameter bored piles (including large diameter bored piles socketed into bedrock) and large diameter bored piles with bell-outs, provide at least one pile under each column and at least two piles under each wall except noted otherwise.

(g) The requirements on minimum spacing of piles, stipulated to be satisfied in the design of piles, need not cater for the construction requirements on maximum permitted tolerances as specified in Clauses 5.23 (b) and (c).

Preliminary ground investigation **5.9**

Carry out preliminary ground investigations deemed necessary prior to the submission of the Tender.

Note: The SO may request evidence, in the form of necessary preliminary ground investigations that the proposed piling design is feasible.

Investigation for positions of piles **5.10**

(a) Carry out necessary probing to ensure that piles may be installed to such depths as will sustain the required loading.

(b) Advise the SO immediately in writing when test probing indicates an area which will not permit piles to be installed to the required depth. Submit for approval proposals to support the relevant loadings. Provide all information regarding subsoil conditions considered necessary by the SO and calculations and drawings to demonstrate that any revision to the pile cap layout submitted in accordance with Clause 5.2 (a) (iii) is the practical minimum. Backfill holes formed due to abortive installation of piles with granite fines or sand before adjacent piles are driven.

Minimum length of piles **5.11**

Piles of nett length (cut off level to tip of piles) less than 5 m or other minimum length specified shall not be accepted unless approved.

Use of diesel hammers **5.12**

The use of diesel hammers for percussive piling shall be prohibited.

Energy reduction factor for followers **5.13**

(a) Whenever followers are used, assess the energy reduction factor of each follower for each pile size.

The energy reduction factor of the follower shall be taken as

$$= \frac{\text{Energy imparted to the pile immediately after the introduction of follower}}{\text{Energy imparted to the pile immediately before the introduction of follower}}$$

(b) The energy reduction factor for every combination of follower and pile size shall be determined from averaging the results of 5 sets of dynamic pile tests performed, at or near to, the set of 5 different piles of the same size.

(c) Dynamic Pile Test (DPT) is a test applied to a pile by impact, using falling weight, hammer or other percussive device. The response of the pile to the impact force is measured in terms of pile strain and pile acceleration or pile displacement. Take measurements at one level on the pile surface near the pile top.

Percussion piles **5.14**

(a) Assess the allowable load capacity of the pile according to an approved dynamic formula, e.g. Hiley Formula. For the purpose of design calculation, the design factor of safety shall not be less than two.

(b) The design final penetration shall generally not be taken as less than 2.5 mm per blow. The set penetration of at least 10 blows shall be recorded on the Site during set. Where it can be demonstrated by DPT that the driving stress at final set is greater than 2 times the design working compressive stress for the allowable load capacity of the pile for steel H-piles, the design final penetration may be taken as not less than 1.0 mm per blow. The pile shall not be considered to have attained the allowable load capacity should the penetration of any blow recorded be in excess of the design final penetration.

(c) If the Hiley Formula is used to calculate the allowable load capacity of a pile, the temporary compression of the pile and hammer cushions (Cc) shall be taken as not less than 7.5 mm when the thickness of the hard wood

packings at the pile head is 50 mm or less and the plastic hammer cushion is 200 mm thick or less (refer to Clause 5.18 for steel 'H' pile).

(d) The efficiency of the hammer (Eh) and the coefficient of restitution of the hammer cushion (e) shall be determined from/verified by carrying out Dynamic Pile Test (DPT) and CAPWAP analysis on trial piles (at least 5 piles for each hammer – pile size – drop height combination). Separate set of trial piles shall be carried out for founded piles with length difference exceeding 20 m. For steel H-piles, the protruded length of all trial piles above ground shall not be greater than 3 m and the measured driving stress of all trial piles in DPTs shall be greater than 2 times the design working compressive stress for the allowable load capacity of the pile as demonstrated with DPTs, and the 90% CAPWAP capacity of each trial pile shall not be less than twice the allowable load capacity of the pile. The combination of Eh and e shall be so chosen such that when these values are substituted into the Hiley Formula, the average of the predicted load capacity of the trial piles is not higher than 90% of the average CAPWAP capacity. If the measured driving stress at final set or 90% CAPWAP capacity requirements of each pile are not satisfied, the allowable load capacity of the piles shall be reduced and submitted for the SO's approval.

(e) If reasonable values of design final set cannot be obtained from the Hiley Formula with Eh and e so chosen and subject to the approval of the SO, all the piles falling into this category shall be driven to a set less than 2.5 mm or 1.0 mm per blow as the case may be. All these piles shall be subjected to DPT and the allowable load capacity of the piles shall be assessed by CAPWAP analysis. For steel H-piles, the measured driving stress of the piles in DPTs shall be greater than 2 times the design working compressive stress for the allowable load capacity of the pile as demonstrated with DPTs. The pile shall not be considered to have attained the allowable load capacity should the 90% CAPWAP capacity is less than twice the allowable load capacity. In addition to the loading test requirements in Clause 5.29, the SO shall select 1% of nos. of piles (minimum one number) for each batch of piles proposed by the Contractor for phased completion to be load tested for acceptance. All the time and cost incurred from the DPTs, CAPWAP analyses and the additional loading tests shall be borne by the Contractor. Employ an Accredited Laboratory to carry out and interpret the DPTs, CAPWAP analyses and the additional loading tests. The Accredited Laboratory shall submit HOKLAS endorsed test reports directly to the SO in sealed envelopes within 14 days of the completion of the testing.

(f) Drop hammer shall not be used for final set measurement. All final sets shall be taken with the hydraulic hammer.

(g) Driving of the last segment of pile shall normally be in one operation and final set taken accordingly. If, for some reasons, this cannot be done, the rate of penetration of the pile shall be recorded before stopping. When pile driving is resumed, it shall be driven to attain at least the previous rate of penetration before final set is taken. In any case, a minimum of 20 blows of the same driving energy as at the previous final set shall be required before final set is taken. Such requirement might be waived if it can demonstrate that the driving stress at the pile exceeds 0.9 fy.

(h) If the protruding length of the pile above ground is more than 3 m during the final set measurement, the measured temporary compression (Cp+Cq) shall be increased by 1 mm per each metre increase beyond 3 m. However, in all cases, the length of the protruding part of the pile above ground level shall not exceed 6 m during the measurement of final set.

(i) The piles selected for DPTs (restrike test) shall be tested under the same driving conditions as in the final set measurement, i.e. same hammer, same hammer drop height and total length of pile not less than that at final set measurement. The set penetration of at least 10 blows shall be recorded. If the measured final set values of the piles during the DPTs are more than that during the final set measurement, the allowable load capacity of these piles shall be assessed by CAPWAP analysis. All the time and cost incurred from

CAPWAP analysis shall be borne by the Contractor.

Precast concrete piles **5.15**

(a) Design, cast and cure piles to develop the strength necessary to withstand transporting, handling and driving stresses without damage. The concrete shall be of quality not inferior to Grade 30 with a minimum cementitious content of 400 kg/m^3. Before commencing pile driving, submit calculations showing that the driving stresses will not exceed twice the permissible stress in direct compression.

(b) Do not splice piles without approval.

(c) The weight of a hammer used during the final set shall not be less than 70% of the weight of the pile.

Precast prestressed tubular piles **5.16**

(a) The piles must be of proprietary type manufactured and handled in accordance with the approved manufacturer's compliance standards. Stack piles neatly and securely off the ground.

(b) Submit to the SO manufacturer's certificates for each batch of piles delivered to the Site stating, (i) that the piles have been manufactured in accordance with the manufacturer's compliance standards approved by the Development Bureau, (ii) that the piles are satisfactory for the purpose intended and, (iii) the mix proportion and admixtures used in the concrete, and (iv) the results of all cube and core tests.

(c) Carry out splicing to increase the pile length by welding the jointing plates of the lower and upper segments in accordance with the manufacturer's details. The welded joints shall be constructed, inspected and tested as described in Clause 5.18 (f).

(d) Do not use a hammer of weight less than 50% of the weight of the pile during the final set. For set calculation in accordance with Clause 5.14 (c), the temporary compression of the pile and hammer cushions (Cc) shall be taken as not less than 7.5 mm. If specified, carry out Dynamic Pile Testing or use other approved means to demonstrate at construction stage that the maximum tensile stress solely arising from pile driving does not exceed 12 MPa.

(e) (i) When precast prestressed tubular piles are proposed, the SO will order at least one pile of each serial size from each batch, to be subjected to the following destructive tests:

(1) Taking Test Cores

3 sets of 3 cores (total 9 numbers) of 76 mm nominal diameter shall be taken, normal to the length of the pile, from 3 transverse sections of a sample pile selected by the SO.

(2) Assessment of Core Strength

The compressive strength of the cores shall be adjusted for length/diameter ratio and direction of drilling (D = 2.3, to be considered as equivalent to cores drilled vertically) and converted to estimate in-situ cube strength in accordance with **CS1**.

The cores shall not be deemed to comply with the Specification if either:

(2.1) The average strength of each set of 3 cores is less than 85% of the strength specified by the manufacturer; or

(2.2) The strength of any individual core is less than 75% of the strength specified by the manufacturer.

(ii) Unless otherwise specified, a batch of piles shall be 100 lengths or less of piles manufactured by the same manufacturer, covered by the same manufacturer's certificate delivered to the Site. Stock each batch of piles neatly as a group on the Site and each pile of a batch shall be identified with unique marking for approval.

(iii) In the event that the coring test results fail to comply with Clause 5.16 (e)(i)(2) above, all piles of the same concreting date will be deemed to be unacceptable and shall be removed from the Site. Consequent to the failure of a coring test, two additional destructive tests shall be carried out to piles of different casting dates selected by the SO.

(iv) Supply sample piles for testing, arrange for all coring to be carried out by an approved specialist core drill contractor, and provide all necessary facilities and attendance. Grind the two ends of each core for compressive test smooth and truly perpendicular to the axis and deliver cores to the Public Works Laboratories (PWL) for testing. Prepare and submit test records to the SO and remove the cored piles off the Site on completion of the tests.

(v) Do not use a pile from any batch until sample piles from such batch have passed the destructive test.

(f) Finish off the pile heads, cast concrete plugs and provide dowel bars in accordance with details shown at Annex "A".

Percussion cast in-situ concrete piles **5.17**

(a) Concrete shall be of quality not inferior to Grade 20 with a minimum cementitious content of 300 kg/m^3.

(b) Piles shall be cast to the full cross-section. Prevent necking and the formation of voids in the concrete caused by faulty consolidation, insufficient head of concrete during placing, concrete of inadequate workability, or inappropriate speed of extracting the casing. Check the volume of concrete at frequent intervals and take steps to maintain a sufficient head of concrete above the bottom of the casing to prevent inflow of soil or water. During extraction of the casing, ensure there is no lifting of the concrete in order to avoid separation.

(c) Do not drive piles within a 3 m radius of any in-situ concrete pile until a minimum period of 48 hr has elapsed, following the completion of casting of any such pile.

Steel 'H' piles **5.18**

(a) Steel sections must comply with the requirement of **BS EN 10025-1:2004** & **BS EN 10025-2:2004** Grade S275, S355JR or S450J0.

(b) Use steel sections with flange and web thicknesses not less than 20 mm.

(c) Testing of steel sections and accessories shall be as Section 15 – Structural Steel Work.

(d) Notwithstanding Clause 5.18 (c), for every one hundred segments or part thereof of each section of same thickness from the same cast, one segment shall be selected at random on the Site by the SO for testing. Provide two test specimens taken at both ends of each of the chosen segment. For the purpose of this clause, "same thickness" means similar sections with a variation in thickness not exceeding +5 mm, and "segment" means every length of pile as rolled.

Prepare the test specimens to **BS EN 10002-1** as directed and appropriately label, mark and deliver them to the Public Works Laboratories (PWL), as directed by the SO.

(e) The energy of the hammer should be so chosen such that the pile will not be damaged during driving. As a minimum requirement, the Contractor shall demonstrate with DPT that driving stresses would not exceed 0.9 f_y.

(f) Carry out splicing to increase the length of steel "H" piles in accordance with the details shown at Annex "B". Unless agreed by the SO, the minimum length of each steel H-pile section shall be 10 m except the uppermost section. Construct joints to maintain the true alignment of the pile section. Welds shall be subject to the following examination:

(i) All welds shall be visually inspected to **BS EN ISO 17637**.

(ii) 10% of the welded joints shall be subjected to ultrasonic examination to **BS EN ISO 17640** Level B and magnetic particle inspection to **BS EN ISO 17638.**

There is no limit on hold time for the examination, except that the initial 2 butt welded joints shall be examined by non-destructive tests after 40 hr. Joints to be tested shall be selected by the SO. The standard of acceptance for welds shall be in accordance with Table 14.3b in the **Code of Practice for the Structural Use of Steel** issued by the Buildings Department.

Employ an Accredited Laboratory to carry out and interpret the inspection and testing of welds, and provide any necessary labour and attendance. The Accredited Laboratory shall submit the HOKLAS endorsed test reports directly to the SO in sealed envelopes within 3 days of the completion of the testing. Tests revealing discontinuity shall be reported separately for the subsequent repair and re-test.

(g) Provide capping plates and dowel bars in accordance with the details shown at Annex "C".

(h) Unless otherwise specified, inspection and testing of welding, other than those shown on the typical splicing details and pile head details shown in Annexes "B" and "C", shall be in accordance with Clause 15.58.

(i) Pile of same size but of different grades shall not be used in the same site.

(j) If Hiley Formula is used to calculate the allowable load capacity of steel 'H' pile, the temporary compression of the hammer cushion (Cc) shall be taken as not less than 5 mm when plastic cushion of 200 mm thickness or less is used.

Large diameter bored piles **5.19**

(a) Large diameter bored piles are those of a diameter exceeding 750 mm formed by boring, chiselling or grabbing, plus filling with concrete.

Provide reinforcement and adequate ties in accordance with details shown at Annex "D".

(b) Before commencement of piling, predrilling to establish bedrock level and quality shall be carried out by an independent Ground Investigation Contractor. Drill hole(s) (one for pile diameter less than or equal to 2.5 m and two for pile diameter greater than 2.5 m) shall be sunk at each bored pile position to determine the bedrock level and quality. The location of drill hole(s) shall be agreed by the SO. For this purpose, at least 5 m of continuous rock core samples of N size (61 mm diameter) shall be taken below the bedrock level for inspection and testing. For piles founded on category 1(c) rock or better as defined in Table 5.2, rock specimens shall be taken at top, middle and bottom along the length of rock core samples for point load test to determine the uniaxial compressive strength (UCS) of rock. Two copies of fieldwork report, including drill hole logs, and the point load test report, if applicable, shall be submitted directly to the SO in sealed envelope from the independent Ground Investigation Contractor and the Accredited Laboratory respectively. However, this predicted bedrock level cannot be considered as final and the actual rock quality at base of pile should be inspected and verified during pile excavation before approval.

(c) Found pile on bedrock with a minimum embedment depth of 500 mm.

(d) Bedrock is defined as rock mass of at least 5 m thick and being Grade III or better rock (as defined in **GEOGUIDE 3**, "Guide to Rock and Soil Descriptions" prepared by the Geotechnical Engineering Office and published by GIS, Hong Kong).

For design purposes, the maximum bearing pressure of piles on bedrock shall not exceed the value given in Table 5.2.

TABLE 5.2
Presumed allowable vertical bearing pressure under foundations on bedrock

Category of rock	Description of rock	Maximum bearing pressure (MPa)
1(a)	Fresh to slightly decomposed strong to very strong granite or volcanic rock of material weathering grade II or better, with 100% total core recovery (TCR) of the designated grade, which has a minimum uniaxial compressive strength (UCS) of rock material not less than 75 MPa (or an equivalent point load index strength PLI_{50} not less than 3 MPa).	12.5
1(b)	Fresh to slightly decomposed strong granite or volcanic rock of material weathering grade II or better, and with not less than 95% TCR of the designated grade, which has a minimum UCS of rock material not less than 50 MPa (or an equivalent point load index strength PLI_{50} not less than 2 MPa).	10
1(c)	Slightly to moderately decomposed moderately strong granite or volcanic rock of material weathering grade III or better, and with not less than 85% TCR of the designated grade, which has a minimum UCS of rock material not less than 25 MPa (or an equivalent point load index strength PLI_{50} not less than 1 MPa).	7.5
1(d)	Moderately decomposed, moderately strong to moderately weak granite or volcanic rock of material weathering grade III or better, and with not less than 50% TCR of the designated grade.	3
2	Moderately decomposed, moderately strong to moderately weak meta-sedimentary rock of material weathering grade III or better, and with not less than 85% TCR of the designated grade.	3

Notes:
(i) The point load index strength of rock quoted in the table is the equivalent value for 50 mm diameter cores.

(ii) The TCR of the designated grade should be proved to a required depth into the specified category of rock. This requirement is deemed to be complied with if the rock has a length of the required depth which can be divided into a number of segments (in consecutive manner) such that (1) each segment is 1 m; and (2) the calculated TCR in accordance with Figure 2.1 in the **Code of Practice for Foundations** issued by the Buildings Department of each segment should satisfy the required percentage of TCR of the designated grade.

(iii) The use of the above presumptive values does not preclude the requirement for consideration of settlement of the structure.

(iv) The bearing surface of rock on which the foundation will be rested should be of the designated category and not in a non-intact condition for a depth not less than 600 mm. Non-intact condition is defined in GEOGUIDE 3.

(e) The requirements of Clause 5.17 (b) apply equally to large diameter bored piles.

(f) Where the water level is higher than the bedrock level, carry out concreting with a tremie pipe. Clean the pile base by air lift before commencing concreting. Ensure the tremie pipe always penetrates well below the top level of the concrete being poured.

(g) Supply concrete in sufficient quantities to ensure that concreting of each pile proceeds without interruption. The concrete shall have a minimum cementitious content of 400 kg/m^3 and a minimum slump of 150 mm.

(h) Where the water level is higher than the bedrock level, the concrete used shall have grade strength 25% higher than the design grade strength.

(i) Where a pile is founded on a stratum which deviates from the predicted depth by more than 4 m, carry out additional borings to satisfy the SO that the pile is acceptable.

(j) Not used.

(k) Where steep bedrock profile is identified, the founding levels of adjacent piles shall not differ by more than the clear distance between the pile bases unless the stability of rock under the piles are checked by recognized engineering principles, taking into account the existence of any adverse joints.

(l) For large diameter bored piles with diameters greater than 2000 mm, reversed circulation drill (RCD) must be used to set the pile shaft in rock and smooth out the rock surface. Should a similar machine and equipment that achieves equivalent results and of equal performance to that of the RCD be proposed, the Contractor shall demonstrate to the satisfaction of the SO before submitting for approval.

(m) Clauses 5.21 (u)(i), (iii) to (vii) on grout material shall apply equally to large diameter bored piles.

(n) The Contractor shall submit a detailed method statement and procedures for controlling and monitoring the verticality and alignment of piles for the SO's approval before commencement of pile installation.

During the pile installation, tolerance for verticality of each pile shall be frequently checked as directed by the SO. In case the deviation exceeding the allowable tolerance, the Contractor shall propose method of rectification for the SO's approval prior to further pile installation.

(o) In addition to those stated in Clause 5.2, the Contractor shall also submit method statement on the fabrication of reinforcement cages for the SO's approval. The method statement shall include the following:

(i) Step-by-step procedures of reinforcement cage fabrication;

(ii) Stability support system;

(iii) Working platform arrangement;

(iv) Safety plan.

(p) Notwithstanding Clause 6.44, for concreting the pile with a tremie pipe, subject to the approval of the SO, the time on compaction of concrete in its final position may be extended if appropriate admixtures or cement containing additives are to be used.

Large diameter bored piles socketed into bedrock **5.19A** (a) Large diameter bored piles socketed into bedrock are those of a diameter exceeding 750 mm formed by boring, chiselling or grabbing without an enlarged base, plus filling with concrete. The embedment depth into bedrock shall be greater than 500 mm and formed by RCD or other method approved by the SO.

Provide reinforcement and adequate ties in accordance with details shown at Annex "D1".

(b) Clauses 5.19 (b), (c) and (e) to (k) and (m) to (p) shall apply. Unless otherwise specified, requirements related to large diameter bored piles as stipulated in other Clauses, apart from Clauses 5.19 (a) to (p), shall also apply to large diameter bored piles socketed into bedrock.

(c) Notwithstanding Clause 5.19 (b), drill hole(s) (one for pile diameter less than or equal to 2.5 m and two for pile diameter greater than 2.5 m) shall be sunk at each bored pile position to determine the bedrock level and quality. The location of drill hole(s) shall be agreed by the SO. For this purpose, continuous rock core samples of N size with length not less than 1.5 pile diameters plus the effective rock socket length plus 500 mm or 5 m, whichever is the greater, shall be taken below the bedrock level for inspection and testing.

(d) Bedrock is defined as rock mass of thickness at least 1.5 pile diameters plus the effective rock socket length plus 500 mm thick or 5 m, whichever is the greater, and being Grade III or better rock (as defined in **GEOGUIDE 3**, "Guide to Rock and Soil Descriptions" prepared by the Geotechnical Engineering Office and published by GIS, Hong Kong).

(e) The allowable load capacity of large diameter bored piles socketed into bedrock may be taken as the sum of the frictional resistance of the effective rock socket and the end bearing resistance of the piles provided that the effective socket length used in the calculation of frictional resistance does not exceed 2 times the rock socket diameters or 6 m, whichever is the shorter. However, the contribution from the minimum embedment depth of 500 mm stipulated in Clause 5.19 (c) shall not be counted in the calculation of frictional resistance (i.e. the top level of effective rock socket shall be at least 500 mm below the bedrock level).

(f) For design purpose, the maximum bearing pressure of piles on bedrock shall not exceed the value given in Table 5.2.

(g) The presumed allowable friction between bedrock and concrete are shown in Table 5.3. The rock sockets of large diameter bored piles socketed into bedrock shall be formed in category 1(c) rock or better, or category 2 rock as defined in Table 5.2.

TABLE 5.3
Presumed allowable bond or friction between bedrock and concrete or grout

Category of rock as defined in Table 5.2	Presumed allowable bond or friction between rock and concrete or grout (kPa)
1(b) or better	1000
1(c)	700
2	300

Notes: (i) Concrete shall not be inferior to Grade 30 concrete.

(ii) Grout shall have minimum cube strength of 30MPa at 28 days.

(iii) The use of the above presumptive values does not preclude the requirement for consideration of settlement of the structure.

(h) Notwithstanding Clause 5.4 (a), the average compressive stress of concrete pile shaft imposed by the working load shall not exceed 25% of the design grade strength of the concrete or 9.0 MPa whichever is smaller. The maximum allowable compressive stress of the reinforcement imposed by working load shall not exceed 225 MPa for ribbed steel reinforcing bars in Grade 500.

(i) Notwithstanding Clause 5.2 (a) (i), for large diameter bored piles socketed into bedrock, piles of same size and material but of different socket lengths may be designed and constructed to different allowable load capacities.

(j) The Contractor shall satisfy himself that the above method of calculating the allowable load capacity provides sufficient factor of safety in his design. Should he consider that this method does not provide an adequate factor of safety in his design, he shall submit an alternative method of calculations for the approval of the SO.

Large diameter bored piles with bell-outs **5.19B**

(a) Large diameter bored piles with bell-outs are piles of a shaft diameter exceeding 750 mm formed by boring, chiselling or grabbing with an enlarged base formed by under-reaming, plus filling with concrete. The bell-out at the pile base shall be formed within the bedrock with the use of a RCD incorporating an under-reaming head.

Provide reinforcement and adequate ties in accordance with details shown at Annex "D2". The depth 'H' in Annex "D2" is bell-out tool dependent. It shall be verified on the Site and agreed with the SO before commencement of pile installation.

(b) Clauses 5.19 (b), (e) to (k), (m) and (o) to (p) shall apply.

(c) Notwithstanding Clause 5.19 (b), drill hole(s) (one for pile bell-out diameter less than or equal to 2.5 m, two for pile bell-out diameter greater than 2.5 m and less than or equal to 3.75 m and three for pile bell-out diameter greater than 3.75 m) shall be sunk at each bored pile position to determine the bedrock level and quality. The location of drill hole(s) shall be agreed by the SO. For this purpose, continuous rock core samples of N size with length not less than 5 m plus 500 mm plus the socket length (as defined in Annex "D2") shall be taken below the bedrock level for inspection and testing.

(d) Bedrock is defined as rock mass of thickness at least 5 m plus 500 mm plus the socket length (as defined in Annex "D2"), and being Grade III or better rock (as defined in **GEOGUIDE 3**, "Guide to Rock and Soil Descriptions" prepared by the Geotechnical Engineering Office and published by GIS, Hong Kong).

(e) The allowable load capacity of large diameter bored piles with bell-outs shall be the allowable bearing pressure on bedrock times the pile base area.

(f) For design purpose, the maximum bearing pressure of piles on bedrock shall not exceed the value given in Table 5.2.

(g) The bell-out at the pile base shall be formed in category 1(c) rock or better, or category 2 rock as defined in Table 5.2.

(h) The gradient of bell-out shall not exceed 30 degrees from vertical, and the diameter of pile at bell-out shall not exceed 1.65 times the diameter of pile shaft. The bell-out shall start at more than 500 mm below the bedrock level (see Annex "D2").

(i) Clause 5.19A (h) on allowable stress of concrete and reinforcement shall apply equally to large diameter bored piles with bell-outs.

(j) The Contractor shall satisfy himself that the above method of calculating the allowable load capacity provides sufficient factor of safety in his design. Should he consider that this method does not provide an adequate factor of safety in his design, he shall submit an alternative method of calculations for the approval of the SO.

(k) Ultrasonic Echo Sounding Test shall be carried out by an approved independent testing laboratory employed by the Contractor to check the shaft and bell-out profile, dimensions and verticality of each bored pile for

the SO's approval prior to installation of reinforcement cage and concreting. In addition, the SO may order to carry out the same test on 5% of the total number of piles rounded up to the next whole number by a Testing Firm employed direct by the Employer. The Contractor shall co-ordinate with the Testing Firm for the test and provide all necessary attendance. The Contractor shall also allow at least 7 working days for the execution of each test by the Testing Firm employed direct by the Employer.

(l) The Contractor shall submit a detailed method statement and procedures for controlling and monitoring the verticality, alignment and bell-out size of bored piles. Site demonstration on reamer operation shall be carried out on the Site to establish the reference mark for developing the movement relation between bell-out bit and drive shaft. The detailed method statement, procedures and site demonstration shall be approved by the SO before commencement of pile installation.

During the pile installation, the drive shaft reference mark shall be checked and monitored to ensure the bell-out size formed by the bell-out bit is in accordance with the design and approved method statement.

The tolerance for verticality of each pile and the bell-out size formed by the bell-out bit shall be frequently checked and monitored as directed by the SO. In case the deviation exceeding the allowable tolerance, the Contractor shall propose method of rectification for the SO's approval prior to further pile installation.

Non-percussion cast in-situ concrete piles **5.20**

(a) Non-percussion cast in-situ concrete piles are those not exceeding 610 mm diameter formed by boring. The requirements of Clauses 5.17 (a) and (b) shall apply. Provide reinforcement as specified.

(b) Before the commencement of piling works, install drill holes as required in the Contract to obtain sufficient information for the calculations of pile lengths. The position and number of the drill holes should be agreed with the SO on the Site. Two copies of the drill hole logs have to be submitted to the SO.

Mini-piles **5.21**

(a) Mini-piles are those consisting of a steel permanent casing with internal diameter not greater than 400 mm, with either one or a group of steel reinforcing bars in the middle as the load bearing element, and the remaining cavity filled with grout. The core of the mini-pile shall be socketed into bedrock. The number of steel reinforcing bars shall not be more than 5 with bar diameter not exceeding 50 mm.

(b) Not used.

(c) The allowable load capacity of the individual pile shall be the design bond strength between the bedrock and grout times the design length and perimeter of the rock socket, or the design bond strength between the reinforcement and grout times the effective perimeter of the reinforcement and design length of the rock socket, or the allowable reinforcement compressive capacity designed in the pile, whichever is the smaller. The steel permanent casing and the grout shall not be taken into account in the calculation of pile capacity. The allowable load capacity of piles in the load case with wind load may be increased to 1.25 times.

End bearing capacity of the pile shall be ignored.

The Contractor shall satisfy himself that the above method of calculating the allowable load capacity provides a sufficient factor of safety in his design. Should he feel that this method does not provide an adequate factor of safety in his design, he shall submit an alternative method of calculation for the approval of the SO.

Design bond strength between bedrock and grout shall not exceed the value given in Table 5.3 for grout having minimum cube strength of 30 MPa at 28 days. No reduction on the design bond strength shall be required for

grouting underwater. Bedrock shall be that defined in Clause 5.21 (t). If a different bond strength value is proposed, submit the details of the design parameters, proposed testing methods of the trial piles (including loading tests) for justification of the proposed parameters and test programme, all to the satisfaction of the SO. All tests for this purpose shall be at the Contractor's own expense and no extension of time shall be granted whatsoever.

The maximum allowable compressive stress of the reinforcement shall not exceed 225 MPa for ribbed steel reinforcing bars in Grade 500. The maximum allowable bond stress between grout and reinforcement for ribbed steel reinforcing bars in Grade 500 shall not exceed 0.8 MPa. No reduction on the maximum allowable bond stress shall be required for grouting underwater. In calculating the allowable load capacity of the pile due to bond, the effective diameter of a group of bars (with spacing between adjacent bars less than 25 mm) shall be equivalent to the diameter of a bar of equal total area.

(d) The pile shall not be designed to resist any horizontal loads unless designed as raking piles. If raking piles are used to resist lateral loads, they should only be designed to resist the lateral load. That is, no vertical load should be considered to be taken by the raking pile if it is designed to take lateral load. The sub-grade reaction of soil shall be ignored in raking pile calculations.

(e) Group reduction factor in Clause 5.7 shall not be applied.

(f) Steel reinforcing bars shall comply with Section 6. Mechanical couplers shall be of type 1 mechanical couplers conforming to the **Code of Practice for Structural Use of Concrete** issued by the Buildings Department.

(g) The steel reinforcing bars may be lengthened by staggering the couplers with details approved by the SO. The percentage of the total cross sectional area of steel reinforcing bars lengthened by couplers at any one section shall not be greater than 50% and the couplers should normally be arranged symmetrically with minimum spacing between couplers of 500 mm c/c along the pile. Also, mechanical couplers shall not be used within the pre-bored hole formed in bedrock.

(h) Separate each reinforcing bar by spacers of 16 mm minimum size at regular intervals not greater than 2000 mm. Unless agreed by the SO, the minimum length of each reinforcing bar shall be 6 m except the uppermost section. Lapping and spacers details shall be submitted for the SO's approval.

(i) Minimum cover to reinforcement inside the pre-bored hole formed in bedrock shall be 35 mm. For other part of the pile, minimum cover to reinforcement shall be 40 mm or the diameter of reinforcement whichever is the greater.

(j) Provide and calculate the minimum lengths of rock socket using Clause 5.21 (c). Grout all piles to a minimum level of 300 mm above the specified pile cut-off level.

(k) Pile shall be installed without use of bentonite slurry or other drilling muds.

(l) Use air as the flushing medium during the drilling operation. Water shall not be used as the flushing medium. The Contractor's attention is drawn to the formation process of the pile shaft using air flushing where special care shall be taken to avoid caving in of soil during forming of the pile shaft.

(m) Permanent casings for piles shall be provided and shall meet the following requirements:

(i) Pile shafts shall be cased for their entire length against soil plus a projection of at least 500 mm into bedrock or such other depth as required avoiding caving in of soil at the interface of soil and

bedrock during cleaning of the rock socket.

(ii) The casings shall be formed of steel of 5 mm minimum thickness with an internal diameter not less than the specified pile diameter. The casings shall be joined where necessary with watertight joints. The casings shall be clean and free of any material adhering to them when first inserted into the pile position.

(iii) Permanent casings shall be Grade S275J0H or S275J2H structural steel complying with Section 15. The casings shall be free from significant distortion and shall be of uniform cross-section throughout the whole length and be free from internal projections, which might prevent the proper formation of the piles. Dents in the casing shall not exceed 5 mm in depth.

(n) Use the Symmetrix system (either with the pilot bit set back from or advanced ahead of the ring bit during drilling), Odex system or other drilling systems approved by the SO to form the pile hole of the mini-piles. Unless the Symmetrix system with special arrangement in which the pilot bit is set back from the ring bit (i.e. the pilot bit is covered by the ring bit) during drilling is adopted, the Contractor shall properly fill the gap between the casing and soil with grout or other means. Submit a method statement detailing the proposed procedures and materials to be used for filling the gap between the casing and soil for the approval of the SO before the commencement of the Works.

Test drilling shall be carried out to confirm safety and suitability of the proposed drilling method and equipment and the control parameters proposed in the drilling method. The drawdown of ground water table and ground settlement induced by the drilling operation should be assessed for reviewing of the proposed drilling operation.

(o) Drill holes for pile shall not be oversized by more than 20 mm.

(p) Founding level of piles shall be taken as the top level of bedrock.

(q) Before commencement of piling, predrilling to establish bedrock level and quality shall be carried out by an independent Ground Investigation Contractor. Drill holes shall be in sufficient number such that any pile tip shall not be more than 5 m away from the nearest drill hole. The location of drill holes shall be agreed by the SO. For this purpose, at least 5 m or the length of rock socket plus 500 mm thick, whichever is the greater, of continuous rock core samples of N size (61 mm diameter) shall be taken below the bedrock level for inspection and testing. For piles with rock sockets formed in category 1(c) rock or better as defined in Table 5.2, rock specimens shall be taken at top, middle and bottom along the length of rock core samples for point load test to determine the uniaxial compressive strength (UCS) of rock. Two copies of fieldwork report, including drill hole logs, and the point load test report, if applicable, shall be submitted directly to the SO in sealed envelope from the independent Ground Investigation Contractor and the Accredited Laboratory respectively. Allow sufficient time for additional drill holes when in the opinion of the SO that the bedrock profile cannot be reasonably established from the data of the completed drill holes.

(r) When the founding level has been reached, collect rock samples at the top, bottom and intermediate intervals along the length of rock socket for inspection. The spacing of rock samples collected shall not be more than 1.5 m. The rock samples shall be stored in plastic bags with labels showing the pile number and retrieval levels. The Contractor's Construction Supervisor for piling works shall sign on the plastic bags after inspecting the samples. The actual founding level of piles shall be agreed with the SO before the commencement of rock socket boring. The method of measuring the founding level and pile toe level of piles shall be agreed with the SO before the measurements are taken.

(s) Proof drilling shall be carried out by an independent Ground Investigation Contractor to verify the adequacy of the socketed length of piles at locations instructed by the SO. The number of proof drilling shall be at least 2 or 1% of the number of piles rounded up to the next higher whole number, whichever is the greater. The depths of the proof drill holes shall be at least 5 m or the length of rock socket plus 500 mm below the founding levels of the adjoining selected piles, whichever is the greater. All reports shall be submitted directly to the SO in sealed envelope from Ground Investigation Contractor.

If the core taken from the proof drilling at the position indicates that the bedrock level is more than 1 m deeper than that adopted for the installation of the adjoining selected pile, the Contractor shall further investigate the difference of bedrock levels including carrying out additional proof drillings. The Contractor shall submit an assessment report with a rockhead contour plan based on the ground investigation to confirm the adequacy of the pile construction.

(t) Bedrock is defined as rock mass of at least 5 m or the length of rock socket plus 500 mm thick, whichever is greater and being Grade III or better rock (as defined in **GEOGUIDE 3**, "Guide to Rock and Soil Descriptions" prepared by the Geotechnical Engineering Office and published by GIS, Hong Kong). The rock sockets shall be formed in category 1(c) rock or better, or category 2 rock as defined in Table 5.2.

(u) Grout material shall meet with the following requirements:

(i) Grout shall consist of ordinary Portland cement and water with an approved non-shrinkage additive. Either PFA or GGBS may be used in combination with Portland cement. The proportion of PFA and GGBS replacement shall be in accordance with Clause 6.30. Other admixtures can be used when approved by the SO. The manufacturer's guidance shall be strictly followed. Cement sand mix is not allowed.

(ii) Grout shall have minimum cube strength of 30 MPa at 28 days. Grout having minimum cube strength less than 30 MPa shall not be accepted.

(iii) Measurements for bleeding shall be taken at 15-minute intervals. The amount of bleeding shall not exceed 2% at the end of the first 3 hr and no interim readings shall exceed 4%. In addition the water must be reabsorbed by the grout within 24 hr after mixing.

(iv) Free expansion of grout when measured at the end of 24 hr after mixing shall have a figure between 0% and 5%. A negative percentage figure shall not be accepted.

(v) Any approved admixtures shall be chloride-free and comply with **BS EN 934**.

(vi) The maximum total chloride content, expressed as a percentage relationship between the chloride ion and the cementitious content by mass in the grout shall be 0.1%.

(vii) Water for grout shall be clean fresh water having a temperature not exceeding 30°C nor less than 5°C.

(v) Mix grout material by weight batching. Measure the amount of water used by a calibrated flowmeter or a measuring tank.

The mixing time in high-speed mixers shall be appropriate for the type of mixer used.

After mixing, the grout shall be continuously agitated in a holding tank and screened before injection. The grout shall be placed within the time limits

specified by the manufacturers of the additives.

(w) Before grouting, clean the bottom of the hole by airlifting or an alternative method approved by the SO.

Agree with the SO the method to measure the grout intake volume.

Grouting of the pile shall be completed within the same day when the pile toe has been inspected and agreed by the SO, and shall be in one continuous operation and under no circumstances shall a pile be left partially grouted. No un-grouted rock sockets shall be of a clear distance less than 3 m from a pile being grouted.

Properly cover and fence off newly grouted piles.

(x) Carry out grouting in such a way that the lowest part of the grout pipes shall be as close to the pile toe as possible and, unless agreed by the SO, the grout pipes shall not be lifted up before the completion of grouting.

(y) Testing of Grout

Employ an approved independent laboratory to carry out the tests for Bleeding, Free Expansion and Flow Cone Efflux of grout. All test reports shall be submitted directly to the SO in sealed envelope from the approved laboratory.

If required by the SO, test results shall be checked by periodic verification using another approved laboratory to conduct identical testing of grout from the same samples, selected by the SO.

(i) Test for Bleeding and Free Expansion

Provide one sample of the grout from each pile after mixing and protect from changes in moisture content before tests are carried out.

Each sample shall be divided into 3 specimens. Each specimen is to be placed in a covered cylinder with a diameter of 100 ±10 mm to a depth of 100 ±5 mm and the amount of bleeding and free expansion is measured by a scale fixed to the outside of the cylinder.

$$\text{Bleeding} = 100\% \times \frac{H_2 - Hg}{H_1}$$

$$\text{Free Expansion} = 100\% \times \frac{H_2 - H_1}{H_1}$$

where H_1 - initial height of grout sample
H_2 - height of sample measured at upper surface of water layer or hardened grout surface if water is fully absorbed
Hg - height of grout portion of sample at upper surface of grout

Submit all preliminary test results directly to the SO in sealed envelope from the approved laboratory within 48 hr after the mixing of grout.

If the result of the bleeding test of the grout for any pile does not comply with the specified requirements or the free expansion of the grout for any pile is greater than the specified upper limit, the Contractor shall propose changes to improve the materials, grout mix or method of production, though the failure does not constitute a failure of the pile.

If the free expansion of the grout for any pile has a negative figure, the Contractor shall carry out test(s) at their own expense to demonstrate that the pile can fulfil the original design requirements.

(ii) Flow Cone Efflux Test

At least one sample from each pile shall be taken and tested in accordance with **ASTM C939** to determine the Flow Cone Efflux time. Agree with the SO the frequency of the test.

Except with the SO's prior agreement for grout mixes containing additives, grout having an efflux time of less than 15 s will be rejected.

(iii) Test for Crushing Strength

Provide one sample of the grout for each pile after mixing and protect it from changes in moisture content before making test cubes.

Cubes shall be prepared using 100 mm cube moulds.

Make two cubes from the sample. Strength compliance requirements shall follow Clause 6.55.

(z) Install and maintain ground settlement and building settlement markers on the Site. The numbers and locations of these markers shall be determined by the SO. Employ an approved independent registered professional surveyor to carry out bi-weekly surveys of the settlement markers during the entire piling construction period. Submit 3 copies of the survey results to the SO within 3 days of the surveying. All survey reports shall be submitted directly to the SO in sealed envelope from the approved surveyor.

(aa) Environmental Control

The Contractor shall keep the Site clean and tidy during the construction period. He shall submit a method statement in reducing the nuisance such as noise, dust, waste water, and deposition of excavated material on public roads by dump truck during haulage to meet EPD's latest environmental requirements for the SO's approval before the commencement of the Works.

The Contractor shall carry out Daily Cleaning in accordance with the Particular Specification for Daily Cleaning and Weekly Tidying. For the purpose of this clause, "waste materials" stated in the above particular specification shall also mean the material retrieved from the pile shaft during the course of boring. Attention is drawn to the prevention and removal of water ponds, and clearing of stockpiling and waste arising from the Works.

The Contractor shall apply for a Wastewater Disposal Licence under the Water Pollution Control Ordinance and no wastewater shall be discharged into communal sewers, storm drains, river courses or waterbodies until the said Licence is granted by EPD and relevant authorities. Provide, operate and maintain suitable works for the treatment and disposal of the wastewater to meet the requirements stated in the said Licence.

Temporary site drainage to keep the Site clear of water and prevent nuisance due to run-off onto adjacent land to be submitted for the SO's approval.

Store cement in bags in a dry, weatherproof store with a raised floor. The storage area for more than 20 bags of cement shall be covered entirely by impervious sheeting or sheltered on the top and the 3 sides.

The setup of grout batching plant shall be properly designed to minimise dust emission and provide sufficient ventilation for workers.

In addition to the use of hung tarpaulin or similar fabric sheets, provide suitable device to the satisfaction of the SO near the top of the casing at all times during the boring of pile shaft to mitigate the scattering of the excavated material from the pile shaft.

During the course of boring, the retrieved material shall be wetted before being flushed out from the pile shaft.

(ab) Safety of Air Receiver, Compressor and Hoses

(i) The use of air receiver and compressor shall be in accordance with the **Boiler and Pressure Vessels Ordinance (The Ordinance) and Regulations**, and the **Code of Practice for Pressure Equipment Owners** published by the Boiler and Pressure Vessels Authority, the Labour Department. For the purpose of this clause, the "appointed examiner" shall be the person defined in the Ordinance.

(ii) Every air receiver together with its fitting, attachments and hoses once delivered to the Site shall be examined by an appointed examiner prior to its operation on the Site. During the examination, the hoses shall be connected to the maximum length intended to be used. The air receiver shall not be used until:

(1) the appointed examiner is satisfied that the air receiver and its associated fitting, attachments and hoses are of sufficient strength to withstand the maximum permissible working pressure to which they may be subjected;

(2) a certificate of fitness for the air receiver as stipulated in the Ordinance is issued accordingly by the appointed examiner and submitted to the SO; and

(3) a written report is issued for the fitness of the hoses.

(iii) Every air compressor on the Site shall have a valid certificate of fitness (for its internal air receiver).

(iv) The air receiver and compressor shall not be operated at a pressure greater than their maximum permissible working pressures specified in the latest certificates of fitness.

(v) A copy of the certificate of fitness shall be attached to the air receiver and compressor.

(vi) The air receiver shall not be used until it is re-examined by the appointed examiner if:

(1) the seal attached to a safety valve has been broken, or the setting of a safety valve has been altered; or,

(2) the air receiver has been repaired extensively; or

(3) the certificate of fitness has expired.

(vii) Where appropriate, the whip-checks shall be properly installed at hose connection points. The first whip-check shall be directly attached to the main body of the air receiver/compressor.

(viii) Every shut-off valve connected to the air receiver shall be fitted with a non-return valve, and shall be closed when the piling plants are idling. The use of elbow connectors to connect hoses to air receiver or compressor is not allowed.

During the course of piling works, every compressor, air receiver and their auxiliary equipment, including the connecting hoses, shall

be properly inspected and recorded daily for the integrity of the system before the commencement of the Works by a designated competent person who shall be assigned by the Contractor and shall have at least 3 years' experience in the maintenance of similar systems. The daily inspection records shall be kept by the Contractor for the examination of the SO. The appointed examiner shall be consulted whenever necessary. If any defect is found, it shall be rectified immediately prior to operating the air receiver system.

(ix) Attendants shall be present to look after the compressed air system during the operation of the air receiver and compressor. The system shall be shut down after the Works.

(x) The routings of hoses shall not present a hazard or obstruct access and shall be routed away from any areas where they may be vulnerable to mechanical damage.

(xi) Include in the Safety Plan a maintenance programme for the compressed air system. Tool-box Talk and Job Specific Training on the potential hazards and safe use of the compressed air system shall be conducted to all relevant site personnel and workers.

(xii) The Contractor shall prepare risk assessment for the use of the compressed air system, and review the safety procedures and control measures for the operation of the compressed air system periodically or after there is a material change in connection with the plant, process, material and environment.

Rock-socketed Steel H-piles **5.22**

(a) Rock-Socketed Steel H-piles (RSSHP) are those in which a steel H-section is installed within a pre-bored hole formed into bedrock and then grouted with cement grout. The pre-bored holes shall be large enough to facilitate the installation of H-piles and to allow sufficient cover for corrosion protection purposes.

(b) The allowable load capacity of individual pile shall not exceed 6106 kN.

(c) The allowable load capacity of individual pile shall be the design bond strength between bedrock and grout times the area of contact between the rock and grout below the effective rock socket top level as defined in Clause 5.22 (k), or the design bond strength between the pile and grout times the total area of contact between the pile and grout below the effective rock socket top level as defined in Clause 5.22 (k), or the allowable axial force of the steel H-pile section, whichever is smaller. The maximum allowable working stress of steel H-pile sections shall be limited to 50% of the yield stress. When the calculations of stresses are based on all loads including wind loads, the permissible stress shall be increased by 25% of the above stresses.

End-bearing capacity of the pile shall be ignored.

The Contractor shall satisfy himself that the above method of calculating the allowable load capacity provides sufficient factor of safety in his design. Should he consider that this method does not provide an adequate factor of safety in his design, he shall submit an alternative method of calculations for the approval of the SO.

Design bond strength between bedrock and grout shall not exceed the value given in Table 5.3 for grout having minimum cube strength of 30 MPa at 28 days. No reduction on the design bond strength shall be required for grouting underwater. Bedrock shall be that defined in Clause 5.21 (t). If different bond strength value is proposed, submit details of the design parameters, proposed testing methods to the trial piles (including loading tests) for justification of the proposed parameters and test programme to the satisfaction of the SO. All tests for this purpose shall be at the Contractor's own expense and no extension of time shall be granted whatsoever.

The maximum allowable average bond stress between grout and steel H-pile shall be 0.48 MPa for grout having minimum cube strength of 30 MPa at 28 days when the shear bars details shown in Annex "E" is applied. No reduction on the maximum allowable average bond stress shall be required for grouting underwater.

(d) Unless specified otherwise, the horizontal loads given in the loading schedule shall be taken by the piles. The effect of rock socketing on the lateral stiffness of the pile may be assessed as given in "**Pile Foundation Analysis and Design**" by Poulos H.G. and Davis E.H. (1980).

(e) Raking piles shall be designed to resist lateral loads only. The sub-grade reaction of soil shall be ignored in raking pile calculations.

(f) Provide capping plate and dowel bars in accordance with the detail shown at Annex "C" for steel 'H' piles. The design of steel capping plates and their connections shall be in accordance with **Code of Practice for the Structural Use of Steel** issued by the Buildings Department.

(g) The minimum clearance (cover) between casing and the steel H-pile shall be 40 mm. Spacer details shall be submitted to the satisfaction of the SO.

(h) Only one steel H-pile in an individual socket shall be accepted.

(i) The minimum length of each pile segment forming the whole length of pile shall be 10 m except the uppermost section.

(j) Provide shear bars to steel H-piles within the rock socket in accordance with the details shown in Annex "E".

(k) Effective rock socket top level is the bottom level of the temporary casing.

The minimum lengths of rock socket below the effective rock socket top level shall be calculated from Clause 5.22 (c).

(l) The entire shaft shall be filled solid with grout, without voids, honeycombing or other defects, up to a level of between 150 mm and 450 mm above cut-off level.

(m) Special care shall be taken to the formation process of the pile shaft using air flushing to avoid caving of soil in forming the pile shaft. The use of bentonite slurry or other boring muds shall be prohibited for the pile installation.

(n) Temporary casing of approved quality shall be lowered at the same time when the hole is made. The embedded depth of temporary casing below the founding level (casing embedded depth) shall be 500 mm minimum or such other depths as required to avoid caving of soil at the interface of soil and bedrock during cleaning of the rock socket.

Temporary casing shall be free from distortion, internal projections and hardened grout.

Extraction of temporary casing shall be carried out only after the completion of grouting. Partial extraction of temporary casing before the completion of grouting shall only be carried out with the approval of the SO.

(o) The temporary casing of raking pile shall not be extracted.

(p) In case the temporary casing, other than that of raking pile, cannot be extracted for whatever reasons, pressure grouting shall be carried out at the peripheral of the temporary casing or down to a depth of 10 m below the cut-off level, whichever is the lesser, to fill up the gaps between the pile and surrounding soils, otherwise the horizontal load carrying capacity of the pile shall be ignored and the Contractor shall revise the design accordingly.

Submit method statement of pressure grouting for the approval of the SO.

(q) Concentric drilling system, e.g. Symmetrix or equivalent, shall be used for drilling. The Contractor shall submit details of the drilling machine to be used, including the complete operating mechanism of the drill bit, the range of anticipated rates of advancement of the drill bit (including the procedures for monitoring) and the maximum volume of the air supply and pressure to be applied in different soil and rock strata for the approval of the SO before commencement of any drilling works.

Clause 5.21 (n) on test drilling shall apply equally to RSSHP.

(r) Clauses 5.21 (p), (q), (r) and (s) on founding level shall apply equally to RSSHP.

(s) Clauses 5.21 (u), (v) and (w) on grout shall apply equally to RSSHP.

(t) Grouting shall be carried out with two non-flexible grout pipes, one at each side of the web of the steel H-pile. The lowest part of the grout pipes shall be as close to the pile toe as possible and, unless agreed by the SO, the grout pipes shall not be lifted up before the completion of grouting.

(u) Clause 5.21 (y) on testing of grout shall apply equally to RSSHP.

(v) 5% of the total no. of piles shall be subjected to core testing on the hardened grout. Take a 84 mm or 76 mm nominal diameter core down to the bottom of the pile in the hardened grout for examination and testing. For a core taken at a level deeper than 50 m, the diameter of the core shall be 76 mm and a triple barrel coring shall be used for core sampling. To facilitate such coring, one mild steel tube terminated at 0.6 m above the founding level and of 150 mm internal diameter sufficient for coring shall be fixed to every pile in the manner as specified in Clauses 5.36 (a) to (g). The tube shall be filled with water before grouting. All tubes shall be filled up by pressure grouting upon completion of all testing.

(w) The pile shall be deemed to have failed the coring test if :

(i) The concrete core exhibits honeycombing which means interconnected voids arising from, for example, inadequate compaction or lack of mortar; or

(ii) The concrete core exhibits discontinuity of grout; or

(iii) When any sample section of the core with length/diameter ratio between 1.0 and 1.2 is taken for compressive testing, the sample has an estimated in-situ cube strength converted in accordance with **CS1** from the compressive strength of the grout core, less than 75% of the specified cube strength.

In case the coring test failed to demonstrate the continuity of grout due to breaking up of the core during coring, subject to the approval of the SO, the grout quality might alternatively be proven by CCTV inspection. All time and cost incurred shall be borne by the Contractor.

(x) When a pile fails a coring test, the following procedures shall be followed:

(i) The Contractor shall carry out remedial measures in accordance with Clause 5.31. In addition, further coring tests shall be carried out on two other piles. The cost of the additional coring tests shall be borne by the Contractor; or

(ii) The Contractor shall carry out a loading test on that pile in accordance with Clause 5.29 to test for acceptance. The cost of the loading test shall be borne by the Contractor. The pile would be accepted if it passes the loading test, otherwise, the pile shall be

deemed a failure and remedial measures shall then be carried out in accordance with Clause 5.31. In either case, further coring tests shall be carried out on two other piles and the cost of the additional coring tests shall be borne by the Contractor. In addition, if a pile fails a coring test in accordance with Clause 5.22 (w)(i), pressure grouting of pile to fill up the honeycombing shall be carried out before the acceptance of the pile.

(y) Clauses 5.18 (a) to (d) and (f) to (h) on Steel H-pile shall apply to RSSHP.

Employ an approved independent testing firm to carry out and interpret the inspection and testing of welds, and provide any necessary labour and attendance. Submit evidence proving that operators carrying out the inspection and testing have been trained and assessed for competence in the inspection and testing of welds. In addition, submit certificates of competence from a recognised authority for operators carrying out ultrasonic examination. All test reports shall be submitted directly to the SO in sealed envelope from the independent testing firm within 3 days of the completion of the testing.

The welded joints of piles shall not be lowered into the pile shaft within one hour after they are completed.

The maximum length of spliced pile sections in horizontal or inclined positions shall be 24 m.

(z) Clause 5.21 (z) in monitoring of ground and building settlement shall apply to RSSHP.

(aa) Clause 5.21 (aa) on environmental control shall apply to RSSHP.

(ab) Clause 5.21 (ab) on safety of air receiver, compressor and hoses shall apply to RSSHP.

(ac) Safety Requirements of Cranes on Casing Extraction

Unless otherwise agreed by the SO, casing extraction shall be carried out by a vibrating pile extractor. The Contractor shall submit method statement of casing extraction for the agreement of the SO.

The test, examination, use and maintenance of a mobile crane suspending a vibrating pile extractor for casing extraction, together with the associated lifting gear, shall be in accordance with the **Factories and Industrial Undertakings (Lifting Appliances and Lifting Gear) Regulations**.

The maximum safe working load (SWL) at the specified operating radius of the crane shall be ample enough to take the weight of the extractor and its vibrating load transmitted through the absorber to the crane, the weight of the casing to be extracted and the frictional force between the soil and the casing during the extraction.

The maximum SWL shall be taken from the data specified in the Form 3 of the **Factories and Industrial Undertakings (Lifting Appliances and Lifting Gear) Regulations**, not necessarily the original capacity of the crane. A copy of the Form 3 shall be kept in the cabinet of the crane for operation use and for inspection upon requested.

The operator of the crane shall possess a valid crane operator certificate. Prior to the casing extraction, the operator shall be briefed by the Contractor's Construction Engineer on the weight and depth of the casing to be extracted. The crane shall be operated with great care. The extractor shall be effected by a smooth pull on the hoist line and under no circumstances shall the hoist rope be jerked, boom swung or the machine tipped to free entanglement and achieve faster results.

The crane for the pile extraction shall be seated on solid level ground in

order to prevent toppling. Under no circumstances shall the pile extraction be performed over the side of the crane.

Tolerances in setting out of piles **5.23**

(a) Carefully set out the position of piles as specified.

(b) Construct piles to the following maximum permitted tolerances on plan measured at cut off level in any direction from the actual geometric centre of the pile to the specified designated position:

(i)	Precast concrete piles Precast prestressed tubular piles Percussion cast in-situ concrete piles Steel 'H' piles Rock-socketed steel H piles Non-percussion cast in-situ concrete piles Large diameter bored piles (including large diameter bored piles socketed into bedrock) Large diameter bored piles with bell-outs	75 mm
(ii)	Mini-piles	15 mm

(c) Construct piles to the following maximum permitted tolerances from the vertical or any specified batter:

(i)	Precast concrete piles Precast prestressed tubular piles Percussion cast in-situ concrete piles Steel 'H' piles Rock-socketed steel H piles Non-percussion cast in-situ concrete piles Large diameter bored piles (including large diameter bored piles socketed into bedrock) Large diameter bored piles with bell-outs	1 in 75
(ii)	Mini-piles	1 in 100

(d) Finish tops of piles to within a tolerance of 0 to -25 mm from the cut-off levels specified in Clause 5.25 (a).

(e) Carry out a survey and record the location of the centres of piles prior to completion of the Works. Submit remedial proposals for piles exceeding construction tolerances for the SO's approval within 10 days after the completion of the said survey. Provide the SO with three complete sets of prints and one set of negatives of the agreed remedial works drawings within three days after receiving the SO's approval.

Effect of vibration on adjacent structures and services **5.24**

(a) Vibration caused by piling work shall not exceed the maximum peak particle velocity of ground movement of 7.5 mm/s and 15 mm/s for water retaining structures and water mains respectively, as measured with a vibroscope. Comply with restrictions on particle velocity caused to adjoining structures as specified.

(b) When specified, install "Test piles" before general piling work commences in order to establish the vibration caused by the proposed piling system. "Test piles" will be piles, selected by the SO, which are adjacent to any water mains or water retaining structures and the like. The maximum peak particle velocity shall be recorded at every meter length of penetration of pile, at final set and at levels where obstructions are encountered. Should vibrograph measurements reveal that the specified vibration levels are being exceeded, cease piling and revise the method of driving or the proposed pile system to ensure that the levels of vibration created are reduced to within the specified limits.

(c) Should any unrecorded water main or similar be located during the construction period, vibrograph measurements shall be taken to establish the vibration caused by the piling system adopted. Should the vibrograph

measurements reveal that the specified vibration levels are being exceeded the general principles contained in Clause 5.24 (b) above will apply.

(d) Provide and retain on the Site, until completion of installation of piling, all necessary equipment for the taking of vibrograph readings to ascertain vibration levels. The vibrograph must be of a type that produces a permanent printed record of the vibration created. Provide experienced personnel for the carrying out of vibrograph readings and give the SO at least 48-hour notice before taking measurements. Provide the SO with a copy of each vibration record.

Cutting off pile heads **5.25**

(a) The cut off levels of piles shown on the tender drawings are tentative and may be altered if so required by the SO.

(b) Excavate to expose, trim and cut off pile heads to the specified levels.

(c) For steel piles, execute cutting by approved means. In the event of damage being made to the head of the pile, cut off the defective parts and make good the pile to the satisfaction of the SO.

(d) Score or chase around concrete piles at cut off level to an approved depth prior to removing pile heads to ensure that concrete below cut off level is not damaged. Cut away and make good cracked or defective concrete with new concrete properly bonded to the old. Rectify displaced dowel bars.

For precast prestressed tubular piles, the cutting off shall be by means of an abrasive disc.

(e) Allow a minimum of seven days between the completion of casting an in-situ concrete pile and the cutting off of the pile head.

Note: (i) For large diameter bored piles (including large diameter bored piles socketed into bedrock) and large diameter bored piles with bell-outs, cast concrete at least 0.75 m above the cut off level such that surface laitance may be removed at completion of concreting leaving sound concrete at cut off level.

(ii) For other cast in-situ piles, the height of concrete cast above the cut off level should be sufficient for maintaining the pressure head as required by the system.

Pile caps, strap and tie beams, and dowel bars **5.26**

(a) Unless otherwise specified, pile caps, strap and tie beams are part of the Works.

(b) (i) All pile caps, strap and tie beams shall be designed by the Contractor to **Code of Practice for Structural Use of Concrete** issued by the Buildings Department, for the worst combination of load cases. The design shall be certified by a Registered Structural Engineer.

Where specified, design tie beams to tie all columns in both directions to take care of moments due to eccentricities between load centre and centroid of pile or pile group underneath. The eccentricities shall not be taken as less than 75 mm in any case.

(ii) All concrete works for pile caps and strap beams shall be to Section 6. Structural concrete shall come from a supplier registered under the Quality Scheme for the Production and Supply of Concrete (QSPSC).

(iii) PFA or GGBS concrete shall be used in all pile caps and substructure construction where the concrete structural elements bear a least dimension over 750 mm. The proportion of PFA or GGBS of the total cementitious content in such concrete shall be in accordance with Clause 6.30.

(iv) A 50 mm blinding layer of grade 10/20 concrete shall be laid prior

to casting of pile caps and strap beams.

(v) Steel reinforcement shall be plain steel reinforcing bars (denoted by R), Grade 500B or 500C ribbed steel reinforcing bars (denoted by T) to Hong Kong SAR Construction Standard **CS2**. All reinforcement shall be cut or bent to comply with **BS 8666** unless otherwise specified.

(vi) Cover to all bars including links and stirrups shall be 50 mm.

(vii) If large concrete rafts are to be constructed:

(1) Allow sufficient chairs to support top reinforcement in rafts.

(2) The positions and method of forming construction joints including sample treatment are to be submitted for approval prior to the Works on the Site.

(3) For concrete in large pile caps and piled rafts, measures should be taken in temperature curing to minimize temperature differential occurring in the concrete sections. The side formwork shall not be removed during the curing and as soon as the concrete is cast and bleeding water disappears, the surface shall be cured for a minimum of 4 days by either:

(3.1) Covering the concrete with a layer of fine aggregate, minimum 25 mm thick, and keep it constantly wet, or

(3.2) Covering the surface with one layer of 50 mm thick polystyrene boards secured with canvas on top.

(viii) Where specified in the Contract, the Particular Specification for Reinforced Massive Concrete Structures shall apply.

(c) Provide dowel bars as specified.

(d) Thoroughly wire brush the dowel bars to remove all rust, scale, adhered mud and the like, and prepare and apply a thick protective coat of approved cement grout on all exposed areas of the dowel bars.

Backfilling **5.27**

(a) Backfill pits after cutting off pile heads if the construction of pile caps does not follow immediately.

(b) Compact all fill around pile caps and tie beams to not less than 90% of the maximum dry density determined in accordance with test method 10.2 or 10.4 of **Geospec 3** – Model Specification for Soil Testing issued by the Geotechnical Engineering Office as directed by the SO. Determine the in-situ field density in accordance with **Geospec 3**, test method 11.1 or 11.2, as directed by the SO.

(c) Remove all surplus excavated materials from the Site.

Report sheets **5.28**

Forward daily to the SO in duplicate, report sheets for piles formed the previous day, giving for each pile its identity number, size, gross and nett length together with the serial number of rigs or machines used, and information on any obstructions or special phenomena met during the formation of the piles. Provide the following data for the appropriate type of pile:

Type of piles	Particulars
(a) Precast concrete piles / Precast prestressed tubular piles	(i) Date pile or segment (with serial number) cast; (ii) Length of pile before cutting off;

		(iii)	Hammer weight and type;
		(iv)	Drop of hammer;
		(v)	Type and length of "follower" adopted if applicable;
		(vi)	Penetration record (number of blows per 300 mm penetration) for the full length of piles, for the number of piles selected by the SO;
		(vii)	Final sets for the last 10 blows;
		(viii)	Field record of temporary compression at the final set stage (by recording on a card or graph paper attached to the face of the pile while drawing a pencil along a straight edge placed against it).
(b)	Percussion cast in-situ concrete piles	(i)	Length of the steel tube;
		(ii)	Hammer weight and type;
		(iii)	Drop of hammer;
		(iv)	Penetration record for the full length of pile, for the number of piles selected by the SO;
		(v)	Final sets of the last 10 blows;
		(vi)	Field record of temporary compression at final stage;
		(vii)	Volume of concrete cast;
		(viii)	Method of compacting concrete;
		(ix)	Casting time on completing each pile.
(c)	Steel 'H' piles	(i)	Length of steel 'H' pile before cutting off;
		(ii)	Number of splices carried out;
		(iii)	Hammer weight and type;
		(iv)	Drop of hammer;
		(v)	Penetration record for the full length of pile, for the number of piles selected by the SO;
		(vi)	Final sets of the last 10 blows;
		(vii)	Field record of temporary compression at final set stage;
		(viii)	Actual length of pile from cut off level.
(d)	Large diameter bored piles (including large diameter bored piles socketed into bedrock) / Large diameter bored piles with bell-outs	(i)	Excavation record for the full length of pile (including classification of each type of soil and rock encountered and the depth at which encountered);
		(ii)	Length of pile;
		(iii)	Slump of concrete;
		(iv)	Graphical plot for theoretical and actual volume of

concrete cast against concrete top level, particularly at withdrawal of casing segments;

(v) Method of compacting concrete;

(vi) Casting time on completion of each pile.

(e) Mini-piles / Rock-socketed Steel H piles

(i) Pile reference number;

(ii) Date and time of boring;

(iii) Soil samples taken and in-situ test carried out if any;

(iv) Date pile installed;

(v) Pile type and size, including diameter and number of reinforcement bars and internal size of casing;

(vi) Date and time of drilling;

(vii) Date of grouting;

(viii) Position of pile in the Works and ground level at pile position;

(ix) Working level;

(x) Drilling rates, compressed air pressure and material encountered;

(xi) Samples of rock cutting flushing in the rock socket;

(xii) Depth from working level to pile toe;

(xiii) Toe level;

(xiv) Depth from working level to pile head level;

(xv) Depth and level of top of rock socket;

(xvi) Length and toe level of casing;

(xvii) Length of reinforcement for Mini-pile, or length of steel H-pile for RSSHP;

(xviii) Grout mix;

(xix) Volume of grout in pile (actual and theoretical);

(xx) Details of obstructions, delays and other interruptions to sequence of the Works;

(xxi) Flow rate and total time required for the grouting operation;

(xxii) Grouting pressure used;

(xxiii) Contours of rock-head inferred from drill hole logs.

Loading tests **5.29** (a) The SO may order not less than 1% of nos. of piles installed (minimum one number or more piles), other than large diameter bored piles (including large diameter bored piles socketed into bedrock) and large diameter bored piles with bell-outs, to be load tested to twice the allowable load capacity (for both vertical piles and raking piles). Loading tests of piles shall be carried out by a Testing Firm employed direct by the Employer. The Contractor shall co-ordinate the Works with the Testing Firm and comply with the

following requirements:

(i) Preparation of Test Piles

The Contractor shall:

(1) Submit method statement of pile loading test and obtain the SO's approval before commencement of the test. The Contractor shall also erect adequate fencing, warning signs or other means to avoid unauthorized access to the testing area during the entire loading test process.

(2) Upon receiving notification from the SO on the selection of test pile for pile loading test, immediately seal the top of the selected test pile(s) with a piece of glass under the supervision of the SO and retain it until further set-up to the test pile for pile loading test. Before the sealing is in place, provide and install video surveillance recording system to conduct continuous monitoring of the selected test pile(s) at 24-hour a day, with the location and details to the satisfaction of the SO. Other effective monitoring measures to avoid interference on the test pile before commencement of loading test may be proposed for the SO's approval. After installation of loading jack for pile loading test by the testing firm, immediately seal the top of the loading jack with a piece of glass under the supervision of the SO and retain it until the commencement of loading test. Method statement for sealing up the pile head and the monitoring system shall be submitted to the SO for approval before selection of test pile.

(3) Expose and prepare pile heads such that the pile heads are level, clean and free from soil and debris and able to accommodate the testing equipment on the pile heads.

(4) If required by the SO, extend the test piles to a suitable level.

(5) Design and construct a suitable pile cap to the test pile.

(ii) Attendance to be provided by the Contractor

The Contractor shall, in addition to those items listed in Clause 1.53, provide the following attendance to facilitate the testing of piles by the Testing Firm:

(1) Provide access to the test piles.

(2) Provide and erect kentledge with adequate stability and safety and approved by the SO for the loading tests. The weight of the kentledge shall be at least 1.15 times the maximum test load and shall be placed such that the load centroid matches the centre of the test pile.

(3) Install any fixtures as required by the Testing Firm, necessary for the carrying out of the loading tests and protect the same against weather.

(4) Provide electricity and lighting 24-hour a day for the pile loading tests.

(5) Witness the testing process throughout the testing period.

(6) Provide a weather protected room for accommodating the equipment and instruments used by the Testing Firm.

The Testing Firm will be responsible for providing the reference

frames, all measuring equipment and for surveying the movement of the reference frames. It will also provide 24-hour security throughout the duration of the loading test.

(iii) Loading Test Failures

Should any pile tested fail to comply with the Contract requirements, the Contractor shall bear all the costs arising from the testing of additional piles.

(b) The test load shall be applied in 2 equal increments up to the allowable load capacity of pile, then released and reapplied in 4 equal increments up to the maximum test load and maintained for at least 72 hr before removal. The load at each incremental stage shall be held for a period of 10 min or longer until the rate of settlement is less than 0.05 mm in 10 min.

(c) Recovery after the removal of the maximum test load is deemed to have ceased when the rate of recovery is less than 0.1 mm/hr observed in a period of not less than 15 min.

(d) A total settlement or residual settlement in excess of that calculated from the formulae below shall be deemed to be failure to satisfy the settlement criterion in the loading test.

Total Settlement	=	d + D/120 + 4 mm
Residual settlement	=	D/120 + 4 mm; and 25% of the maximum pile head settlement during the test, whichever is the greater.

where:

d	=	PL/AE
D	=	Diameter of circular pile in mm, or = The least lateral dimension of steel 'H' pile section in mm (for driven steel 'H' pile) = Outer diameter of steel casing for Mini-pile, or = Diagonal of rectangle enclosing H-section for RSSHP)
P	=	Test load
L	=	Nett length of pile (For piles with rock sockets, L shall be measured to the centre of the rock socket.)
A	=	Cross sectional area of pile, or = Transformed section comprising casing, grouting and rebars for Mini-pile, or = Cross sectional area of steel 'H' pile for RSSHP
E	=	Young's modulus of pile given below:

		Young's modulus (MPa)
Concrete or same strength of grout		
Grade	20	18,700
	25	20,500
	30	22,200
	78.58	33,900

Steel piles 205,000

In calculating the elastic compression / extension of the test pile for RSSHP, the following shall be considered:-

(i) The contribution from cement grout within the length of the rock socket.

(ii) The contribution from the casing if it cannot be extracted for whatever reasons.

(e) Complete preparatory works for the loading test not later than 28 days from the date the instruction to test is received.

(f) Make good the test pile after completion of the test including breaking up and clearing away any temporary pile cap and backfilling the pit in accordance with Clause 5.27.

Coring tests **5.30**

(a) The SO may order one or more coring tests to be carried out to any number of barrettes, large diameter bored piles (including large diameter bored piles socketed into bedrock) and large diameter bored piles with bell-outs.

(b) 5% of the total number of barrettes, large diameter bored piles (including large diameter bored piles socketed into bedrock) and large diameter bored piles with bell-outs shall be subjected to coring test. For coring tests, continuous cores shall be taken through the concrete shaft from the top and carried down to a distance of at least half a diameter of the pile base, or 600 mm, whichever is larger, into bedrock with a diamond bit and double barrels and subsequently pressure grouting the drill holes with cement grout of not less than the specified grade strength of the pile. The diameter of the cores to be as follows:

(i) 100 mm (minimum) where the maximum size of aggregate in the concrete shaft does not exceed 25 mm.

(ii) 150 mm (minimum) where the maximum size of aggregate in the concrete shaft exceeds 25 mm and does not exceed 40 mm.

(c) Arrange cores recovered in core boxes in proper sequence. Deliver sample sections of cores to the Public Works Laboratories (PWL) for testing. When honeycombing or incomplete recovery of cores at any location along the full length of cores occurs, the pile shall be deemed to have failed the coring test. Honeycombing shall mean interconnected voids arising from, for example, inadequate compaction or lack of mortar.

(d) Should the estimated in-situ cube strength of any sample section of core be less than 85% of the design grade strength, the pile shall be deemed to have failed the coring test. The estimated in-situ cube strength shall be assessed in accordance with **CS1**.

Toe coring tests **5.30A**

(a) All barrettes, large diameter bored piles (including large diameter bored piles socketed into bedrock) and large diameter bored piles with bell-out shall be subjected to toe coring tests.

(b) One number of toe coring test shall be carried out for each barrette, large diameter bored pile (including large diameter bored pile socketed into bedrock) and large diameter bored pile with bell-out with shaft diameter up to 2500 mm and two numbers of toe coring tests shall be carried out for each large diameter bored pile (including large diameter bored pile socketed into bedrock) and large diameter bored pile with bell-out with shaft diameter exceeding 2500 mm.

For each toe coring test, a core of N size shall be taken to examine the interface between pile and bedrock. The length of the core shall be not less than 2 m of which the core-drilling should cover at least 1 m above and

below the interface. The Contractor may make use of the mild steel tubes for sonic logging as specified in Clause 5.36 (g) for carrying out the toe coring test.

(c) Arrange cores recovered in core boxes in proper sequence. When defects such as unbound sediment or segregation of concrete are observed at or above the interface between pile and bedrock in any cores of a pile, the pile shall be deemed to have failed the toe coring test.

Alternatively, the Contractor may carry out remedial works to rectify such defects as approved by the SO. The Contractor shall first submit a method statement for the SO's approval. Remedial works shall, inter alia, consist of further drilling to determine the extent of the defects, cleaning by high pressure jetting and subsequent pressure grouting with cement grout of not less than the specified grade strength of the pile. After completion, the Contractor shall carry out verification coring to prove all defects are properly rectified. When defects at any location along the verification cores occurs, the pile shall be deemed to have failed the toe coring test. The Contractor may carry out further remedial works and verification coring until all defects are properly rectified. The SO may carry out other test(s) as he deems appropriate. All the time and cost incurred from the remedial works and verification coring shall be borne by the Contractor.

Failure of loading test or coring test or toe coring test **5.31** When a pile fails a loading test or coring test or toe coring test, install additional pile(s) such that the revised piling layout is sufficient to sustain the loadings as given in the loading schedule. For driven steel H-piles, the Contractor may choose to retain the pile as a working pile and redrive it to a deeper level to attain a bearing capacity complying with the contract requirements. However, DPT and CAPWAP analysis shall be carried out to test the pile for integrity and determine pile capacity. The cost of DPT and CAPWAP analysis shall be borne by the Contractor. The SO may carry out other test(s) as he deems appropriate.

Carry out test probes if required to position additional piles. Design extended or extra pile caps and strap beams and any other work necessitated by the pile failure and obtain the agreement of the SO in writing.

Inspection of piles **5.32** The SO may direct that piles be exposed for inspection.

NON-DESTRUCTIVE INTEGRITY TESTS OF PILES

Non-destructive integrity testing **5.33** Non-destructive integrity tests shall be carried out by a Testing Firm appointed by the Employer. The Contractor shall, in addition to those items listed in Clause 1.53, provide attendance and other preparatory works as required.
The Contractor shall notify the SO 5 working days in advance for carrying out the non-destructive integrity tests of piles on the Site.

Number of tests required for non-destructive testing **5.34** Unless otherwise specified, the number of piles to be tested is as indicated in Annex "F".

Preparation of piles for non-destructive integrity testing generally **5.35** Preparation of piles for non-destructive integrity testing generally:

(a) The type and extent of preparation work and attendance required for non-destructive integrity testing depends on the type of pile used in the contract.

(b) Co-ordinate with the Testing Firm to facilitate the testing of piles.

(c) Provide the Testing Firm access to the test pile and witness the testing process throughout the testing period.

(d) Provide the Testing Firm with a copy of the ground investigation report, a Site plan showing bore hole locations and pile layout and a list of the piles to be tested with the date of concreting, total length, length of casing (if any), diameter and volume of concrete used plus any other relevant information required for the testing of the pile.

Preparation for piles for Sonic Logging **5.36** Prepare piles for Sonic Logging

(a) Place in all large diameter bored piles (including large diameter bored piles socketed into bedrock), large diameter bored piles with bell-outs, barrettes and diaphragm wall panels, tubes of mild steel not less than 42 mm internal diameter which shall be regular and free from defects, so as to permit the free and unobstructed passage of the testing probes. Tubes shall be watertight, free from corrosion with clean internal and external faces.

(b) The tubes shall be fitted with a screw-on steel watertight shoe and shall be securely fixed to the interior of the reinforcement cage or fixed by other methods approved by the SO. The tubes shall be parallel to each other and to the axis of the pile. Where sections of tubing are required to be spliced, joints shall be made watertight.

(c) The tubes shall be plugged or capped before concreting. The tubes shall extend the full depth of the pile, barrette or diaphragm wall panel, and stop at about 300 mm above the top of the concrete cast.

(d) Install tubes in the number tabulated below and at spaces as directed by the SO:

(i)	Large diameter bored piles (including large diameter bored piles socketed into bedrock) and large diameter bored piles with bell-outs, 750 - 900 mm shaft diameter	- 3 No./pile
(ii)	Large diameter bored piles (including large diameter bored piles socketed into bedrock) and large diameter bored piles with bell-outs, exceeding 900 mm shaft diameter	- 4 No./pile
(iii)	Barrettes up to 3.0 m long	- 4 No./barrette
(iv)	Barrettes over 3.0 m long and diaphragm wall panels	- Sets of 2 No. at 3.0 m centres/barrette or diaphragm wall panel

(e) Before testing, fill up the tube with water to provide the necessary acoustic coupling and refill with water prior to testing as necessary. A plan shall be provided to the Testing Firm showing the layout and the constructed length of the structural elements to be tested.

(f) All tubes shall be cut off flush with the concrete and filled up by pressure grouting with cement grout of not less than the specified grade strength of the pile at completion of all testing.

(g) Notwithstanding Clause 5.36 (a), for barrettes, large diameter bored piles (including large diameter bored piles socketed into bedrock) and large diameter bored piles with bell-outs with shaft diameter up to 2500 mm, one of the mild steel tubes shall be replaced with a larger tube of 100 to 150 mm internal diameter. For large diameter bored piles (including large diameter bored piles socketed into bedrock) and large diameter bored piles with bell-outs exceeding 2500 mm shaft diameter, two numbers of the mild steel tubes shall be replaced with a larger tube of 100 to 150 mm internal diameter. Size of tube shall be big enough to obtain a core of N size. The bottom of the larger steel tube should be fitted with a mild steel cap, at about 1000 mm above the founding level of the pile.

Preparation of piles for Integrity Testing **5.37** Prepare piles for Integrity Testing

(a) Pile head surface

Cut off the piles to the required level and trim off reinforcement bars if necessary and make good as directed by the SO. Provide a level and smooth surface for the motion sensor attachment at impact locations as advised by the Testing Firm.

(b) For cast in-situ piles

(i) No cast in-situ concrete pile shall be tested until at least 7 days after construction.

(ii) The pile head shall be free of debris and the like, and shall not be more than l m above or below adjacent ground level. All weak mortar, broken concrete and the like, shall be removed from the pile head to expose sound concrete, and the head made horizontal over its complete cross-section.

(c) For precast prestressed tubular piles

Testing may be performed on the steel plate of the original pile head. In such case, prepare the pile such that the pile head and the screw holes are clearly exposed, dry and free from soil and debris.

(d) Inspection

Before testing, the heads of the piles shall be inspected by the Testing Firm for regularity and soundness.

Preparation of piles for Dynamic Testing **5.38** Prepare piles for Dynamic Testing:

(a) Testing may be performed during piling construction (installation testing) or at some time after construction (restrike testing). Provide the following equipment and work for carrying out the tests.

(i) Access to the test pile.

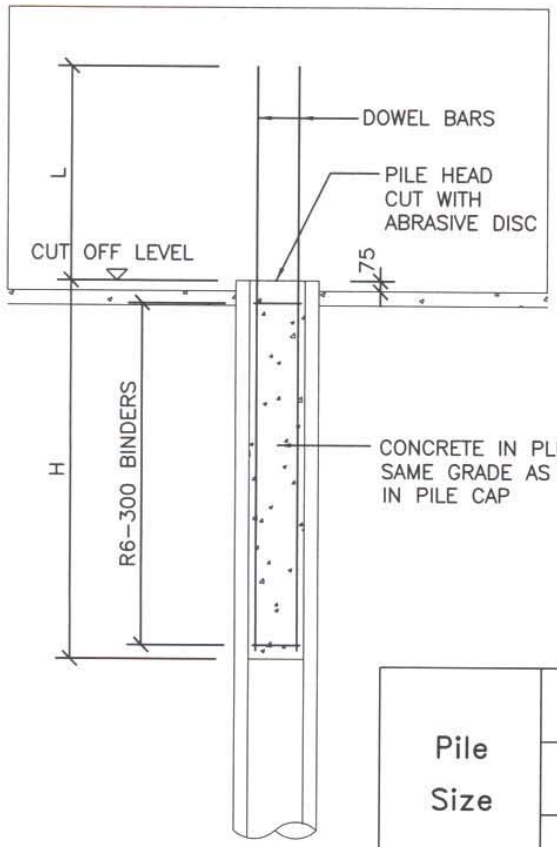
(ii) Driving equipment for piles selected for pile driving analysis and driving the piles.

(iii) Extension to the test piles to a level as and when required for the dynamic testing.

(iv) Welders and welding facilities when required.

(v) Electric power supply at the test pile location.

(vi) Final set record measurement during the test.



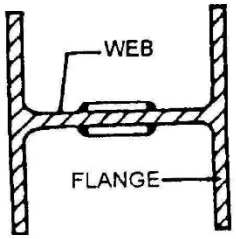
NOTE:

THE PLUGGING DETAIL IS CONSIDERED AS A MINIMUM PROVISION. IF THIS ARRANGEMENT IS CONSIDERED AS INSUFFICIENT, THE DETAIL MAY BE MODIFIED BY THE CONTRACTOR WITH THE APPROVAL OF THE STRUCTURAL ENGINEER.

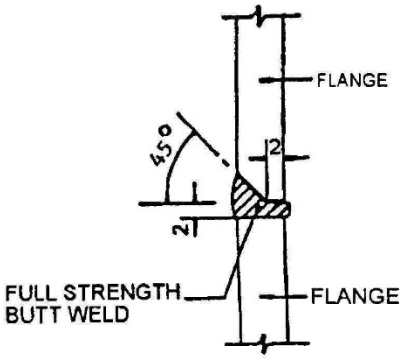
Pile Size	Concrete in pile cap/plug					
	Grade 25			Grade 30		
	H	Dowel Bars	L	H	Dowel Bars	L
500 Overall Diameter 125 thick	1700	5T40	1150	1350	4T32	500
500 Overall Diameter 100 thick	1200	4T32	900	1000	4T16	600
400 Overall Diameter 97 thick	1300	5T32	900	1050	4T25	700

TYPICAL PILE HEAD DETAILS FOR PRECAST PRESTRESSED TUBULAR PILES

ANNEX A



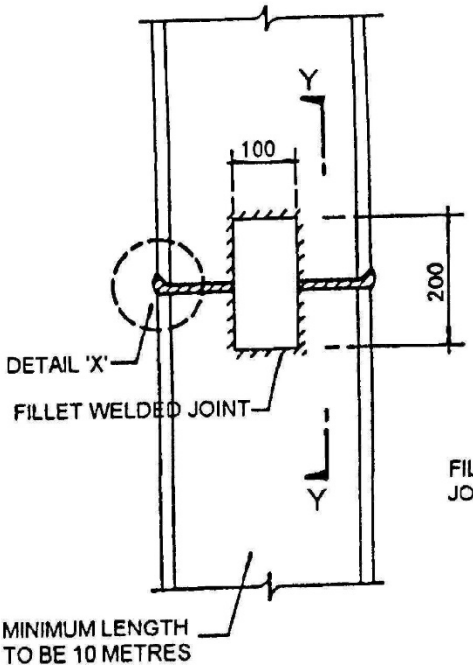
PLAN



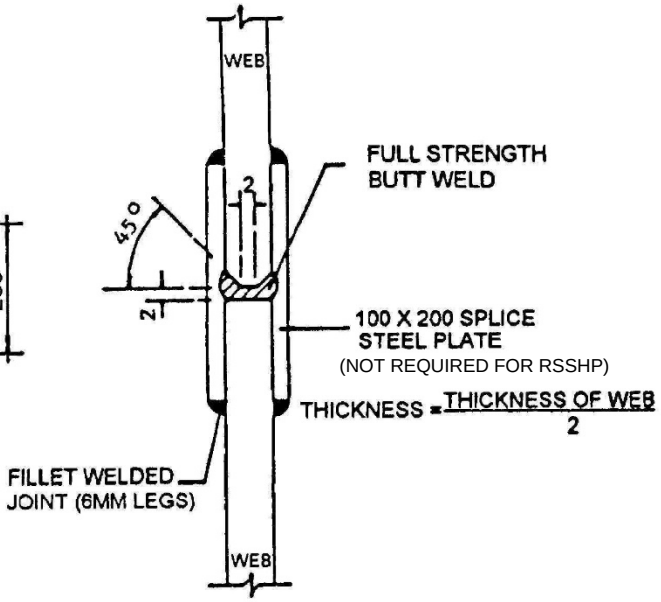
DETAIL 'X'
(VERT. WELD)

NOTES :

1. FUSION SURFACE TO BE MACHINE GROUND
2. SPLICE STEEL PLATES FOR STEEL H PILE SHALL BE MINIMUM GRADE S275 STRUCTURAL STEEL COMPLYING WITH BS EN 10025.
3. SPLICE STEEL PLATES FOR STEEL H PILE ARE NOT REQUIRED FOR ROCK-SOCKETED STEEL H-PILE (RSSHP)



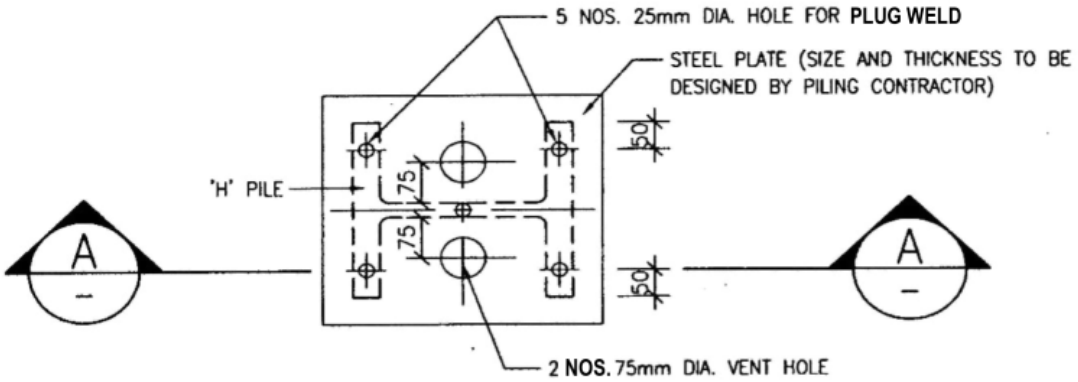
ELEVATION



SECTION Y-Y

TYPICAL SPLICING DETAIL FOR STEEL H PILE

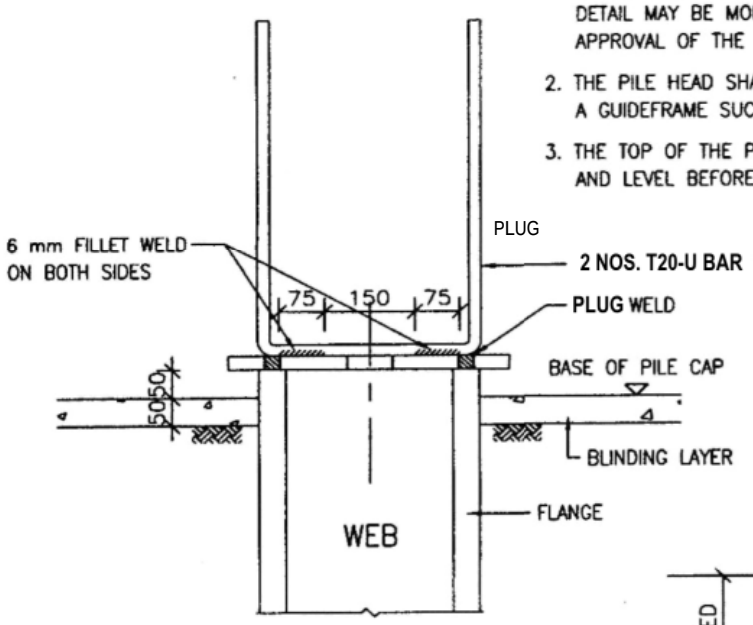
ANNEX B



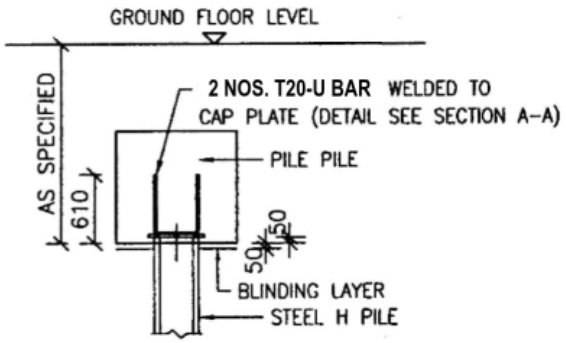
PLAN

NOTES :

1. THE CAPPING DETAIL IS CONSIDERED AS MINIMUM PROVISION. IF THIS ARRANGEMENT IS CONSIDERED AS INSUFFICIENT, THE DETAIL MAY BE MODIFIED BY THE CONTRACTOR WITH THE APPROVAL OF THE **SUPERVISING OFFICER.**
2. THE PILE HEAD SHALL BE CUT WITH A FLAME CUTTER MOUNTED ON A GUIDEFRAME SUCH THAT AN EVEN SURFACE IS ACHIEVED.
3. THE TOP OF THE PILE TO BE MACHINE GROUND SMOOTH AND LEVEL BEFORE **PLUG** WELDING.

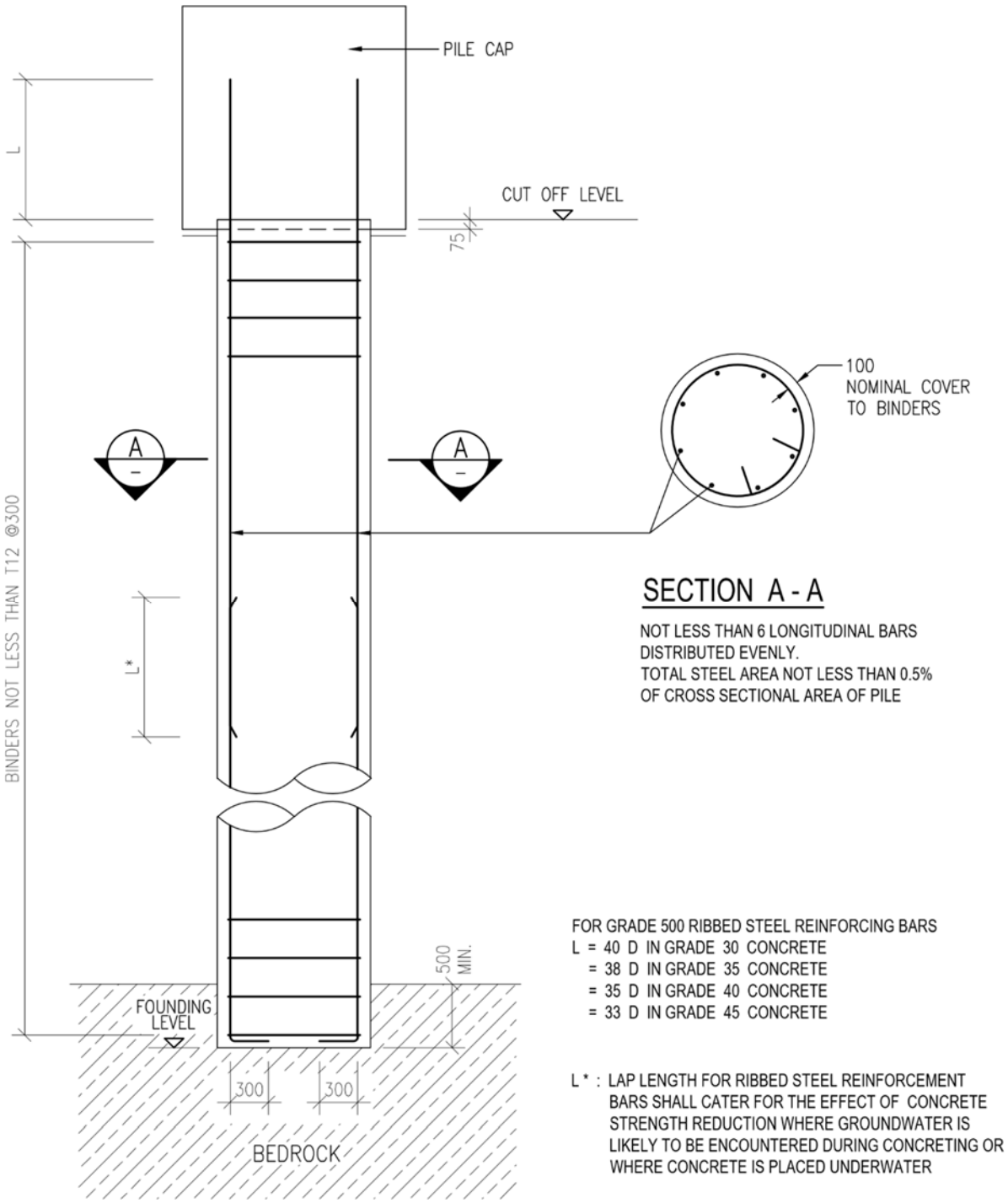


SECTION A–A



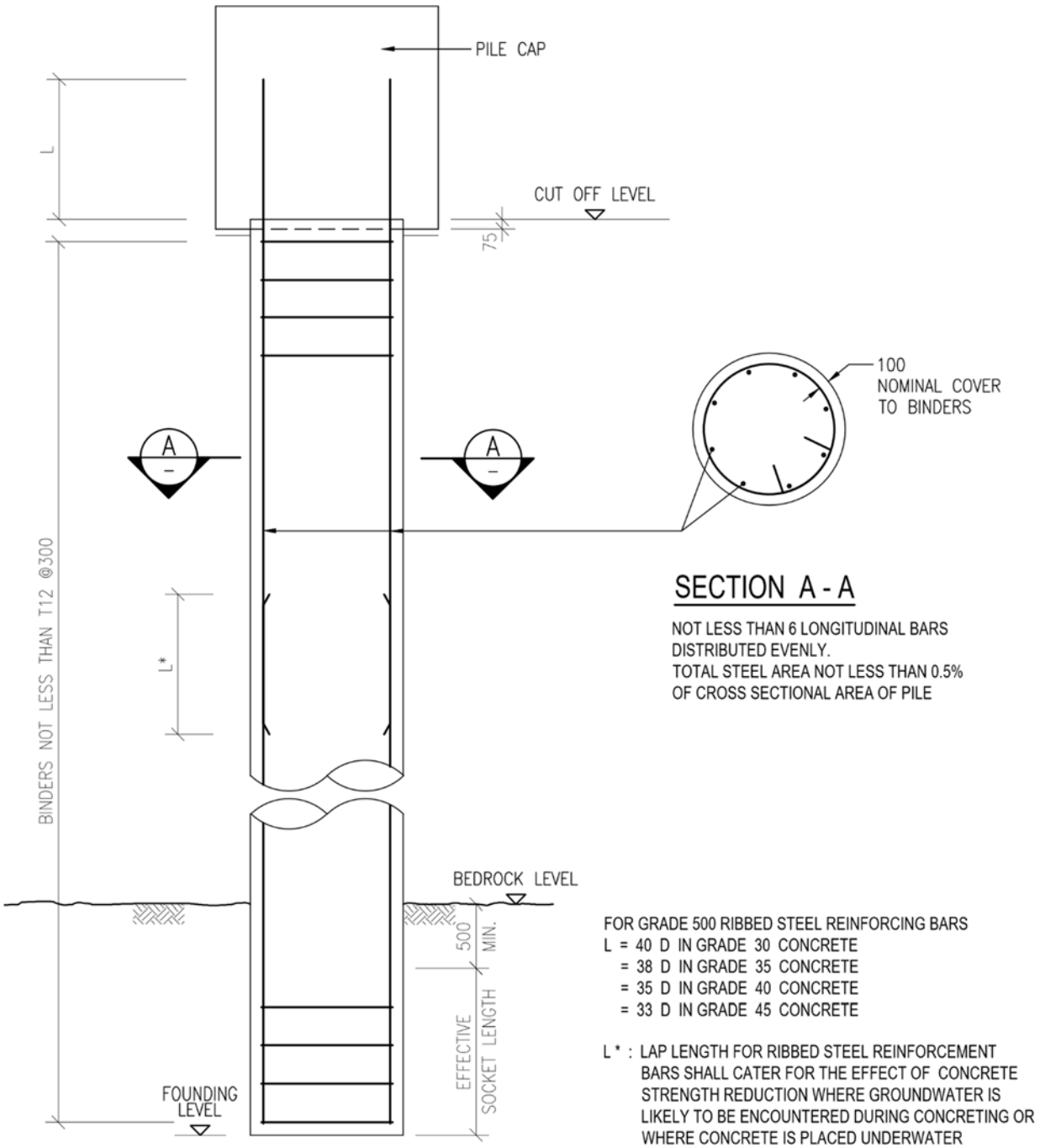
DETAIL SHOWING STEEL H PILE HEAD

ANNEX C



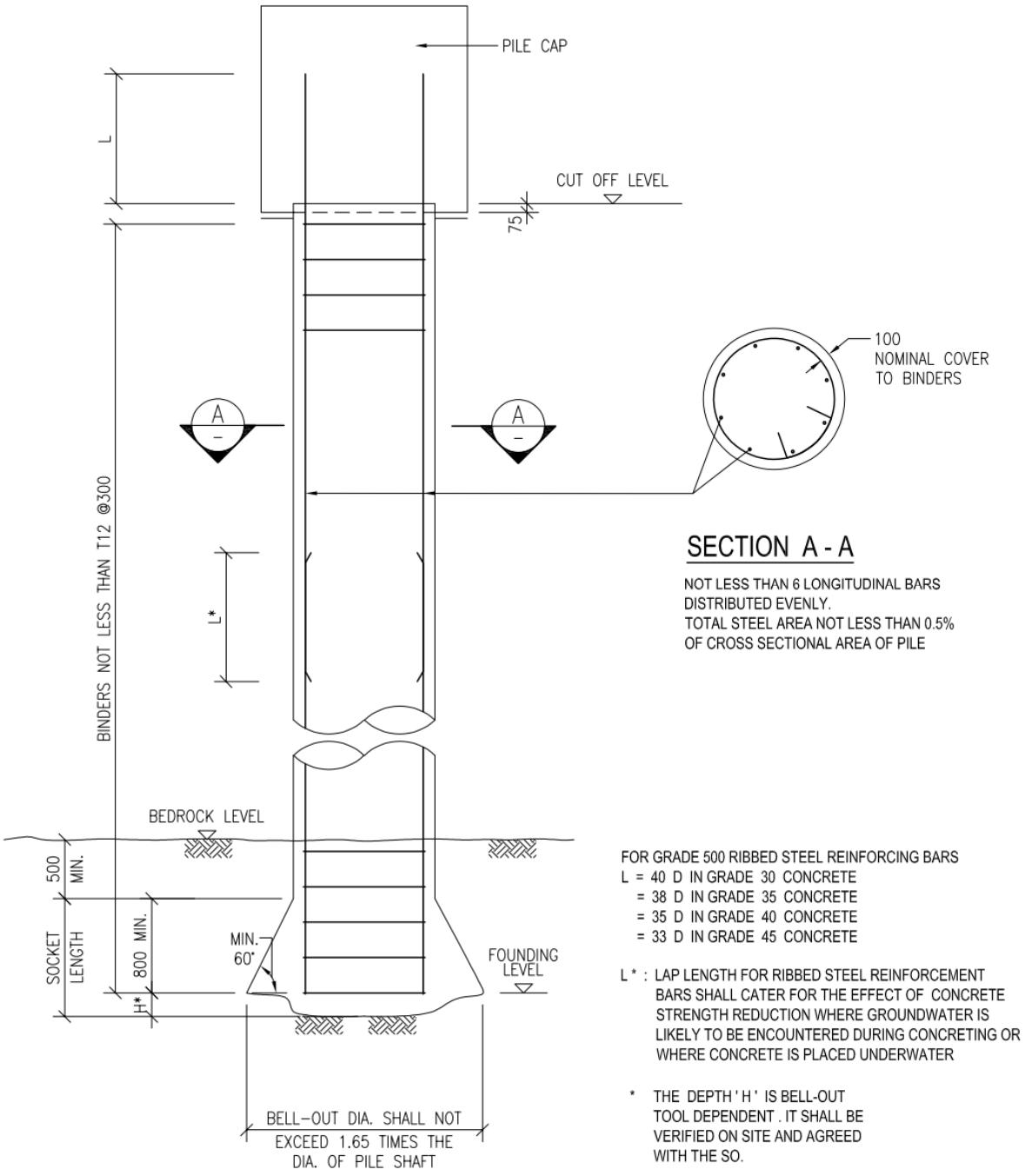
TYPICAL DETAIL OF LARGE DIAMETER BORED PILE

ANNEX D



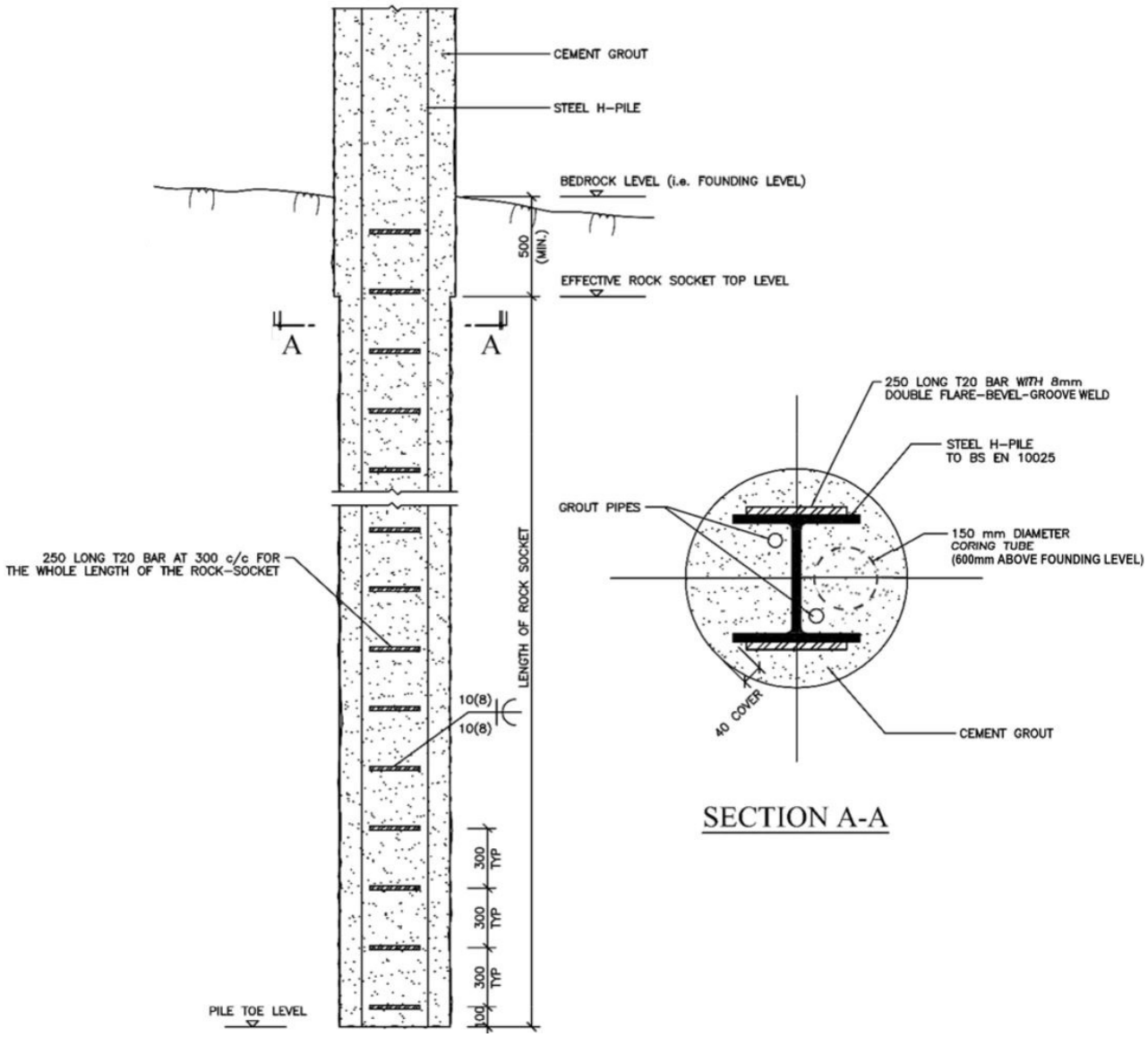
TYPICAL DETAIL OF LARGE DIAMETER BORED PILE SOCKETED INTO BEDROCK

ANNEX D1



TYPICAL DETAIL OF LARGE DIAMETER BORED PILE WITH BELL-OUT

ANNEX D2



TYPICAL SHEAR BARS DETAILS FOR ROCK-SOCKETED STEEL H-PILE

ANNEX E

Number of Piles requiring Non-Destructive Integrity Test

Type of pile Tests	Large diameter bored piles (including large diameter bored piles socketed into bedrock), Large diameter bored piles with bell-outs & Barrettes	Steel H-piles, Precast concrete piles, Precast prestressed tubular piles	Non-percussion cast in-situ concrete piles
Pile Integrity Test	-	-	15%
Dynamic Pile Test	-	Not less than 30 nos. or 15% whichever is the greater	-
CAPWAP Analysis	-	5%	-
Sonic Logging	All piles	-	-

ANNEX F

SECTION 6

STRUCTURAL CONCRETE WORK

GENERAL

Generally **6.1**

(a) Falsework is defined as any temporary structure used to support a permanent structure during erection until the permanent structure is self-supporting. No tropical hardwood propping shall be used to support formwork for concrete work unless otherwise agreed by the SO.

(b) Traditional formwork is assembled from individual elements comprising of sheathing material and the backing structure which supports the sheathing.

(c) Formwork or forms is that section of the temporary works used to give the required shape, surface finish and support to poured concrete. It consists primarily of sheathing material in direct contact with the concrete and joists or stringers supporting the sheathing.

(d) Permanent formwork or formwork left-in is formwork designed to remain in position as part of the permanent work.

(e) Notwithstanding any other clause in the GS, the Contractor shall take sole responsibility for the safe transportation, assembly, erection, maintenance and removal of formwork and falsework.

(f) The design of formwork or falsework shall be such that no part of the formwork or falsework shall project into the finished surface of the concrete.

DESIGN REQUIREMENTS

Design submission **6.2**

(a) Prior to construction, submit for approval the design, supporting calculations and working drawings of formwork and falsework in accordance with **BS 5975:2019**.

(b) When specified, submit the design of falsework (including supports and foundations) and provide certification by an independent professional engineer, at various stages, for the adequacy of the design as well as its proper execution. The independent professional engineer shall be a member of the Hong Kong Institution of Engineers (Structural or Civil Engineering Discipline) or equivalent.

Loadings for design and construction **6.3**

Design and construct formwork and falsework to withstand the worst combination of the following without causing bulging or deflection:

(a) Total weight of formwork, reinforcement and wet concrete.

(b) Construction loads, including dynamic effects of placing, compacting and construction traffic.

(c) Wind loads.

MATERIALS

Props & bracings **6.4**

(a) Props shall be to **BS EN 1065:1999**. No timber props and bracings shall be permitted.

Formwork

(b) Formwork shall be timber or moulds of other materials against which the concrete is cast.

(c) Formwork shall not be split, or have other defects such as cracks.

Formwork ties

(d) Formwork ties shall be of a removable type.

(e) In waterproof concrete, any tie through the concrete shall be of a type with a baffle and shall leave no holes in the concrete.

Surface retarders

(f) Surface retarders shall be of a type which shall not stain or colour the concrete.

Release agents

(g) Release agents used on formwork for structures containing potable water shall be non-toxic and shall not impart a taste to the water.

(h) Release agents containing mineral oil shall not be used. These include barrier paint, polyurethane varnish, or wax.

(i) Release agent used on steel formwork shall contain a rust-inhibiting agent.

Void formers

(j) Polystyrene shall not be used as void formers and box-out material unless permitted by the SO.

Wood preservatives

(k) Wood preservatives in permanent timber formwork shall be to Clause 21.30.

STORAGE

Storage of formwork **6.5**

(a) Store formwork off the ground on level supports and in a manner which shall not result in damage or in deformation or in contamination of the formwork.

Storage of release agents and surface retarders

(b) Release agents and surface retarders in sealed containers shall be properly marked to identify the contents. They shall be protected from exposure to conditions which may affect the material. Store materials in accordance with the manufacturers' recommendations and do not use the materials after the recommended shelf life has expired.

APPROVAL PROCEDURES

Work below ground **6.6**

(a) Prior approval from the SO shall be obtained before work proceeds for casting concrete below ground against sides of excavation.

Holes, inserts or fixings

(b) Prior approval from the SO shall be obtained before work proceeds for size, type and position of any holes, inserts or fixings by the Contractor or his sub-contractor. No part of the concrete shall be drilled or cut without prior approval of the SO.

Surface retarders and release agents

(c) Prior approval from the SO shall be obtained before application for the use, type and location of surface retarders and release agents.

CONSTRUCTION

Generally **6.7**

(a) Scaffolding shall not be used to support formwork or falsework even under the erection or dismantling process.

Cambers

(b) Cambers shown on drawings relate to the concrete immediately before the formwork is struck.

Falsework	**6.8**	(a)	Falsework shall be carried down to construction which is sufficiently strong to afford the necessary support without damage to any portion of the structure. Falsework supported directly on soil shall not be permitted. Where necessary, falsework shall be carried down to foundations or other suitable bases.
		(b)	Falsework shall be arranged so that it can be readily dismantled and removed from the cast concrete without difficulty or damage to the permanent structure. Where necessary, falsework shall be arranged so that the soffit can be retained in position for such period as required by Clause 6.12 / Table 6.1 of the GS.
Props	**6.9**	(a)	Props shall be of sufficient strength and number and placed in such a manner that they adequately, and without excessive deflection, support the loads likely to be imposed on them.
		(b)	Props shall be spaced at no more than 2 m centres in both directions and shall be adequately cross-braced.
Formwork	**6.10**	(a)	Formwork shall be firmly supported and individual panels shall be of a rigid nature.
		(b)	Wall formwork shall at all times be secured so that it will not be toppled over by wind. Do not leave unsecured wall formwork in a vertical position.
		(c)	The faces and edges of formwork shall be clean and free of projecting nails.
		(d)	Formers for formwork profile, chamfers, splays, rebates and other features shall be rigidly and firmly fixed to the formwork.
Left-in formwork		(e)	Wood preservatives shall be applied to all surfaces of left in timber formwork.
Sloping formwork		(f)	Where the inclination exceeds 15º from the horizontal, formwork to the top surface shall be provided.
Joints in formwork		(g)	All joints in formwork including joints between formwork and completed work shall be closely fitted to prevent leakage of grout. Gaps, if any, shall be sealed with gasket, filler, sealant or tape before fixing reinforcement.
		(h)	All joints in formwork shall be tightly secured against completed work to prevent the formation of stepping or ridges in the concrete.
Forming holes and chases		(i)	Inserts or box-out to form holes and chases to specified sizes and shapes shall be fixed in correct positions before placing concrete.
Fixing devices		(j)	Any device for securing formwork or falsework shall not be allowed to remain within the specified concrete cover.
Formwork ties and components		(k)	Formwork ties and components shall be fixed in such a manner that they do not touch reinforcement or build-in component. Any part left in the concrete shall be at least 40 mm or equivalent to the specified nominal cover to the reinforcement, whichever is greater.
		(l)	Formwork ties and components shall be fitted tightly against formwork faces such that no loss of grout occurs.
		(m)	Unless otherwise permitted by the SO, formwork ties and components used with profiled formwork shall be a type such that holes left by the ties and their components are small enough to be completely located within the recesses of the concrete surface.

Use of release agents

(n) Where surface treatment requires bonded adhesion, release agents shall not be used.

(o) Formwork faces shall be cleaned before release agents are applied. Concrete, reinforcement and built-in components shall not be contaminated by the release agents.

Cleanliness

(p) Temporary openings in the formwork for cleaning or inspection shall be provided if required. Immediately before concrete is placed in any section of the formwork, the interior of that section shall be completely cleared of all extraneous materials including water.

REMOVAL / DISMANTLING OF FORMWORK AND FALSEWORK

Striking **6.11** Formwork and falsework shall be struck without disturbing, damaging, or overloading the finished concrete work or the structure.

Minimum periods before striking **6.12** Minimum periods for retaining formwork and falsework in position before striking shall be in accordance with Table 6.1, unless otherwise consented by the SO.

TABLE 6.1
Striking time

Type of formwork	Concrete without PFA, GGBS or PFAC	Concrete with PFA, GGBS or PFAC
Vertical formwork to columns, beams and walls (unloaded)	16 hr	24 hr
Soffit formwork to slabs (props left under)	4 days	4 days
Props to slabs (unloaded)	10 days	10 days
Soffit formwork to beams (props left under)	7 days	7 days
Props to beams (unloaded)	16 days	16 days
Props to cantilevers	28 days	28 days
Inclined formwork to top surface	12 hr	12 hr

(a) These periods are for Portland cement, at 15ºC temperature. Increase these periods for lower temperatures as instructed by the SO.

(b) Where the props shall be left in place whilst the soffit formwork to slabs and beams shall be removed, such props shall either be designed to remain in position throughout the striking process without having to be temporarily removed or alternatively, if agreed by the SO, be so designed that a few can be removed at a time and replaced immediately.

(c) Do not place construction loads on any unshored portion of the structure under construction. The number of floors requiring propping shall be as instructed by the SO according to the design loads of such floors.

6.13 Not used.

REINFORCEMENT

Steel reinforcement **6.14** Steel reinforcement shall be plain steel reinforcing bars or ribbed steel reinforcing bars to **CS2** or steel fabric to **BS 4483:2005**. Cold reduced steel wire used for the manufacture of steel fabric shall be to **BS 4482:2005**.

Test certificate **6.15** Obtain steel reinforcement from suppliers who shall be able to produce certificates for each batch of steel reinforcement supplied to site. The certificates shall be submitted to the SO for approval. The certificates to be submitted for steel bars shall be in accordance with the class of reinforcement delivered to the Site, all as detailed in **CS2**. The certificates to be submitted for each batch of fabric reinforcement delivered to the Site shall come from a manufacturer with a third party certification by a certification body, accredited by the Hong Kong Accreditation Service or its Mutual Recognition Arrangement / Arrangement partners, to ISO 9001. The certificate shall show the manufacturer's name, the date and place of manufacture and that the reinforcement complies with the requirements of **BS 4483:2005** and including details of:

(a) The bond classification;

(b) The cast analysis;

(c) The carbon equivalent value;

(d) The results of the tensile and rebend tests, including the effective cross-sectional area for tensile tests;

(e) The results of the bond performance tests; and

(f) The results of the weld tests.

A batch of fabric reinforcement is any quantity of fabric reinforcement of the same type, size and grade, produced by the same manufacturer, covered by the same mill and test certificates and delivered to the Site at any one time.

Cleanliness **6.16** Supply steel reinforcement free from loose mill scale, loose rust, oil grease or other matter likely to adversely affect the bond with concrete.

Test specimens **6.17**

(a) Provide and cut test specimens from each batch of steel reinforcement as directed by the SO. All test specimens shall be appropriately labelled, marked and delivered to the Public Works Laboratories (PWL) for testing. No claim in respect of steel suffering from damage or rod lengths being reduced due to the taking of testing specimens will be entertained.

(b) Alternatively the Contractor may deliver test specimens to the independent laboratories approved by the SO.

(c) Test certificates shall be sent to the SO directly from these independent laboratories.

(d) Allow sufficient time for the testing of specimens. Do not use steel reinforcement until the relevant test specimens have successfully passed all tests. Remove unsatisfactory material off the Site when instructed by the SO.

(e) For steel reinforcing bars, determination of mass per metre, tensile test, rebend test, chemical analysis and test on bond property based on surface geometry shall be carried out on test specimens for each batch of steel reinforcing bars delivered to site in accordance with **CS2**.

(f) For fabric reinforcement, provide one sample from each batch for testing. The size of each batch shall not exceed 50 t.

(g) Each sample shall comprise three 1.2 m long x 1.2 m wide test specimens taken from different sheets in the batch. Each test specimen shall contain at least three wires in each direction.

(h) The method of testing shall be in accordance with the following:

Cold reduced steel wire : **BS 4482:2005**
Steel fabric : **BS 4483:2005**

(i) The number of tests on each sample of fabric reinforcement shall be as follows:

Description	Type and number of tests				
	Tensile	Rebend	Unit Mass	Weld Shear Force	Pitch Dimension
Steel fabric					
- fabric sheet	-	-	2 [(a)]	2	-
- longitudinal wire	3	1	-	-	1
- transverse wire	3	1	-	-	1
[(a)] One sample for the longitudinal direction and one for the transverse direction					

(j) If the result of any test for yield stress, tensile strength, elongation, weld shear force, rebend, unit mass or pitch dimension does not comply with the specified requirements for the property, two additional test specimens shall be provided from different reinforcement of the same batch and additional tests for the property shall be carried out.

(k) The batch of fabric reinforcement is considered as not complying with the specified requirements for any particular property if the result of any additional test does not comply with the specified requirements for that property. The non-complying batch of fabric reinforcement shall be removed from the Site.

Security – sampling **6.17A** Cut test specimens under the direction and supervision of the SO.

Security – before delivery **6.17B** Keep selected samples under the charge of the SO securely under lock before delivery to the laboratory.

Security – delivery **6.17C** Deliver samples to the testing laboratory under the close supervision of the SO, or through collection service operated by the Public Works Laboratories (PWL).

Security – stock management **6.17D** Submit for approval by the SO during commencement of Contract a stock management system to preclude unauthorized use of steel reinforcement prior to receipt of test results as well as swapping of reinforcement of different testing status. The followings shall be included:

(a) Provide identification marks to different reinforcement batches arriving on the Site which are uniquely traceable to the record of each batch.

(b) The record of a batch of reinforcement shall include date of arrival to the Site, quantities delivered, bar size, bar mark, delivery note, weighting certificate, mill certificate, QA Stockist Certificate or supplier's certificate, and steel reinforcement classification number stated in the QA Stockist certificate.

(c) Establish and maintain a record system, such as colour coding or other approved systems, for identifying and showing clearly steel reinforcement stockpiles that are under different testing status (awaiting test results, approved for use, non-compliant, re-test, omitted for testing etc.).

(d) Keep separately reinforcement stockpiles of different testing status at different locations.

Security – removal of non-compliant re-bars	**6.17E**	Remove non-compliant reinforcement bars from the Site as soon as possible under the supervision of the SO.
Storage	**6.18**	Store bar reinforcement so that each size is kept separate, and in such a manner as to avoid contamination by dirt and mud. Steel shall be clean when fixed in position and subsequently concreted.
Cutting and bending	**6.19**	Cut and bend bars to **BS 8666:2005** unless otherwise specified. Bend bars cold and do not rebend without prior approval. Do not cut or bend bars for use in foundations until the size and depth of the foundation have been approved and the bottom of the foundation has been blinded.
Fixing of reinforcement	**6.20**	Fix reinforcement in the position specified. Support reinforcement with chairs and cover spacers. Secure reinforcement at sufficient number of intersecting and lapping bars with annealed steel tying wire of suitable diameter to prevent movement of the reinforcement. Bend wire back well clear of formwork. Unless otherwise specified, the permitted tolerances for fixing reinforcement shall be in accordance with **Code of Practice for Structural Use of Concrete** issued by the Buildings Department.
Chairs	**6.21**	Provide sufficient steel chairs to support top reinforcement in slabs, stair flights and rafts, and U-bars to keep vertical wall reinforcement and the like in position. Where high tensile steel wire chairs supporting top reinforcements in slabs are to rest on formwork, they shall have plastic covered feet. The plastic cover shall have a minimum thickness of 1.5 mm and a length not less than 25 mm.
Cover spacers	**6.22**	Provide sufficient cover spacers of the following types to support reinforcement in position: (a) Concrete blocks of similar quality to that of the surrounding concrete. (b) Plastic or other approved proprietary type. Cover spacers shall be capable of supporting the weight of reinforcement and construction load without breaking, deforming or overturning.
Welding of reinforcement	**6.23**	Do not weld steel reinforcements without prior approval.
Reinforcement connectors	**6.24**	Reinforcement connectors shall be of a proprietary type approved by the SO and shall be used strictly in accordance with the manufacturer's instructions unless otherwise specified.
Concrete cover	**6.25**	Nominal concrete cover for any reinforcement unless otherwise specified shall be as Table 6.2.

TABLE 6.2
Nominal concrete cover

Conditions of exposure		Concrete elements	C 30	C 35	C 40	C 45	C50	C55/ C60
Mild	Internal concrete surfaces.	Slabs	30	25	25	25	25	25
	External concrete surfaces protected from the effects of severe rain or cyclic wetting and drying e.g. concrete finish with mosaic tiles, painting or rendering.	All other elements	30	30	30	25	25	25
	Concrete surfaces continuously under water, or rarely dry - not sea water.							
	Concrete in contact with non-aggressive soil.	Soffit of slabs on grade	30	25	25	25	25	25
	Concrete cast against adequate blinding.	All other elements	50	50	50	50	50	50
Moderate	Internal concrete surfaces exposed to high humidity e.g. public toilet, shower, bathrooms and kitchens.	All elements	40	35	35	30	30	30
	External concrete surfaces exposed to the effects of severe rain or cyclic wetting and drying e.g. fair faced concrete							
	External concrete surfaces covered by non-weather proof cladding							
	Fresh water tank	All elements		40	40	35	35	35
Severe	Concrete surfaces exposed to sea water spray through airborne contact but not direct exposure, i.e. structures on or near the coast.	All elements			50	45	45	45
	Concrete surfaces exposed to corrosive fumes.							
	Sea water tank.							
Very Severe	Concrete surfaces frequently exposed to sea or flowing water with pH ≤ 4.5.	All elements					55	50
	Concrete in sea water tidal zone down to 1 m below lowest low water level.							

REINFORCEMENT (EPOXY COATED)

Epoxy coatings to reinforcement **6.25A** Epoxy coatings to reinforcement and patching materials for epoxy coatings shall comply with **BS 7295-1:1990** and **BS 7295-2:1990** except as stated in Clauses 6.25H, 6.25J, 6.25K and 6.25L hereinafter. The coatings shall be applied by the electrostatic spray method in accordance with **BS 7295-1:1990**.

Chairs, supports and spacers **6.25B** Chairs, supports and spacers other than cover spacers for reinforcement shall be steel. The steel shall be coated with nylon, epoxy, plastic or other dielectric material for epoxy coated reinforcement.

Tying wire **6.25C** Tying wire for epoxy coated reinforcement shall be 1.6 mm diameter soft annealed steel wire coated with nylon, epoxy, plastic or other dielectric material.

Document and test results to be supplied by the manufacturer **6.25D**

(a) The following documents and particulars shall be submitted to the SO for approval:

(i) Name and location of the coating factory.

(ii) Mill sheets of steel reinforcement bars complying with **CS2**.

(iii) Date and place of the coating application.

(iv) Certificate of the coating materials in compliance with **BS 7295-2:1990**, including:
(1) corrosion resistance
(2) chemical resistance
(3) cathodic disbonding of coating
(4) adhesion
(5) abrasion resistance
(6) impact strength
(7) hardness

The above tests shall be carried out once every 5 years or when there are changes in the composition of the coating materials whichever is the earlier.

(b) The particulars, including certificates and test results in (a) above, shall be submitted to the SO for approval at least 14 days before the first delivery of epoxy coated reinforcement to the Site. Certificates shall be submitted for each batch of epoxy coated reinforcement.

Handling of reinforcement **6.25E**

(a) Reinforcement shall not be subjected to rough handling, shock loading or dropping from a height.

(b) Nylon, rope or padded slings shall be used for lifting epoxy coated reinforcement; bundles shall be lifted with a strong back or with multiple supports to prevent abrasion.

Storage of reinforcement **6.25F**

Epoxy coated reinforcement shall be stored on wooden or padded cribbing and protected from direct sunlight.

Cutting and bending reinforcement **6.25G**

Epoxy coated reinforcement shall be bent cold. Bar cutting and bar bending equipment for epoxy coated reinforcement shall have padded supports and contact areas shall be fitted with nylon or plastic mandrels.

Repairs to epoxy coatings on site **6.25H**

(a) If the coating to epoxy coated reinforcement is delaminated or split at any point or if the coating to epoxy coated reinforcement is damaged:

(i) At any point by an amount exceeding 25 mm^2 in area or 50 mm in length, or

(ii) At more than three points in a 1m length by amounts each even not exceeding 25 mm^2 in area or 50 mm in length,

that part of the reinforcement shall not be used in the permanent work. If the coating to epoxy coated reinforcement is damaged at more than six points in the cut and bent length of a bar by amounts each even not exceeding 25 mm^2 in area or 50 mm in length, that length of bar shall not be used in the permanent work.

(b) All damaged areas not exceeding 25 mm^2 in area or 50 mm in length and cut ends of epoxy coated reinforcement shall be repaired using patching material applied in accordance with the manufacturer's recommendations.

(c) Repairs to epoxy coatings shall be carried out within 8 hr of cutting or damage. Traces of rust shall be removed from the surface of the reinforcement before the repair is carried out.

Additional test specimens for epoxy coating tests for each batch **6.25I**

Provide and cut 2 test specimens from each batch of reinforcement, as directed by the SO for epoxy coating tests in addition to the requirements of tensile tests, bend tests and rebend tests. Each specimen shall be a 2 m length piece cut at least l m from the ends of a 12 m length bar. Specimens shall be selected from different bundles of the reinforcement batch.

Testing of epoxy coating **6.25J**

(a) Thickness, adhesion, and continuity tests shall be performed on each additional test specimens as selected in accordance with Clause 6.25I.

Tests shall be carried out on specimens within a temperature range of between 5°C and 30°C.

(b) The thickness test shall be in accordance with Method No.6 of **BS 3900-C5:1992**. For bars of 12 mm diameter or below, only instruments which operate on magnetic flux principle - Method 6 A(a), can be used. For bars of 16 mm diameter or above, instruments which operate on either magnetic flux principle or magnetic pull-off principle, Method 6 A(b), can be used. All measuring instruments shall be calibrated to an accuracy of ±5%.

For thickness test, five recorded measurements shall be obtained approximately evenly spaced along each side of the test specimen (a total of ten recorded measurements per bar). A single recorded thickness measurement is the average of three individual readings obtained in between the ribs of three consecutive deformations.

(c) The adhesion and continuity tests shall be in accordance with **BS 7295-1:1990** with the following exceptions:

(i) If the bars used in the permanent works are straight or bent to no more than 90°, then 90° bending test shall be adopted in the coating adhesion test. Otherwise, 180° bending shall be adopted.

(ii) The bending of bars for adhesion tests shall be at a uniform rate and be completed within 15 seconds.

Compliance criteria: epoxy coatings to reinforcement **6.25K**

The results of tests for thickness, adhesion and continuity of epoxy coatings to reinforcement shall comply with the following requirements:

(a) Coating thickness
At least 90% of all the recorded thickness measurements of coating shall be within the range of 0.18 mm to 0.30 mm. Thickness measurements below 0.13 mm shall be considered cause for rejection.

(b) Coating adhesion
The surface of the bent test piece shall not exhibit cracking or ductile tearing when viewed under well-lit conditions using normal or corrected vision. There shall be no disbonding of the coating from the surface of the bar and the coating shall not contain more than 5 holidays per metre of bar.

(c) Coating continuity
The continuity of the coating shall contain no more than 5 holidays per linear metre of bar length, when tested in accordance with A.3 of **BS 7295-1:1990** and shall be free of holes, voids, cracks and damaged areas discernible to a person with normal or corrected vision. Holiday is defined as a discontinuity in a coating which is not discernible to a person with normal or corrected vision and detected by a discharge from a Holiday detector.

Non-compliance thickness, adhesion & continuity **6.25L** If one test specimen fails to meet the coating thickness, coating adhesion or coating continuity requirements, retests of specimens of the same batch are permitted, and two further specimens from the same batch shall be subjected to the test or tests in which the original specimen failed. If both additional specimens pass the retest, the batch from which they were taken shall be deemed to comply with the specification. If either or both of them fails in the retests, the batch shall be deemed not to comply with the specification, and this batch shall be rejected and removed from the Site.

Time required for testing of epoxy coated reinforcement **6.25M** Allow minimum 12 working days for the availability of test results after delivery of the test specimen to the Laboratory.

Testing Laboratory **6.25N** All specimens shall be delivered to the Public Works Laboratories (PWL) for testing.

CONCRETE

Generally **6.26** The use of concrete for reinforced concrete structures shall be to the **Code of Practice for Structural Use of Concrete** issued by the Buildings Department unless otherwise specified.

Structural concrete shall come from a supplier registered under the Quality Scheme for Production and Supply of Concrete (QSPSC).

MATERIALS

Cement **6.27** Portland cement shall be to **BS EN 197-1:2011** (Type CEM I). Strength Class of cement used in structural concrete shall be 52.5 N, unless otherwise approved by the SO. Sulphate-resisting Portland cement shall be to **BS 4027:1996**. High alumina cement shall not be used in structural concrete.

PFA **6.28** Pulverized-fuel ash (PFA) shall conform to either **BS 3892-1:1997** with the following modifications:

(a) Use Portland cement CEM I (strength class 52.5 N) to **BS EN 197-1:2011** to determine water requirement, strength factor at 28 days, soundness and initial setting time.

(b) The criteria for water requirement and strength factor at 28 days shall not apply, but the values as determined shall be stated in the certificates for submission.

(c) PFA shall contain up to 10% total lime content or high lime PFA shall contain up to 20% total lime content and with soundness value not more than 10 mm.

or **BS EN 450-1:2012** with the following requirements:

(a) The loss on ignition shall be either Category A or B.

(b) The fineness of Category N PFA, if used, shall be declared.

PFAC **6.29** Portland-fly ash cement (PFAC) shall be to **BS EN 197-1:2011** (Type CEM II/A-V and CEM II/B-V). Strength Class of cement used in structural concrete shall be 42.5 N or higher, unless otherwise approved by the SO.

CSF **6.29A** Condensed Silica Fume (CSF) shall be to **CSA-A23.5 M86** (Canadian Standard) or **BS EN 13263-1:2005+A1:2009**.

GGBS **6.29B** Ground Granulated Blast Furnace Slag (GGBS) shall be to **BS EN 15167-1: 2006** except that the scheme for the evaluation of conformity of GGBS specified in **BS EN 15167-2:2006** is not required. The glass content as determined by X-ray diffraction or optical-microscopy method shall be not less than 67%. The X-ray diffraction method detailed in Appendix D of **BS 6699:1992** is acceptable.

Use of PFA, PFAC, CSF and GGBS **6.30** PFA shall not be used in addition to PFAC and GGBS shall not be used in combination with PFA or PFAC. PFA, CSF and GGBS can only be used in designed mixes only.

If CSF, PFA or GGBS is incorporated in the concrete as separate cementitious materials, the following requirements shall be complied with unless specified/ approved otherwise by the SO:

(a) The proportion of PFA replacement shall not exceed 35% of the total cementitious content.

(b) The proportion of CSF replacement shall not exceed 10% of the total cementitious content.

(c) The proportion of GGBS replacement shall not exceed 40% of the total cementitious content and the use shall be subject to the approval by the SO of the Contactor's proposal on concrete curing method and formwork striking times.

Either PFA or GGBS shall be used in concrete of all pile caps and substructure construction where the concrete structural elements have a least dimension greater than 750 mm. The PFA content shall constitute 25% or above of the total cementitious content in such concrete.

Cementitious content **6.31** Cementitious content is the combined mass of cement, CSF and either PFA or GGBS per cubic metre of compacted concrete. For CSF, the dry mass shall be used.

Free water/cement ratio **6.32** The free water/cement ratio is the ratio between the mass of the free water in the concrete mix and the cementitious content.

Aggregates **6.33** Aggregates shall be obtained from a source approved by the SO. Aggregates from marine source and all-in aggregates shall not be used.

Coarse aggregate shall consist of clean, hard and durable crushed rock complying with **CS3**.

Fine aggregate shall consist of clean, hard and durable crushed rock complying with **CS3**. Natural sand shall not be used in production of concrete unless otherwise agreed by the SO.

The flakiness index of coarse natural aggregates, when determined to **CS3** shall not exceed 30.

The potential alkali-reactivity category of coarse aggregate and fine aggregate shall be determined from the results of tests on potential alkali-reactivity of aggregates using the test method given in CS1. Aggregates in the "Reactive" category shall not be used unless with the prior approval of the SO.

Unless otherwise specified in the Contract, Sub-section 4.2.1 of **CS3** on Los Angeles value shall not be required for aggregates.

Grading of aggregate **6.34** The grading of the combined fine and coarse aggregates shall be such as to produce a dense concrete of suitable workability, using the specified proportions of cement and water.

Aggregates shall be subjected to sieve analysis to **CS3**. The SO may require further analysis to be made if there is any alteration in the type of aggregate.

Water **6.35**

Water for concreting shall be clean and uncontaminated potable water from Government main supply or any other approved source. If taken from a source other than Government main supply, it shall be tested in accordance with **BS EN 1008:2002** when required by the SO.

Wash water from concrete mixer washout operations (recycled water) may be used for mixing concrete of grade strength not exceeding 35 MPa provided that :

(a) The density of recycled water in the combined water (comprising tap water and recycled water) does not exceed 1030 kg/m^3.

(b) The 28-day strength of test cubes with combined water shall not fall below 90% of control test cubes made with tap water.

(c) The chemical limits of the combined water shall not exceed those in Table 6.12.

(d) Tests shall be conducted in accordance with Table 6.12.

Admixtures and additives **6.36**

Submit the following details of any admixtures or cement containing additives for approval before using:

(a) Brand name and manufacturer's literature.

(b) Proposed dosage and detrimental effects, if any, of underdosage and overdosage.

(c) The chloride content which shall not exceed 2% by mass of the admixture or 0.03% by mass of the cementitious content as required in Clause 6.40.

(d) Method of adding to the concrete mix.

Pigments for colouring cement and concrete shall comply with **BS EN 12878:2014**.

Accelerators, retarders, normal water-reducing, superplasticizing admixtures and combinations of these shall comply with **BS EN 934-2:2009+A1:2012**.

When the use of admixtures or cement containing additives is approved or specified, use strictly in accordance with the manufacturer's instructions and at approved dosage levels.

Store admixtures in watertight weatherproof containers clearly marked to show the contents.

Concrete curing compound **6.37**

The curing compound shall, when applied by a mechanical sprayer, become stable and impervious to evaporation of water from the concrete surface within 60 min of application. It shall not react chemically with the concrete to be cured and shall not crack, peel or disintegrate within one week after application.

Concrete curing compound for structures shall be a liquid resin or wax-resin base membrane curing compound of an approved proprietary brand. It shall have a minimum curing efficiency of 85% and shall contain a fugitive dye. The curing compound shall degrade completely within 3 weeks after application and the concrete surface so treated shall not impair the bonding of applied finishes.

Concrete curing compound for carriageways shall be a non-pigmented liquid resin or wax-resin base membrane curing compound of a proprietary brand. It shall achieve a 96% efficiency index and shall be available both with or without a fugitive dye.

Submit the following details of the curing compound for approval before using:

(a) Brand name and manufacturer's literature.

(b) Method of application.

(c) Recommended rate of application.

(d) Test certificates, prepared by an approved testing laboratory, to show that the curing compound will provide the required curing efficiency.

Delivery and storage of materials **6.38**

Deliver cement in quantities sufficient to ensure that there is no suspension or interruption of concreting work at any time.

Store cement in bags in a dry, weatherproof store with a raised floor. Keep each consignment separate, and identify and use it in the order of delivery. Store bulk cement in dry, weatherproof silos and store cement from different sources in separate silos. Do not use cement from different sources in the same pour and only use in the same structure with the SO's prior approval.

Store pulverized-fuel ash in dry, weatherproof silos clearly marked so as to be easily distinguishable from cement silos. Charge and discharge silos in such a manner as to prevent nuisance by dust.

Do not use the cement until the source is approved. Samples of cement may be required from time to time by the SO for routine testing by the Public Works Laboratories (PWL).

If the less popular brands of cement shall be used, submit samples for testing and do not use the cement until the test results are passed.

Remove from the Site immediately any cement which does not comply with the specification or which has become adversely affected by dampness or other agency.

Deliver coarse aggregate to the Site in separate sizes unless otherwise agreed by the SO. Coarse aggregate shall be in 2 sizes when the maximum size is 20 mm and 3 sizes when the maximum size is 40 mm or more for designed mixes.

Keep all aggregates brought to the Site free from contact with deleterious matter. Store aggregate of different sizes in separate hoppers or stockpiles.

Store aggregates on specially prepared well-drained concrete floors, divided into compartments as necessary. Alternatively make such other arrangements for the storage of aggregates as may be approved.

Remove from the Site immediately any aggregates failing to meet the requirements of the specification.

Testing of materials **6.39**

Submit samples, carry out tests and obtain approval before making concrete for use in the Works, or before preparing trial mixes. Deliver samples of materials to be used in concrete to the Public Works Laboratories (PWL), as directed by the SO in sufficient time and in sufficient quantities to allow for all tests to be carried out. Arrange taking and delivering additional samples of aggregates or other constituents of concrete to PWL for testing during the progress of Works when instructed by the SO.

MIXES

Generally **6.40**

Designed mix concrete shall be designated by the grade strength in MPa followed by the nominal maximum size of aggregate in mm with suffix "D".

Standard mix concrete shall be designated by the grade strength in MPa followed by the nominal maximum size of aggregate in mm with suffix "S".

Grade strength is the compressive strength of the concrete stated in the Contract. Compliance with the grade strength shall be ascertained in accordance with Clause 6.55.

The cementitious content of any mix up to Grade 60 shall meet the requirements in Table 6.5 but shall not exceed 550 kg/m^3 of compacted concrete.

The nominal designed slump value for designed mix for reinforced concrete shall not be less than 75 mm unless the contractor can demonstrate that proper compaction can be achieved with a lower slump which shall in no case be less than 50 mm. The free water cement ratio shall comply with Table 6.5 unless otherwise stated in the Contract.

The quality and strength of concrete shall be determined by tests on samples taken on the Site and tested at the Public Works Laboratories (PWL) as directed by the SO.

Standard mixes **6.41** If it is not proposed to use designed mixes, the standard mix proportions shown in Tables 6.3 and 6.4 shall be used.

Compliance testing shall be in accordance with Clauses 6.55, 6.56 and 6.57. Notwithstanding the provisions of these clauses the SO may reduce the frequency of sampling and testing if he is satisfied with the Contractor's quality control.

Admixtures may be used subject to the provisions of Clause 6.36.

TABLE 6.3
Standard mix concrete
Mass of total aggregate to be used with 100 kg of PC
or 110 kg of PFAC

Grade strength (MPa)	Nominal maximum aggregate size(mm)	40	20	10
	Range of measured slump value (mm)	85 - 170	75 - 150	65 - 130
10	Mass of total aggregate (kg)	800	690	-
20		550	500	400
25		490	440	360
30		440	380	300

TABLE 6.4
Percentage by mass of fine aggregate to total aggregate
for standard mix concrete

Grade strength (MPa)	Grading of the aggregate	Nominal maximum aggregate size (mm)	40	20	10
10	C, M or F	Percentage by mass of fine aggregate to total aggregate (%)	30 - 45	35 - 50	-
20 , 25 or 30	C		30 - 40	35 - 45	45 - 55
	M		25 - 35	30 - 40	40 - 50
	F		25 - 30	25 - 35	35 - 45

Note: Grading C, M and F refer to those given in **CS3**

Designed mixes **6.42** Design the concrete mix to fulfill the minimum cementitious content and maximum free water cement ratio requirements shown in Table 6.5 unless otherwise specified in the Contract.

The designed concrete mix shall have a mean strength greater than the required grade strength by a margin sufficient to ensure compliance with Clause 6.55.

Submission **6.42A** Submit details of mix design for provisional approval. Details submitted shall include:

(a) Type and source of cement.

(b) Source of aggregates.

(c) Source of PFA, CSF and GGBS.

(d) Admixtures.

(e) Nominal grading details of the fine and coarse aggregates in tabular and graphical form.

(f) Nominal grading details, in tabular and graphical form, of the combined aggregates together with details of the proportions in which the fine and coarse aggregates are combined.

(g) Cement content of concrete in kg/m^3.

(h) PFA content of concrete in kg/m^3.

(i) Aggregate content of concrete in kg/m^3 for each size of aggregate.

(j) Free water/cement ratio.

(k) Designed workability in terms of slump or flow value, having due regard to the final location and dimensions of the concrete element.

(l) Type of plant to be used, location and plant standard deviation if ready-mixed off site.

(m) Test or trial mix data for the designed mix concrete of the same grade and with similar constituents and properties, if available.

(n) Test data for designed mix concrete of the same or other grade produced in the plant or plants proposed to be used, if available.

(o) A certificate issued within 6 months for each type of cement, PFA, CSF and GGBS showing the source and name of the manufacturers of the materials and showing that they comply with the requirements stated in the Contract. The certificate for GGBS shall include results of tests for:

(i) 7-day and 28-day activity indexes of a 50% combination of the GGBS with 50% of test cement, determined in accordance with **BS EN 15167-1:2006**. The test cement shall conform to **BS EN 197-1:2011** and shall be subject to the following restrictions:
(1) It shall be a type CEM I, of strength 42.5 N or higher;
(2) The Blaine fineness shall be at least 300 m^2/kg;
(3) The tricalcium aluminate shall be between 6% and 12%; and
(4) The alkali content (expressed as equivalent Na_2O) shall be between 0.5% and 1.2%.

(ii) Initial setting time of a 50% combination of the GGBS with 50% of test cement;

(iii) Initial setting time of the test cement and its 7-day and 28-day strength;

(iv) Chemical oxide composition of the GGBS, comprising the contents of calcium oxide (CaO), silicon dioxide (SiO_2), aluminium oxide (Al_2O_3), magnesium oxide (MgO), titanium dioxide (TiO_2) and manganese oxide (Mn_2O_3);

(v) Total content of alkalis determined in accordance with **BS EN 196-2:2005**, or other method agreed by the SO, and expressed as equivalent Na_2O;

(vi) Fineness value determined in accordance with the air permeability method in **BS EN 196-6:2010**;

(vii) Relative density determined in accordance with **BS EN 196-6: 2010**;

(viii) Glass content and the method used for its determination; and

(ix) The method(s) of rapid cooling used to produce the granulated blast furnace slag(s) during the manufacture of the GGBS (Rapid cooling includes quenching in water (granulation) and projecting through water and air (pelletisation).

(p) Certificates showing that the production and supply of aggregates are certified to the **ISO 9001** standard in accordance with **CS3**, and test certificates / documents issued within 6 months for each nominal maximum aggregate size in accordance with Clause 6.2.2 of **CS3** showing the compliance of requirements as stated in the Contract.

Liquid retaining structures **6.42B** For liquid retaining structures, PFA or GGBS shall be used and the PFA content if used shall constitute 25% or above of the total cementitious content in the designed mix concrete. The mix shall also satisfy the following requirements:

(a) Maximum Water/Cement ratio to be 0.45.

(b) Minimum cementitious content to be 325 kg/m^3.

(c) Maximum cementitious content to be 450 kg/m^3.

(d) Slump shall be greater than 75 mm.

20% recycled coarse aggregates **6.42C** When specified, concrete with 20% recycled coarse aggregates shall be used in designed mix concrete of 25 to 35 MPa grade strength except in water retaining structures, subject to the following :

(a) Either Type CEM I of Portland cement to **BS EN 197-1:2011** or Type CEM I Portland cement in combination with PFA can be used in accordance with Clause 6.30.

(b) Coarse aggregates shall consist of 80% natural rock aggregates as defined in the GS and 20% recycled coarse aggregates.

(c) Recycled coarse aggregates shall be produced by crushing old concrete and shall meet the requirements in Table 6.13.

(d) Tests on recycled aggregates from a particular source, with the exception of Government sources, shall be carried out by the aggregates producer at weekly intervals in compliance with Table 6.13.

(e) Fine aggregates shall be as defined in the GS.

(f) Fine aggregates recycled from old concrete shall not be used.

(g) The grading of the coarse aggregates shall comply with the limits as defined in the GS for single-sized 20 mm and 10 mm aggregates.

(h) Recycled coarse aggregates shall be thoroughly wetted before being used.

(i) The concrete shall have a minimum slump of 75 mm when it is ready to be compacted to its final position.

(j) Before any concrete is produced for use in the works, trial mixes shall be performed in accordance with the GS.

(k) Compliance criteria in cube strength shall be as defined in the GS.

(l) Recycled aggregates shall be stored in separate stockpiles or silos to prevent inadvertent mixing with natural aggregates.

(m) A separate compartment shall be provided for recycled aggregates in the batching plant.

(n) Natural aggregates shall be used in lieu of the recycled aggregates in case of supply shortage of recycled aggregates.

TABLE 6.5
Minimum cementitious content (kg/m^3) and
maximum free water cement (W/C) ratio

Grade strength (MPa)	Maximum aggregate size (mm)	Plain concrete			Reinforced concrete and prestressed concrete#		
		Exposure conditions	Minimum cementitious content	Maximum free W/C ratio	Exposure conditions	Minimum cementitious content	Maximum free W/C ratio
20/25	40 20 10	Mild	260 290 330	0.65	Mild	260 290 330	0.6
30	40 20 10	Moderate and below	260 290 330	0.65	Moderate and below	280 310 350	0.6
35	40 20 10	Severe and below	295 325 365	0.55	Moderate and below	300 330 370	0.6
40	40 20 10	Severe and below	295 325 365	0.55	Severe and below	320 350 390	0.55
45	40 20 10	Very Severe and below	320 350 390	0.5	Severe and below	345 375 415	0.45
50	40 20 10	Very Severe and below	320 350 390	0.5	Very Severe and below	370 400 440	0.4
≥55 and ≤60	40 20 10				Very Severe and below	370 400 440	0.35

For prestressed concrete, Grade 30 or lower should not be used.

Trial mixes **6.43** Trial mixes are not required for designed mix of concrete of grade below Grade 20 or for standard mix concrete.

Concrete shall come from a supplier registered under the QSPSC. Where a designed mix is used, trial mixes may be required to be carried out to determine the suitability of the proposed mix proportions for production of concrete of the required quality, at the intended workability for compaction of the concrete in the position, shape and location specified. Prepare trial mixes on receipt of provisional approval of the mix design and complete at least 35 days before commencement of concreting. Carry out trial mixes in accordance with the following table:

Test required	No previous cube strength records submitted or the records submitted in accordance with Clause 6.42A found unsatisfactory		Previous cube strength records found satisfactory			
	< Grade 40	≥ Grade 40	Same mix Same plant	Different mix Same plant	Same mix Different plant	
					< Grade 40	≥ Grade 40
Laboratory Mix Trials	Yes	No	No	Yes	No	No
Plant Trials	No	Yes	No	No	No	Yes

The size of test cubes shall be 100 mm for concrete with maximum aggregate size not exceeding 20 mm and shall be 150 mm for maximum aggregate size exceeding 20 mm.

Plant Trials **6.43A** Plant Trials shall be made using the plant proposed and the mix designs and constituents provisionally approved by the SO. The volume of each batch shall be at least 60% of the nominal volume of the mixer's discharge.

Make one trial mix on each of three different days for each grade of concrete using materials typical of the proposed supply. Three samples of concrete shall be taken from each batch at approximately 1/6, 1/2 and 5/6 of the discharge from the mixer. Each sample shall be of sufficient size to perform a slump test or a flow table test, and make two test cubes. The method of sampling shall be as stated in **CS1**. Each sample shall be tested to determine its slump value or its flow value in accordance with **CS1**, and two test cubes shall be made, stored, cured and tested to determine the compressive strength at 28 days in accordance with **CS1**.

Compliance criteria of Plant Trials **6.43B** The results of tests on concrete taken from Plant Trials shall comply with the following requirements:

(a) The average of the nine measured slump values shall be within 20 mm or ±25%, whichever is the greater, of the designed slump value. The average of the nine measured flow values shall be within ±50 mm of the designed flow value.

(b) The range of the three measured slump values for each batch of concrete shall not exceed 20% of the average of the three measured slump values for that batch. For flow table tests, the range of the three measured flow values for each batch of concrete shall be within 70 mm.

(c) The average compressive strength at 28 days of the 18 test cubes shall exceed the grade strength by at least 12 MPa for 100 mm test cubes or 10 MPa for 150 mm test cubes. The compressive strength of each individual test cube shall exceed the grade strength by at least 5 MPa for 100 mm test cubes or 4 MPa for 150 mm test cubes.

(d) The range of the compressive strength of the six test cubes from each batch of concrete shall not exceed 20% of the average compressive strength of the six test cubes from that batch.

Laboratory Mix Trials **6.43C**

Laboratory Mix Trials shall be made in the supplier's laboratory using the mix designs and constituents provisionally approved by the SO.

Laboratory Mix Trials shall be carried out in accordance with Section 11 of **CS1**. Three separate batches shall be made, each of sufficient size to provide samples for carrying out two slump tests or two flow table tests, and to make six test cubes, stored, cured and tested for compressive strength at 28 days in accordance with **CS1**.

Compliance criteria of Laboratory Mix Trials **6.43D**

(a) The average of the six measured slump values shall be within ±20 mm or ±25%, whichever is the greater, of the designed slump value. The average of the six measured flow values shall be within ±50 mm of the designed flow value.

(b) The results of compressive strength tests at 28 days of the test cubes on Laboratory Mix Trial concrete shall comply with the following table:

Standard deviation of test data of the proposed plant	The average of the 18 test cubes shall exceed the grade strength by at least (MPa)	Individual test cube shall exceed the grade strength by at least (MPa)
Does not exceed 5.5 MPa for 100 mm test cubes	10	3
Does not exceed 5.0 MPa for 150 mm test cubes	8	2
Exceeds 5.5 MPa for 100 mm test cubes	14	7
Exceeds 5.0 MPa for 150 mm test cubes	12	6

Approved concrete mix **6.43E**

When the mix has been approved, do not make variations in the proportions and sources of materials or in the type, size and grading of aggregates without the consent of the SO, who may require further trial mixes to be made.

Notwithstanding the above, after approval of the mix, the approved cementitious content may be varied during routine production by an amount not exceeding 20 kg/m^3, provided that the specified maximum and minimum limits for cementitious content are maintained. The approved fine and coarse aggregate content may be adjusted up to a maximum of ±20 kg per 100 kg of cementitious content provided that the adjusted mixes comply with all requirements of this Specification in respect of materials, quality and strength of such mixes, and the aggregate/cementitious content ratio is kept unchanged. In the event that the approved fine aggregate content is adjusted, the approved coarse aggregate content shall be adjusted accordingly to keep the approved aggregate/cementitious content ratio unchanged. The same is applied to the adjustment of the approved coarse aggregate content.

The SO may also require practical tests to be made on the Site by filling trial moulds or by pumping to confirm the suitability of the mix for the Works. In such tests, the type of plant used for mixing, transporting and placing, the method of compaction used, the formwork face to the mould and the size and disposition of reinforcement shall be similar in all respects to those intended for use in the Works.

Ready-mixes **6.44**

Ready-mixed concrete shall be as defined in **BS EN 206:2013+A1:2016**, and shall comply with the GS, or as otherwise specified. Any concrete batched off the Site may be used only with the approval of the SO.

Carry the concrete in purpose made agitators operating continuously, or in truck mixers. Compact the concrete in its final position within 2½ hr of the introduction of cement to the aggregates, and within 30 min of discharge from the agitator or truck mixer. Concrete, which in the opinion of the SO is no longer sufficiently

workable, shall be rejected. Record the time of the introduction of cement to the aggregates on the delivery note, together with the weight of the constituents of each mix.

When truck-mixed concrete is used, add water under supervision either on the Site or at the batching plant as agreed by the SO. Do not add water in transit.

Maintain and operate truck-mixer units strictly in accordance with the manufacturer's recommendation.
Truck-mixer units and their mixing and discharging performance shall comply with the manufacturer's requirements unless otherwise agreed by the SO. Continue mixing for the number, and at the rate of revolutions recommended by the manufacturer or, in the absence of the manufacturer's instructions, for not less than 100 revolutions at a rate of between 7 and 14 revolutions per minute (inclusive).

Do not deliver ready-mixed concrete to the Site without prior approval for the supplier's production plant. Arrange for the SO to inspect the supplier's plant if required before and/or during the period of supply.

Keep a record book on site available for inspection at all times. This shall contain the following information relating to each delivery of concrete to the Site:

(a) Registration number of truck, name of supplier and location of batching plant.

(b) Time of introduction of cement to the mix.

(c) Time of arrival of lorry at the concreting location.

(d) Mix proportions, including admixtures if any and grade of concrete.

(e) Position where concrete was placed.

(f) Whether test cubes were taken from the delivery, and details of cube markings.

(g) Slump test or flow table test results.

The acceptance criteria for workability and strength shall be as specified in Clauses 6.55, 6.56 and 6.57, provided that for standard mixes, if the SO is satisfied with the supplier's quality control, he may reduce the frequency of sampling and testing specified therein.

Chloride content **6.45** The total chloride content of the concrete shall not exceed the limits shown in Table 6.6 expressed as a percentage relationship between chloride ion and mass of cementitious material in the mix.

TABLE 6.6
Chloride content

Type of concrete	Maximum total chloride content %
Prestressed concrete Steam cured structural concrete	0.1
Reinforced concrete made with sulphate resisting Portland cement	0.2
Reinforced concrete Concrete with embedded metal	0.35

Workability **6.46** Adopt a free water/cement ratio complying with Table 6.5 to produce concrete of adequate workability with the aid of admixtures as necessary. Check the workability by using slump or flow table tests to **CS1**. A guide to the degree of workability required for various types of work is shown in Table 6.7.

Concrete mix with a nominal slump less than 75 mm shall not be used unless the Contractor can demonstrate that proper compaction can be achieved with a lower slump which shall in no case be less than 50 mm.

TABLE 6.7
Workability

Degree of workability	20 mm maximum size aggregate		40 mm maximum size aggregate		Uses of which concrete is suitable
	Slump (mm)	Flow (mm)	Slump (mm)	Flow (mm)	
Low	50		50 – 75		Simply reinforced large sections, concreting with vibration
Medium	75 - 100		100 – 150		Moderately reinforced sections such as ordinary beams and slabs, concreting with vibration
High	100 - 150		125 – 175		Sections with congested reinforcement where vibration is difficult
Very high	150-200	340-600			Sections with very congested reinforcement where vibration is very difficult

No-fines concrete **6.47** No-fines concrete shall be composed of Portland cement and 20 mm - 10 mm aggregate of which not more than 15% shall be retained on a 20 mm BS sieve, and not more than 10% shall pass a 10 mm BS sieve. The aggregate/cement ratio shall lie within the range 10 to 15 by weight and the cement content shall be such that each particle of aggregate is coated with cement paste but there is no continuous matrix. The free water/cement ratio shall be 0.45 by weight unless agreed otherwise by the SO.

CONTROL OF ALKALI-SILICA REACTION IN CONCRETE

Measures to control ASR in concrete **6.47A**

(a) Measures to prevent the occurrence of alkali-silica reaction (ASR) in concrete structures shall be the control of reactive alkali content of the concrete.

(b) The reactive alkali content of concrete expressed as the equivalent sodium oxide (Na_2O) content per cubic metre of concrete shall be obtained in accordance with Clause 6.47B.

(c) Unless with the prior approval of the SO, the reactive alkali content of the concrete, expressed as the equivalent sodium oxide (Na_2O) content per cubic metre of concrete defined in Clause 6.47B, shall not exceed 3.0 kg.

Equivalent sodium oxide (Na_2O) content **6.47B**

(a) The equivalent sodium oxide (Na_2O) content of the concrete shall be calculated from the following expression:

Equivalent $Na_2O = A + B + C$

Where

A is the sum of the acid-soluble alkali content (expressed as equivalent Na_2O) of cement, admixtures and water;

B is equal to 1/6 the total alkali content of PFA (expressed as equivalent Na_2O) or 1/2 of the total alkali content of GGBS (expressed as equivalent Na_2O). If the proportion of PFA is less than 20% or that of GGBS is less than 25% of the total cementitious content, the value of B shall be equal to the total alkali content of PFA or GGBS expressed as equivalent Na_2O; and

C is equal to 0.76 times the chloride ion (Cl^-) of the aggregate.

(b) The acid-soluble alkali content of the cement shall be determined in accordance with **BS EN 196-2:2005** and shall be taken as the average of the latest 25 daily determinations of equivalent sodium oxide plus twice the standard deviation of the results.

(c) The acid-soluble alkali content of admixtures shall be determined in accordance with **BS EN 480-12:2005**.

(d) The acid-soluble alkali content of water shall be determined in accordance with **BS EN 1008:2002**.

(e) The total alkali content of the PFA or GGBS shall be determined in accordance with **BS EN 196-2:2005** and shall be taken as the average of 25 weekly determinations plus twice the standard deviation of the results.

(f) The chloride ion content of the coarse and fine aggregates shall be measured in accordance with **CS3**.

Submission **6.47C** (a) The following particulars of the proposed concrete mix shall be submitted to the SO:

(i) HOKLAS endorsed test certificates issued within 6 months giving the results of tests required in Clauses 6.47B (b) to (f).

(ii) Calculation of the reactive alkali content of the proposed mix.

(ii) Documentation of a quality system to control the active alkali content in the concrete.

(b) Within five working days of any instance of the active alkali content in the concrete supplied having been found to have exceeded, the Contractor shall submit the relevant HOKLAS endorsed test certificates and calculations to the SO together with his remedial proposals for approval.

(c) The HOKLAS endorsed test certificates giving the results of tests required in Clauses 6.47B (b) to (f) shall be submitted at quarterly intervals unless agreed otherwise by the SO. The certificates shall be accompanied by any necessary calculations to demonstrate that the mix continues to comply with the limit on reactive alkali content during the period of delivery of the approved concrete mix to the Site.

MIXING AND PLACING

Mixing **6.48** Concrete shall come from a supplier registered under the QSPSC. Mixing and transporting concrete shall be in accordance with their quality control manual.

Do not remix partially hardened concrete with or without additional cement, aggregate or water. Mix and place light-weight concrete including light-weight "air-entrained" concrete in accordance with the manufacturer's instructions and as required by the SO.

Place no-fines concrete with the minimum of punning.

Transporting and placing **6.49**

Transport and place concrete by an approved method which ensures that there is no contamination, segregation or loss of the constituent materials.

The temperature of fresh concrete shall not exceed 30°C when it is placed in position, submit for approval details of the measures proposed to ensure that this temperature will not be exceeded.

Clean all areas where concrete shall be placed and, except for concrete placed under water, render free from standing water immediately before the placing of the concrete.

Do not place concrete in any part of the structure until approval has been given. If concreting is not started within 24 hr of that approval being given, approval shall be obtained again. Inform the SO at least 24 hr in advance to inspect the Works for which approval for concreting is being sought.

Proceed with concreting continuously between construction joints. Unless the SO agrees otherwise, do not place fresh concrete against in-situ concrete which has been in position for more than 30 min unless the in-situ concrete has been kept damp with a layer of wet hessian and protected from the weather. When in-situ concrete has been in place for 4 hr or in the opinion of the SO the concrete has stiffened to such an extent that it no longer responds to the action of an internal vibrator, do not place further concrete against it for a further 20 hr and form a construction joint in accordance with Clause 6.51.

Compact concrete in its final position within 2½ hr of the introduction of cement to the mix, and within 30 min of discharge from the agitator. Concrete, which in the opinion of the SO, is no longer sufficiently workable shall be rejected.

Deposit concrete in horizontal layers to a compacted depth not exceeding 450 mm where internal vibrators are used, or 150 mm in all other cases, unless otherwise agreed by the SO.

Do not allow concrete to free fall in excess of 2.7 m unless otherwise agreed by the SO. When trunking or chutes are used, keep them clean and use them in such a way as to avoid segregation.

Place and compact concrete in such a way as to avoid disturbance to the formwork and reinforcement. Where sections of the Works are carried out in lifts, support the reinforcement projecting above the lift being cast to prevent movement of the bars during the casting and setting of the concrete.

Do not place concrete in flowing water.

Do not use concrete pumps without prior approval.

Place underwater concrete in accordance with the requirements given in **Code of Practice for Structural Use of Concrete** issued by the Buildings Department.

Compaction **6.50**

Compact concrete so as to produce a dense homogeneous mass. Unless otherwise agreed by the SO, compact concrete with vibrators. Provide adequate number and types of vibrating equipment to compact the concrete fully at the rate at which it is placed. Provide a sufficient number of vibrators in serviceable condition on the Site to ensure that reserves are always immediately available in the event of breakdowns.

Internal vibrators shall operate at not less than 10 000 cycles per minutes and external vibrators not less than 3 000 cycles per minute. Vibrating tables operating at a minimum of 5 000 oscillations per minute may be used for precast elements subject to approval.

Do not use external clamp-on type vibrators without prior approval.

Do not apply vibration by way of the reinforcement. Where vibrators of the immersion type are used, avoid all contact with reinforcement, formwork and inserts so far as is practicable.

Do not use vibration as a means of distributing concrete into position.

Construction joints **6.51**

The position and details of any construction joints not specified in the Contract shall be subject to approval. Arrange the joints in such a way as to minimize the possibility of the occurrence of shrinkage and thermal cracks. Submit sample treatment of construction joints prior to work on site.

Finish the upper surface of lifts of concrete walls and columns and clean the formwork of adhering concrete before the next lift is placed.

Remove laitance and all loose material and expose the aggregate by an approved method as soon as practicable after casting, but where this shall be done by means of an air-and-water jet, or by mechanical means, minimum periods after casting of 4 hr and 12 hr respectively shall have elapsed.

Ensure the surface of the construction joint is damp, but free from ponding of water when fresh concrete is placed against it.

Formwork to construction joints shall be rigid and to accommodate projecting reinforcement without bending or displacement.

Where kickers are cast at the base of walls and columns, these shall be cast monolithically with the base slab.

If placing of concrete has to be unexpectedly stopped, form construction joints as directed by the SO.

Curing of concrete **6.52**

Immediately after compaction, protect finished concrete against harmful effects of weather, running water and drying out. Apply the protection by using one of the following methods:

(a) Cure the concrete by the application of an approved liquid curing membrane. Application shall be by means of a low-pressure spray at the rate recommended by the manufacturer. On horizontal surfaces, apply the membrane immediately after finishing the concrete, and on vertical surfaces immediately after removing the formwork.

(b) After thoroughly wetting, cover the concrete with a layer of approved waterproof paper or plastic membrane for a minimum of 4 days.

(c) Cover the concrete with a layer of fine aggregate minimum 25 mm thick, hessian, sacking, canvas or similar absorbent material. Keep this covering layer constantly wet for a minimum of 4 days.

Increase the times given above by 25% for concrete containing PFA, GGBS or PFAC.

Provide adequate amount of waterproof paper or plastic membrane to protect freshly placed concrete against heavy rain as required or directed by the SO.

Early loading **6.53**

Unless otherwise specified do not subject concrete at any time to loading which will induce a compressive stress in it exceeding 33% of its compressive strength at the time, or of the specified grade strength whichever is the least. When determining the loading, make due allowance for the self-weight of the concrete.

For the purpose of this clause, the assessment of the strength of concrete and the stresses produced by the loads shall be subject to the approval of the SO.

SAMPLE AND TESTING

Sampling of fresh concrete

6.54 Carry out sampling of concrete in accordance with the requirements given in **CS1**. Take each sample from a single batch. The location of batches to be sampled shall be decided by the SO, and the frequency of sampling for compressive strength testing and workability testing shall be as set out in Table 6.8, provided that a minimum of one sample shall be taken from each grade of concrete produced on any one day. The SO may agree to a reduced frequency of sampling for exceptionally large pours. The samples shall be taken at random times.

TABLE 6.8
Sampling rates

Type of structure	Approximate quantity of concrete to be represented by each sample
Critical structures	10 m^3 or 10 batches whichever is the smaller volume
Intermediate structures	25 m^3 or 25 batches whichever is the smaller volume
Massive concrete construction	100 m^3 or 100 batches whichever is the smaller volume

Where the type of structure is not specified, all concrete shall be deemed to be for intermediate structures.

Concrete cubes

6.55 For compressive strength testing, make, cure and test concrete cubes in accordance with **CS1**. The size of test cubes shall be 100 mm for concrete with maximum aggregate size not exceeding 20 mm and shall be 150 mm for maximum aggregate size exceeding 20 mm.

(a) Standard mixes

(i) Where a batch shall be sampled for the purpose of determining the strength of the concrete, make two cubes from a sample for test at 28 days.

(ii) The strength requirement for each pair of cubes shall be satisfied if neither of the strengths of the cubes is below the strength indicated by the grade of concrete. If the strength requirement is not satisfied, the SO may order such further testing, including chemical analysis of samples of hardened concrete in the structure, as he considers necessary.

(b) Designed mixes

(i) Make two cubes from a single sample taken from a batch of concrete selected at random. Take the sample at the point of discharge from the mixer, or, in the case of ready-mixed concrete, at the point of discharge from the delivery vehicle, or elsewhere as directed by the SO. On completion of curing for 28 days, test the two cubes. The average of the two results shall be taken as the test result.

(ii) The strength requirement shall be satisfied if the average strength determined from any group of four consecutive test results, and the individual test results comply with the strength determined from limits given in Columns A and B of Table 6.9 respectively. Where there are less than four test results available the average of the first two or first three consecutive test results shall be treated in the same manner as groups of four consecutive test results.

(iii) If the difference between the compressive strengths of two test cubes made from one sample of designed mix concrete exceeds 15% of the test result:

(1) the higher of the compressive strengths of the two test cubes shall be used to assess compliance in Column B of Table 6.9, and

(2) the test result for that sample shall not be used to assess compliance in Column A of Table 6.9 and shall not be used to calculate the standard deviation.

TABLE 6.9
Strength compliance requirements for designed mixes

Specified grade	Compliance requirement	Column A Average of any 4 consecutive test results shall exceed the specified grade strength by at least		Column B Any individual test result shall not be less than the specified grade strength by more than	
		100 mm Cube	150 mm Cube	100 mm Cube	150 mm Cube
20D and above	C1	7 MPa	5 MPa	2 MPa	3 MPa
	C2	5 MPa	3 MPa	2 MPa	3 MPa
Below 20D	C3	3 MPa	2 MPa	2 MPa	2 MPa

(c) For concrete of Grade 20D and above, calculate the standard deviation for each grade of concrete after every 40 test results. Compliance requirement C2 of Table 6.9 may be adopted under the following conditions :

(i) Where there is sufficient previous production data using similar materials from the same plant under similar supervision to establish that the standard deviation of at least 40 test results is less than 5.5 MPa for 100 mm test cubes or 5 MPa for 150 mm test cubes; or

(ii) Where the calculated standard deviation of a set of 40 consecutive test results does not exceed 5.5 MPa for 100 mm test cubes or 5 MPa for 150 mm test cubes.

(d) If the calculated standard deviation exceeds 5.5 MPa for 100 mm test cubes or exceeds 5 MPa for 150 mm test cubes, compliance requirement C1 shall apply to subsequent test results.

(e) When the following situation occurs, no further concrete shall be placed in the permanent works until an investigation of the materials, mix design, methods of production, sampling and testing has been carried out and measures, which in the opinion of the SO will result in restoring a satisfactory standard of quality control, have been taken:

(i) For concrete of Grade 20D and not exceeding Grade 60D, the calculated standard deviation exceeds 8.5 MPa for 100 mm test cubes or 8 MPa for 150 mm test cubes; or

(ii) For concrete grade exceeding 60D, the coefficient of variation as calculated after every 40 test results, exceeds 14%.

(f) If the compliance requirements are changed from C1 to C2 or from C2 to C1, the new compliance requirements shall apply from the 35th day after making the last pair of test cubes in the set of 40 on which the decision to

change was based. For the purpose of calculating the average of any 4 consecutive test results, test results immediately before and immediately after the change shall be treated separately.

(g) For concrete of grade below 20D, adopt compliance requirement C3 of Table 6.9.

(h) If the average strength determined from any group of four consecutive test results, or the first two or first three consecutive test results if applicable, fails to meet the requirement of Column A in Table 6.9, then all the concrete in all the batches represented by the samples shall be deemed not to comply with the strength requirements. For the purposes of this clause the batches of concrete represented by a group of two, three of four consecutive test results shall include the batches from which the first and last samples in the group were taken together with all the intervening batches. Provided that when there is a period exceeding two weeks between any two consecutive test results in a group, the SO may direct that the test results immediately before and immediately after the intervening period shall be treated separately.

(i) If any individual test result fails to meet the requirement of Column B in Table 6.9, then that result may be considered to represent only the particular batch of concrete from which the sample was taken, provided that the averages of any 4 consecutive results, in which the failed individual test result lies, satisfy the requirements of Column A in Table 6.9.

(j) If designed mix concrete is considered as not complying with the specified requirements for compressive strength, the SO may instruct that tests as stated in Clauses 6.57 and 6.59 be carried out on concrete cores or on samples taken from the hardened concrete.

Workability **6.56** Where a batch shall be sampled to determine the workability of the concrete, take samples in accordance with **CS1**. In all cases the sample shall be re-mixed, divided into two specimens and each specimen tested for slump or flow value in accordance with **CS1**. Unless otherwise specified, adopt the testing method for workability as below:

Normal Workability (designed slump value from 20 mm to 200 mm)	High Workability (designed flow value from 340 mm to 600 mm)
Slump Test (For designed slump value >175 mm and ≤ 200 mm, see Note to Clause 2.1.1 of **CS1**)	Flow Table Test

(a) Standard mixes:

The average of the two measured slump values shall be within the appropriate range of measured slump value specified in Table 6.3. The SO may reject any concrete for which the average measured slump falls outside the specified range.

(b) Designed mixes:

The average of the two measured slump values shall correspond to that of the accepted trial mix and fall within the limit of ±25 mm or ±33% of the designed slump value, whichever is the greater, up to the limit of ±50 mm. The average of the two measured flow values shall correspond to that of the accepted trial mix and fall within the limit of ±50 mm of the designed flow value. The SO may reject any concrete for which the average measured slump or flow value falls outside this limit.

Concrete that fails to comply with the specified requirements for workability as specified in Clause 6.56 (a) or 6.56 (b) shall not be placed in the permanent works.

Test cores **6.57**

Where specified or when ordered by the SO, take core samples from the finished concrete work for visual examination and compressive strength tests. The number and locations of the cores shall be as stated in the Contract or as instructed by the SO. The diameter of cores shall be 100 mm and 150 mm for concretes with 20 mm and 40 mm aggregates respectively.

If concrete represented by test cubes in any concreting day fails to meet the standard of acceptance specified in Clause 6.55, the SO may order the taking of twelve or any other number of core samples from the finished concrete work of the same concreting day for test at the Contractor's expense. The location of these cores shall be decided by the SO.

Complete all coring within 7 working days of the date the instruction is given by the SO.

All cores shall be drilled and tested in accordance with **CS1**.

Make good core holes to the approval of the SO with cement mortar or concrete of similar strength to that of the parent concrete.

The concrete represented by a set of twelve cores shall be deemed not complying with the specification if:

(a) The concrete core exhibits honeycombing which means interconnected voids arising from, for example, inadequate compaction or lack of mortar;

(b) The average estimated in-situ cube strength converted in accordance with **CS1** from the compressive strength of the concrete cores, less than 85% of the specified grade strength of the concrete from which the cores are taken; or

(c) Any individual core has an estimated in-situ cube strength less than 75% of the specified grade strength.

Subject to the approval of the SO, the number of cores taken may be less than 12. If the number of cores taken is less than 12, the acceptance criteria stated in Clauses 6.57(b) and 6.57(c) above are not applicable. Instead the Contractor shall propose a set of statistically equivalent acceptance criteria to the SO for agreement before the core testing.

Cores shall not be tested for strength at ages less than 28 days and no adjustment shall be made to the measured strength in respect of the age of the core when tested.

Testing and test record **6.58**

Appropriately label, mark and deliver all concrete cubes and cores to the Public Works Laboratories (PWL), as directed by the SO.

Indicate on the works test records the parts of the structure represented by the samples tested. Keep records on the Site.

Security – sampling **6.58A**

Carry out sampling for preparing concrete cubes, and/or taking core samples from the finished concrete work under the direction and supervision of the SO.

Security – before delivery **6.58B**

Keep concrete cubes and/or cores in locked curing tanks or by other approved means under the charge of the SO before delivery to the laboratory.

Security – delivery **6.58C**

Deliver concrete cubes and/or cores to the testing laboratory under close supervision of the SO or through collection service operated by the Public Works Laboratories (PWL). Other security arrangements are not permitted without prior approval by the SO.

Other tests **6.59** During the progress of the Works, the SO shall have the power to order tests other than cube tests and core tests. The details of the tests and the standard of acceptance shall be in accordance with the relevant BS and CP.

When concrete is tested either in a plastic or hardened condition by chemical analysis or other means for cement content it shall be deemed not to comply with the specification if the cement content is found to be below the specified figure after making due allowance for the accuracy of the test method employed.

Failures **6.60** If any part of the finished concrete fails to comply with the standards of acceptance specified in Clause 6.55(a) to (i), 6.57 or 6.59, the SO may instruct the Contractor to take any one of the following steps or a combination thereof as the SO considers appropriate:

(a) Adjust the mix proportion and carry out further trial mixes until a new mix proportion satisfying the requirements of Clause 6.55 is obtained and approved. Standard mix proportions shown in Table 6.3 may be used during this period.

(b) Improve the standard of quality control.

(c) Carry out, at the Contractor's expense, other tests as directed by the SO.

(d) Replace any Site concrete condemned as a result of failing to comply with the standards of acceptance specified and meet all costs arising from such replacement. Submit for approval the method statement for replacing the condemned concrete before the replacement is carried out. In certain cases, the SO may require the method statement to be prepared and the remedial work to be supervised by a Registered Structural Engineer.

MOVEMENT JOINTS

Materials **6.61** Water stops shall be an approved proprietary make with prefabricated angle and intersection pieces.

Impregnated fiberboard joint filler for roads, pavings etc. shall be an approved proprietary make.

Inorganic joint fillers, bond breakers and back-up material shall be an approved proprietary make in either sheet form, strip or cord sections.

Sealants shall be approved proprietary make and shall contain no more than 0.01% and 0.5% by wet weight of formaldehyde and total aromatic compounds (including benzene, toluene, xylenes, and ethylbenzene, etc.) respectively.

Hot applied joint sealants for concrete pavements shall be to **BS 2499-1:1993; BS 2499-2:1992; BS 2499-3:1993,** Type N1.

Cold poured joint sealants for concrete pavements shall be to **BS 5212-1:1990; BS 5212-2:1990; BS 5212-3:1990**.

Two-part polysulphide-based sealants shall be to **BS 4254:1983.**

One-part gun-grade polysulphide-based sealants shall be to **BS 5215:1986.**

Mechanical expansion joints shall be obtained from one of the specialists included in the Development Bureau List for Supply and Installation of Expansion Joints for Highway Structures.

Workmanship **6.62** Construct joints strictly as specified and in accordance with the relevant manufacturer's recommendations. Keep edges true, free from cracks, spalling or

other imperfections. Ensure that edges of joints are clean, dry and free from dust or grease.

Do not place concrete on both sides of a movement joint simultaneously.

All water stops shall be installed in accordance with manufacturer's recommendation and be securely held in position. Make all joints properly, using hot or cold vulcanizing. Prevent edge-bulbs from moving during concreting. Special care shall be taken to compact concrete around water stops such that no voids or porous areas result.

Fix joint filler to the concrete with a bituminous adhesive before casting the adjoining bay. Form a sealing slot by casting in a removable former.

Apply sealants in accordance with **BS 6213:1982**. Ensure that they are properly pressed home and finished with a smooth regular surface. Type and uses of sealant are shown in Table 6.10.

Treat surfaces with recommended primer to suit type of sealant where necessary.

Apply bond breakers and back up material where necessary.

Mix two - part sealants until the colour is uniform throughout.

TABLE 6.10
Types of Sealant

Type of sealant	Application	General use	Specific use
Oil based mastic	Applied cold by gun	Weather sealing, low movement joints	Pointing frames
Butyl mastic	Applied cold by gun or trowel	Bedding	Bedding frames and glazing
Hot applied joint sealants (**BS 2499-1:1993; BS 2499-2:1992; BS 2499-3:1993,** Type N1)	Hot poured	Horizontal and inclined joints where the degree of inclination does not exceed 1 in 20	Joints in concrete roads, car parks etc.
Cold poured joint sealants (**BS 5212-1:1990; BS 5212-2:1990; BS 5212-3:1990,** Type F)	Two part compound mixed and applied cold by gun or poured	High movement joints, resistance to fuel, oil & hydraulic fluid	Ditto but where resistance to fuel & oil is required
Two part polysulphide (**BS 4254:1983**)	Ditto	High movement joints, resistance to aging & damage, acids & alkalis	Joints in walls & floors. Sealing to precast units
One part polysulphide (**BS 5215:1986**)	Applied cold by gun	Ditto	Joints in cladding panels pointing aluminium windows glazing
One part polyurethane	Applied cold by gun	Ditto	Ditto

SUNDRY ITEMS

Water tanks **6.63**

Concrete for water tanks shall comply with the requirements in Clause 6.42. Where no predetermined construction joints are specified, cast the walls and bottom slab of each tank in one operation. Allow for fittings to be cast in and use only formwork-ties which do not leave holes through the concrete. Test the tank for watertightness by filling it up with water and leave for 3 days for absorption. Allow the water to stand for another 7 days and record the drop in water level. The watertightness test is passed if the drop is less than 1/500 the average water depth or 10 mm whichever is the least.

Watertight construction **6.64**

Where watertight construction is specified, such as basements, lift and escalator pits, ensure that the work is free from leaks. Use only formwork ties which do not leave holes through the concrete.

The blinding layer shall form a clean and dry base for the main structural slab. There shall be no loss of cement paste to, or gain of water from, the base.

If waterproof membrane sheets shall be applied, exercise special care to prepare the surface for the application in strict accordance with the manufacturers' instructions and to avoid damage to the membrane after application. The installation shall be under the supervision of a competent representative from the membrane manufacturer. The strength properties of the sheeting material shall not be less than 110 kN/m^2 in lap shear and 3.3 kN/m in lap peel under site conditions, unless otherwise approved by the SO. Construction details such as corners and joints shall be in accordance with the manufacturer's drawings or catalogues.

Provide water stops as described in Clauses 6.61 and 6.62 for all construction joints. Carefully plan the positions of the construction joints according to daily concreting progress and keep to a minimum. If ready-mixed concrete is used, it shall be supplied to the Site at regular intervals. The joint between the base slab and the walls shall be minimum 250 mm above the top of the base slab.

Ensure that ground water levels are maintained below the blinding level so that the cast concrete will not be subjected to water pressure until it has attained sufficient strength.

Carry out remedial work required to eliminate any leaks and damp patches that occur, and obtain approval of method to be used.

Mass concrete retaining walls **6.65**

Concrete for mass concrete retaining walls shall be Grade 20/40 unless otherwise specified.

Build in 75 mm diameter plastic weep pipes through the full thickness of walls, falling to the outside and spaced at 1.5 m centres both ways and staggered.

In-situ concrete slabs to roads, car parks and paved areas **6.66**

Mix, transport, place, compact and cure concrete in accordance with the relevant preceding clauses.

Cast concrete slabs in chequerboard pattern in bays of 36 m^2 (maximum) with length not exceeding 1½ times width.

Finish surfaces true to the levels, gradients, falls and cambers required.

Concrete hollow blocks for slabs **6.67**

Construct concrete hollow blocks as follows:

(a) Concrete mix shall be Grade 20/10. Cure blocks for at least 28 days before use.

(b) Outer casing and web shall be 25 mm thick. Form 25 mm x 5 mm groove along both sides for key.

(c) Compression strength of blocks shall be minimum 20 MPa measured on the net section.

Lay in straight rows with butt joints on formwork. Seal exposed open ends with similar concrete to a depth of 25 mm.

Lintels **6.68** Cast lintels in concrete Grade 20/20 either precast or cast in-situ, and construct as shown in Table 6.11.

Provide 25 mm minimum concrete cover between steel bar reinforcement and soffit.

Allow bearing of 150 mm (minimum) at each end.

TABLE 6.11
Lintels

Clear span (m)	Depth of lintel (mm)	No. and diameter of steel reinforcing bars per 105 mm (or part) in width
0 - 1	150	One 12 mm
1 - 2	225	One 16 mm
2 - 3	300	One 20 mm

Underlays **6.69** Underlays to concrete pavings and slabs on recycled rock fill shall be:

(a) Subsoil grade reinforced waterproof building paper to **BS 1521:1972**, grade B1F; or

(b) 65 μm to 80 μm polythene sheet.

Lap underlays 150 mm at joints.

Concrete blinding **6.70** Provide 50 mm blinding layer of Grade 10/20 concrete to underside of all reinforced concrete works in contact with earth.

FINISHES FOR CONCRETE

Samples **6.71** Provide samples of at least 1 m^2 of any exposed formed or worked finishes required, and obtain approval.

Fair-faced finish **6.72** Fair-faced finish shall be produced as follows:

(a) Obtain an even finish with a sheet material (e.g. plywood).

(b) Arrange panels in pattern as specified.

(c) The finished surface shall be left as struck. Do not make good until inspected by the SO.

(d) Blowholes not exceeding 10 mm diameter will be permitted, but otherwise surface shall be free from voids, honey-combing or other large defects.

(e) Variations in colour will be permitted when the finished concrete is to receive an applied decoration.

(f) Make good small defects, and fill blowholes and formwork-tie holes with mortar.

Rough board finish **6.73** Rough board finish shall be produced as follows:

(a) Formwork or formwork linings to consist of approved rough textured seasoned wood boards with moisture content of between 10% and 20%.

(b) Arrange boards of varying textures to give uniform overall effect.

(c) Assemble boards to prevent penetration of grout between them.

(d) Soak formwork with water before erecting, and keep damp until concrete is placed.

(e) Position cover spacers and bolts to the satisfaction of the SO.

(f) The number of uses of formwork lining shall be limited to its ability to provide the required finish.

(g) The finished surface shall be left as struck. Do not make good until inspected by the SO. Fill minor voids and irregularities on surfaces with a matching mortar to approval, using a sponge rubber faced float.

(h) Discolouration will not be permitted.

Worked surface finishes **6.74** Surface of concrete after casting shall be finished with one of the following surface finishes, level or to falls and currents as specified:

(a) Wood float to give an even textured surface.

(b) Steel trowel or power float to give a smooth untextured surface.

(c) Scratch with a stiff brush to give a slightly roughened even texture.

(d) Tamp with the edge of a board to give an even texture of parallel ribs.

(e) Other finishes as specified and executed in an approved manner.

Do not wet the surface to assist working and do not add cement to produce the specified finish without approval.

Applied surface treatments **6.75** Where specified the wearing characteristics of concrete shall be enhanced by one of the following:

(a) Mixing the concrete with an approved hardening admixture in accordance with the manufacturer's recommendations.

(b) Applying an approved liquid surface hardener in accordance with the manufacturer's recommendations.

(c) Applying an approved metallic or mineral surface treatment in accordance with the manufacturer's recommendations.

TABLE 6.12
Chemical Limits for Combined Water (Recycled water and tap water) for each batching plant

Description	Limits	Test method	Test frequency
Physical test			
(a) Density test for recycled water	≤ 1030 kg/m^3	Note 1	At least once per day
(b) Initial setting time of cement with recycled water (time of set, deviation from control, hr:min)	From 1:00 earlier to 1:30 later	**BS EN 196-3:2005+A1:2008**	Once every 3 months for the first year and thereafter at half-yearly intervals
Chemical test for recycled water			For all tests: (i) Once per week for the first 2 months (ii) Once per month for the next 12 months thereafter (iii) In case of a weekly or monthly test indicates that the limits are exceeded, the water shall immediately be suspended for use in concrete mixing until two sets of consecutive test results taken from the same source are satisfactory. In such case, the testing frequency shall be maintained at or reverted back to once per week until two sets of consecutive test results are satisfactory. (iv) The testing frequency shall be subject to review after the 12-month period for the monthly test.
(a) Chloride content (as $C\bar{l}$): - prestressed concrete steam-cured structural concrete	500 ppm	**APHA 4500-CL-B 21st Edition (2005)**	
- concrete with reinforcement or other embedded metal	1,000 ppm	**APHA 4500-CL-B 21st Edition (2005)**	
(b) Sulphate content (as SO_4)	3,000 ppm	**APHA 4500-SO42 C 21st Edition (2005)**	
(c) Acid-soluble alkali content	600 ppm	**BS EN 1008:2002**	

Notes: 1. Test method to be proposed by the Contractor for the acceptance of the SO.
2. Accredited Laboratory for the relevant tests shall be used, if available, in which case results shall be issued on HOKLAS endorsed test reports.
3. Where ppm means part per million by mass

TABLE 6.13
Recycled coarse aggregate

Mandatory Requirements	Limits	Testing Method
Minimum dry particle density (kg/m^3)	2000	Section 17 of **CS3**
Maximum water absorption	10%	Section 17 of **CS3**
Maximum content of wood and other materials less dense than water	0.5%	Manual sorting in accordance with: BRE Digest 433
Maximum content of other foreign materials (e.g. metals, plastics, clay lumps, asphalt and tar, glass.)	1%	
Maximum content of fines	4%	Section 10 of **CS3**
Maximum content of sulphate (% m/m)	1%	Section 21 of **CS3**
Flakiness index	40%	Section 11 of **CS3**
10% fines test	100 kN	Section 16 of **CS3**
Grading	Table 3.1 of **CS3**	
Maximum chloride content	Table 5.1 of **CS3** – 0.05% by mass of acid soluble chloride ion of combined aggregates	

Regulations, Ordinances, etc. **6.76** Comply with all relevant legislation, Codes of Practice and Practice Notes listed in Clause 2.1.

SECTION 7

PRESTRESSED CONCRETE WORK

GENERAL

Generally **7.1** The use of prestressed concrete shall be to **Code of Practice for Structural Use of Concrete** issued by the Buildings Department.

Supervision **7.2** Carry out prestressed work under the direction and supervision of fully competent personnel with previous experience in the particular type of work involved. Submit particulars of the personnel for approval.

Safety Precautions **7.3** Take all necessary precautions and adopt working procedures that ensure the safety of workmen and other persons in the vicinity during tensioning. Secure jacks in such a manner that they will be effectively restrained should they lose their grip on the tendons.

CONCRETE

Concrete **7.4** All concrete work shall be in accordance with Section 6 of the GS.

GROUT

Material **7.5** Cement shall be Portland Cement.

Admixture shall be approved by the SO and shall contain no chloride, nitrate, sulphate, or aluminium powder.

Properties **7.6** Grouts shall be non-shrink, low bleeding in the plastic state and be fluid.

Tests for bleeding or grout settlement shall be made at ambient temperature on 100 mm deep samples contained in 100 mm diameter airtight vessels. The upper surface of the cement particulars shall not settle more than 2 mm after 3 hr or 4 mm maximum. Any water separated at the surface shall be re-absorbed within 24 hr.

Tests for fluidity shall be by the measurement of the time for L of grout to flow from a funnel or flow cone. A flow cone with a 10 mm outlet pipe with a water outflow time of 5 s may be used. With this cone, grouts shall have the outflow times between 12 s to 25 s.

Mix proportions of grout **7.7** Water/Cement ratio shall not exceed 0.4.

Quantity of sand/filler used shall not exceed 30% of the mass of cement.

Admixtures shall be used as recommended by the manufacturer and shall be free of any chemical liable to promote corrosion of the tendon or cause damage to the grout.

If gas-producing expanding agents are used, the total unrestrained expansion shall not exceed 10% at ambient temperature.

Chlorides from all sources, i.e. cement, water, sand, filler and admixture shall not exceed 0.1% by mass of the cement.

Trial mixes of grout **7.8** Trial mixes shall be completed 35 days before the grout mix is used in permanent work.

Carry out trial mixes to determine the mix proportions to provide the required viscosity, strength and other required properties, taking into account the ambient temperature and any other relevant factors.

Make three separate batches of grout under conditions similar to those used for production of grout in the Works and use materials typical of the proposed supply.

Make six 100 mm cubes from each batch for testing, three at 7 days and three at 28 days. Cubes shall be cured and tested in accordance with Clause 6.55.

Trial mix proportions will be approved if the average strength of the nine cubes tested at 28 days exceeds 35 MPa and the properties of the trial mix comply with Clause 7.6.

Notwithstanding approval of the trial mix, the SO may require further trial mixes where circumstances change or inconsistent workmanship is observed.

PRESTRESSING TENDONS

7.9 Low relaxation prestressing tendon shall be as follows, unless otherwise specified:

(a) Round cold drawn high tensile single steel wire to **BS 5896:1980** with plain finish.

(b) Seven wire steel strand to comply with **BS 5896:1980**.

(c) High tensile steel bars to **BS 4486:1980** comprising open hearth steel with sulphur and phosphorous contents each below 0.05%.

All wire and strand shall be in the stress-released or stabilised condition.

Manufacturer's test certificates **7.10** Provide in respect of each consignment of tendon supplied to the site, a manufacturer's certificate showing that the material supplied complies with the relevant BS. The certificate shall contain all the data specified to be included in manufacturer's certificate by the relevant BS.

Provide in addition a manufacturer's certified stress-strain curve for every 20 coils of wire and strand.

Test specimens **7.11** Provide test specimens of sufficient length for the specified test, for each type and size of tendon required by the SO. The rate of sampling and the tests to be carried out are as follows:

Type of tendon	Sampling rate	Test
Wire	One sample from every 5 coils or part thereof	Tolerance on diameter, tensile test & reverse bend test
Strand	One sample from every 5 coils or part thereof	Tensile test and elongation test
Bar	One sample from every 5 t or part thereof	Tensile test

Surface condition **7.12** Tendon shall be free from grease or other material likely to impair bond and shall not be rusted to a degree that has produced pitting visible to the naked eye. Longitudinal surface defects not exceeding 4% of nominal wire, strand or bar diameter are acceptable.

Straightness **7.13** Transport wire and strand in coils of sufficiently large diameter to ensure that the steel runs off straight.

Cutting **7.14** Cut to length and trim ends of tendon using a high speed abrasive cutting wheel, friction-saw or other approved mechanical methods.

Do not cut post-tensioned tendons less than one diameter from the anchorage.

Welding **7.15** Do not weld close to the tendons or anchorage.

Defects **7.16**

Do not allow tendon to be kinked or twisted. Ensure that individual wires or strands can be readily identified at each end of the member.

Do not use tendon where any strand has become unravelled from the composite unit.

Reject and remove from the Site any materials which reveal defects during or prior to their installation in the Works.

Joints **7.17**

Joints shall be made using couplers fixed in accordance with manufacturer's recommendations.

DUCTS

Ducts **7.18**

Ducts for prestressing tendons shall be an approved proprietary type with permanent sheathing or extractable core. All ducts shall be:

(a) Strong enough to withstand all forces acting on them during construction.

(b) Impervious, to prevent penetration of laitance which might subsequently hinder the movement of the tendons.

(c) Rigidly supported at 450 mm centres maximum.

Sheathing **7.19**

Provide sheathing with a profile that gives a strong bond with the outside concrete and inside grout but does not cause undue friction or resistance to the tendons during stressing.

Keep joints to the minimum practicable. Joints shall be formed using sleeve connectors, adequately sealed against ingress of any material. Stagger joints in adjacent sheathings by 300 mm minimum.

Extractable cores **7.20**

Do not coat extractable cores with any release agent unless approved.

Retain extractable cores for a minimum period of 24 hr or until the concrete has hardened sufficiently.

Grout vents **7.21**

Grout vents for entry and outlet points shall have:

(a) An internal diameter of 20 mm minimum.

(b) Approved connections suitable for the attachment of the feed from the grout pump.

(c) High pressure taps or similar approved taps which permit their closure without reducing the pumping pressure.

Obtain approval of the number and position of grout vents for entry and outlet points before ducts are fixed in position.

No grout vents shall be provided at an interval greater than 15 m.

ANCHORAGES

Anchorages **7.22**

Anchorages shall be of an approved proprietary type to **BS EN 13391:2004**, capable of distributing the stress evenly in the end blocks. Anchorages shall maintain the prestressing force under both sustained and fluctuating loads and be able to withstand the effect of external shock with minimum movement of the tendon.

Clean all bearing surfaces of the anchorage prior to concreting and tensioning.

Provision shall be made for the protection of anchorages against corrosion.

Manufacturer's test certificates **7.23** Provide a manufacturer's test certificate for all anchorages supplied to the Site in accordance with Section 6 of **BS EN 13391:2004**.

JACKS

Jacks **7.24** Jacks and other equipment used for prestressing shall be a type and of capacity suitable to the system adopted.

Maintenance **7.25** Provide documentary proof that jacks have been properly maintained and checked by an agent approved by the manufacturer of the equipment within a period of two years prior to the commencement of stressing.

Measurement equipment and test certificate **7.26** Use direct-reading load cells or an indirect reading system e.g. gauges fitted in the hydraulic system to determine the pressure in the jacks for measuring the stressing load. Test measuring equipment, calibrate to an accuracy within ±2% and provide a calibration certificate issued by an approved testing laboratory once every 6 months.

Pressure gauges **7.27** Calibrate pressure gauges against the load cell before stressing where these are used as load indicators. The working pressure required to stress tendons to the specified load shall lie within the central half of the range of the gauge.

TOLERANCES

Generally **7.28** Do not exceed any tolerance specified e.g. relaxation of steel, line of sheathing, anchorage set, frictional losses during stressing.

Justification of proposed tolerances **7.29** Submit for approval information or literature to substantiate tolerances proposed.

Carry out tests to justify the tolerance, if so required by the SO.

Deviation from specified tolerances **7.30** Modify the design to comply with the specified tolerance when a proposed tolerance deviates from that specified. The revised design shall be approved by the SO.

FIXING DUCTS AND TENDONS

Profile of ducts **7.31** Submit details showing the profile of the ducts for approval prior to the fixing of the ducts.

Determine the profile of the ducts such that the final position of the tendon after stressing complies with the drawings.

Sealing ducts **7.32** Temporarily seal the ends of all ducts until the tendons are threaded through and stressing is commenced.

Placing of tendons **7.33** Carefully assemble and place or insert prestressing tendons in the positions indicated on the drawings with no crossings, sharp bends, kinks and the like.

The centre of the duct shall be maintained at all times such that it does not deviate from the designed position by more than 5 mm in any direction.

Ducts free from laitance **7.34** Demonstrate to the satisfaction of the SO that tendons are free to move in the ducts or that the ducts are free from obstruction.

STRESSING

Concrete strength and transfer **7.35** Ensure concrete in post-tensioned work has attained at least 80% of its characteristic strength before tensioning commences.

Prepare concrete test cubes to ascertain the time at which transfer may be made.

The time for transfer will be determined by the successful testing of a batch of minimum three test cubes. If the initial batch of cubes tested indicate that the concrete has not attained the required strength a further batch of cubes shall be tested at a later date. This process will be repeated until a batch of cubes successfully passes the strength test.

Submit the results of strength testing for approval.

Stressing **7.36** Stress prestressed elements at the designated ends.

The sequence of stressing shall be as specified or as directed by the SO.

Stress tendons at a gradual and steady rate without interruption until they attain the specified load.

Stress simultaneously at both ends when two end stressing, in stages as directed and carry out de-wedging consecutively.

Give the SO a minimum of 3 days' notice before stressing.

MEASUREMENT OF FORCE

Duct friction **7.37** Before the actual stressing, the SO may order a reasonable number of tests to be carried out to ascertain the amount of duct friction. The details of such tests shall be agreed by the SO and will generally consist of stressing a tendon from one end and attaching a jack to the other end capable of measuring the load transmitted to it by the tendons.

Extension of tendons **7.38** Provide approved facilities for the measurement of the extension of the tendons and of any movement of the tendons in the gripping devices.

Provide a comparison between the measured tendon force and that calculated from the extension. Carry out approved remedial work where the difference exceeds 6%.

If the extension of a tendon deviates substantially from the anticipated value during the initial stage of stressing, the SO may require the tendons to be stressed incrementally and the extension shall be measured and recorded for each increment of load.

Record **7.39** Submit for approval, records in the format and quantity as required by the SO, of the extension of, and jacking forces for, all tendons.

Format of record shall contain the following details:

(a) Location of tensioning operations.

(b) Coil, heat and bundle numbers of strand used.

(c) Date and time of starting and completing tensioning operations.

(d) Technical personnel supervising or carrying out tensioning.

(e) Prestressing tendon reference no.

(f) Tensioning apparatus identification.

(g) Measured extensions.

(h) Pressure gauge or load cell readings.

(i) Amount of draw-in.

GROUTING

Generally **7.40** Grout ducts for bonded tendons as soon as practicable and in no case more than 5 days after tensioning in such a manner as to fill the void surrounding the tendons completely with neat cement grout.

Grouting equipment **7.41** Mixing equipment shall be of a type capable of producing a grout of colloidal consistency, whilst imparting only a slow motion to the body of the grout.

Injection equipment shall be capable of continuous operation with minimal variation of pressure and shall include a system for recirculating grout when grouting operations are interrupted. Injection delivery pressure shall generally not exceed 1 MPa. Baffles to the pump shall be fitted with 1.18 mm sieve strainers

All equipment shall be thoroughly washed through with clean water at either the completion of each series of operations or after 3 hr have elapsed since the previous cleaning, whichever is the shorter period.

Cleaning ducts **7.42** Thoroughly clean ducts formed with sheathings using compressed air before grouting.

Fill ducts formed without sheathings with water for at least one hr and subsequently blow water out with compressed air before grouting.

Mixing **7.43** Mix grout for a minimum of 2 min and not more than 4 min until uniform consistency is obtained.

Grouting **7.44** Grouts shall be used within 30 min of mixing unless a retarder is incorporated in the grout.

Do not commence grouting without prior approval.

Seal anchorages before grouting.

Inject grout in one continuous operation and allow it to flow from the vents until its consistency is equivalent to that of the grout injected. Seal the vents consecutively in the direction of flow.

Seal and pressurize the system to 0.5 MPa for 5 min upon completion of grouting.

Grouted ducts shall not be subjected to shock or vibration within 24 hr of grouting.

Records **7.45** Prepare records of grouting operations in the format and quantity as required by the SO. Records shall include the following:

(a) Date when each duct was grouted.

(b) Mix proportions of the grout.

(c) Details of admixture introduced.

(d) Pressure applied.

(e) Details of any interruptions.

(f) Location of grouting.

(g) Supervising staff.

(h) Grout injection pressure.

(i) Volume of grout used.

Submit these records to the SO within 3 days of completing the relevant grouting.

PROTECTION OF TENDONS AND ANCHORAGES

Recesses **7.46** Form recesses where shown at the prestressing anchorages in all end blocks in accordance with the prestressing manufacturer's recommendation.

The size of the recesses shall be sufficient to provide a minimum of 25 mm cover, measured from the finished face of the end block to the anchorage head and protruding cropped prestressing tendons.

Protection **7.47** Fill recesses with dense concrete secured to the structural concrete by wire or binders projecting from the recesses after completion of stressing, grouting and cropping of prestressing tendons.

Handling and storage of tendons **7.48** Prestressing tendons shall not be subjected to rough handling, shock loading or dropping from a height. All prestressing components shall be handled in accordance with the manufacturer's recommendations. Prestressing tendons and sheaths shall be stored off the ground on level supports and in a manner which will not result in damage or deformation to the material or air contamination of materials.

PRECAST PRESTRESSED MEMBERS

Storage **7.49** Firmly support precast prestressed members during storage at such bearing positions as will ensure that the stresses induced in them never exceed the permissible design stresses.

Lift or support such members only at the points specified. Handle and place without impact.

PRETENSIONED MEMBERS

Debonded tendon **7.50** Cover tendons with sleeves of PVC or other approved material where these are specified as debonded from the concrete. Tape ends of the sleeves to the tendon to prevent the ingress of grout.

Tensioning **7.51** Stress tendons in accordance with the requirements for post-tensioning unless otherwise agreed by the SO.

Pretensioning proposal **7.52** Submit proposals for pretensioning for approval prior to undertaking pretensioning work. Provide full details of the proposed tensioning-bed, jacks and fixing equipment.

Ensure that the tendons are maintained in their correct positions during concreting by providing tensioning-beds with sufficient locator plates. Where a number of moulds are positioned in line, they shall be free to move in the direction of their length, and thus permit the transfer to the prestressing force to the concrete along the whole line.

Temperature **7.53** When the temperature of the pretensioning steel is below 10°C at the time of tensioning, steel elongation computations shall allow for the increase in temperature of the steel between the time of tensioning and the time when the concrete takes its initial set.

Concrete strength and transfer **7.54** Transfer the load gradually when the concrete has attained the required strength as specified in Clause 7.35. Agree the order of release with the SO.

Trim tendons flush with the face of the concrete and apply the specified protection to their ends.

Marking **7.55** Indelibly mark members to show the following:

(a) Member reference.

(b) Production line on which they were manufactured.

(c) Date on which the concrete was cast.

(d) Load applied.

(e) The face which will be uppermost when the member is in its correct position in the Works where members are of symmetrical section.

Locate markings so that they shall not be exposed to view when the Works are completed and the members are in their final positions.

LOADING TEST

Generally **7.56** Loading tests shall be required as a check on structures or parts of structures when:

(a) There is doubt regarding the strength or deformation of members under load.

(b) Specified in the Contract.

(c) Ordered by the SO.

(d) Required to check the concrete quality control in precast prestressed members as Clause 7.57 hereunder.

Precast prestressed elements **7.57** Carry out a load test on one element, selected at random by the SO, when the 28-day cube strength for concrete used in the same batch as the selected element fails to comply with the specification. Arrange for the loading test on precast prestressed elements to be carried out by an approved independent testing firm, using their own equipment. Provide the necessary labour and attendance.

Remove the element tested if the load test fails, and prove to the satisfaction of the SO that other elements from the same batch are acceptable by carrying out further load tests.

Age of concrete **7.58** Carry out all tests as soon as possible after 28 days from the time of placing the concrete.

Test Loads **7.59** The test load shall be equal to the sum of the total dead load plus 1.25 times the total imposed load specified for the element in the Contract. The load shall be maintained for a period of 24 hr.

Testing arrangement **7.60** Submit details of the proposed arrangement for the loading test for approval prior to commencing the test.

Support the element under test on rigid supports at its designed points of bearing.

Apply test load gradually to the element in the approved stages.

Measurement **7.61** Measure deflection at the mid-span of the elements:

(a) Before application of the test load.

(b) Immediately after application of the test load.

(c) At the end of the 24-hour period for loading.

(d) After removal of the test load.

(e) After a 24-hour recovery period.

Deflection shall be measured at the mid-span relative to a line joining the supporting points. Take sufficient measurements to enable side effects to be taken into account.

Test records **7.62** Provide test records in the format and quantity as required by the SO. Records shall include the following:

(a) Age of the element at the time of the test.

(b) Total load applied and increments of load adopted.

(c) Deflection.

(d) Load/deflection curves with time.

(e) Calculated value of Young's modulus of elasticity.

(f) Temperature and weather conditions prevalent throughout the test.

Assessment of results **7.63** The prestressed element shall be deemed to have failed to comply with the strength requirement if any of the following conditions occur:

(a) Visible cracks occur under the test load.

(b) Maximum deflection due to applied load exceeds l/500 of the effective span.

(c) After the 24-hour recovery period, the recovery of deflection is less than 85% of the maximum deflection.

SECTION 8

CONCRETE FOR MINOR AND NON-STRUCTURAL WORK

Formwork **8.1** Construct and remove formwork and falsework as Clauses 6.1 to 6.12.

Reinforcement **8.2** Steel reinforcement shall be as Clauses 6.14 to 6.16 and Clauses 6.18 to 6.25.

Provide, if so instructed by the SO, test specimens of steel reinforcement as Clause 6.17.

Cement **8.3** Portland Cement shall be to **BS EN 197-1:2011** (Type CEM I). Strength Class of cement used in structural concrete shall be 52.5 N, unless otherwise approved by the SO.

Aggregate **8.4** Provide coarse aggregate of 20 mm nominal maximum size with grading within limits as defined in **CS3** and fine aggregate with grading lying within the limits of Grading C or M. Natural sand shall not be used in production of concrete unless otherwise agreed by the SO.

Aggregates, if so instructed by the SO, shall be subject to sieve analyses to **CS3**.

Water **8.5** Water shall be as Clause 6.35.

Admixtures **8.6** Admixtures shall comply with **BS EN 934-2:2009+A1:2012**. Use strictly in accordance with the manufacturer's recommendations.

Delivery and storage **8.7** Store bagged cement in a dry weatherproof store with a raised floor.

Store aggregates of different sizes in separate stockpiles and keep free from contact with deleterious matter.

Remove from the Site immediately any materials failing to meet the requirements of the GS.

Testing of materials **8.8** Testing of materials shall be as Clause 6.39.

Mixes **8.9** The grade of prescribed mix concrete shall be denoted by the minimum 28-day cube strength in MPa and the nominal maximum size of aggregate in mm with suffix “P”.

The mix proportions used shall be as Tables 8.1 and 8.2 for batching by weight and batching by volume respectively.

The maximum free water/cement ratio shall be 0.7.

TABLE 8.1
Batching by weight

Grade	Material	Batch weights (kg)	
		for approx. one cubic metre yield	for one-bag cement mix
10 P	Cement Fine aggregate 20 mm coarse aggregate	255 835 1065	45 145 185
20 P	Cement Fine aggregate 20 mm coarse aggregate	345 725 1105	45 95 145

TABLE 8.2
Batching by volume

Grade	Material	Batch volume (litres)	
		for approx. one cubic metre yield	for one-bag cement mix
10 P	Cement Fine aggregate 20 mm coarse aggregate	6 bags 575 725	1 bag 100 125
20 P	Cement Fine aggregate 20 mm coarse aggregate	8 bags 540 770	1 bag 70 100
Each bag of cement shall be 45 kg.			

Batch mixing **8.10** Mix concrete by machine where practicable. Hand mixing, on prepared platforms to prevent picking up rubbish and defacement of surfaces, may be permitted by the SO for small quantities. The SO may require tests to demonstrate that the methods of hand mixing will achieve adequate and consistent mixing of the constituents.

Do not remix partially hardened concrete.

Ready-mixed concrete **8.11** Ready-mixed concrete may be used. The batched quantities shall comply with Table 8.1.

Transport and placing **8.12** Transport and place concrete using a method which ensures that there is no contamination, segregation or loss of the constituent materials.

Clean all areas where concrete shall be placed and render free from standing water.

Do not place concrete in any part of the structure until approval has been given.

Compact concrete in its final position within 2½ hr of the introduction of cement to the mix, and within 30 min of discharge from the mixer. Concrete, which in the opinion of the SO, is no longer sufficiently workable shall be rejected.

Deposit concrete in horizontal layers to a compacted depth not exceeding 450 mm where internal vibrators are used or 150 mm in all other cases.

Do not allow concrete to free fall in excess of 2.7 m, unless otherwise agreed by the SO.

Compaction **8.13** Compact concrete to produce a dense homogeneous mass. Do not apply vibration by way of the reinforcement.

Construction Joints **8.14** The position and details of any construction joints not specified in the Contract shall be subject to approval. Allow such joints to minimise the possibility of the occurrence of shrinkage cracks.

Remove laitance and all loose material from the construction joints and expose the aggregate as soon as practicable after casting to provide adequate bond to subsequent concrete.

Ensure the surface of the construction joint is dry and free from debris when fresh concrete is placed against it.

Protection of immediately finished concrete **8.15**

Immediately after compaction, protect finished concrete against harmful effects of weather, running water and drying out. Apply the protection by either:

(a) Application of a liquid curing membrane.

(b) Covering with plastic sheets/wet sacks.

(c) Flooding with water.

Protection shall be maintained for a minimum period of 4 days.

Acceptance **8.16**

Regular strength and slump testing shall not be used to judge compliance, although the SO may require these and other tests as specified in Clauses 6.57 and 6.59 to be undertaken from time to time.

Where tests are required, compressive strength testing shall be in accordance with **CS1** and the acceptance criteria shall be as for standard mixes in Clause 6.55 (a). Slump testing shall be as Clause 6.56 and the average of the two measured slump values shall be within the range 75 - 135 mm.

Appropriately mark and deliver all concrete cubes to the Public Works Laboratories (PWL) as directed by the SO.

Failure **8.17**

If any concrete fails to comply with Clause 8.16, the SO may instruct the Contractor to take any of the following steps or a combination thereof as are considered appropriate:

(a) Improve the standard of quality control.

(b) Carry out other tests as directed by the SO.

(c) Replace any concrete condemned as a result of failing to comply with the standards of acceptance specified and meet all costs arising from such replacement.

In-situ concrete slabs to roads, car parks and paved areas **8.18**

Provide in-situ concrete slabs as Clause 6.66.

Underlays **8.19**

Provide underlays as Clause 6.69.

Concrete blinding **8.20**

Provide concrete blinding as Clause 6.70.

Finishes for concrete **8.21**

Provide exposed formed or worked finishes as Clauses 6.71 to 6.75.

Prescribed mix concrete with 100% recycled coarse aggregates **8.22**

When specified, concrete with 100% recycled coarse aggregates shall be applicable to prescribed mix concrete of 20 MPa grade strength and shall be used only in benches, stools, planter walls, concrete mass walls and other minor concrete structures, in compliance with Section 8 and subject to the followings which shall take precedence in case of discrepancies:

(a) Recycled coarse aggregates shall be produced by crushing old concrete and shall meet the requirements in Table 6.13.

(b) Fine aggregates shall be as defined in the GS.

(c) Fine aggregates recycled from old concrete shall not be used.

(d) The grading of the coarse aggregates shall comply with the limits as defined in the GS for single-sized 20 mm and 10 mm aggregates.

(e) Concrete shall be mixed in the following proportions:

Portland Cement	:	100 kg
Fine Aggregate	:	180 kg
20 mm Coarse Aggregate	:	180 kg
10 mm Coarse Aggregate	:	90 kg

(f) Recycled coarse aggregates shall be thoroughly wetted before being used.

(g) The concrete shall have a minimum slump of 75 mm when it is ready to be compacted to its final position.

(h) 4 concrete cubes shall be made on each concreting day, 2 for crushing tests at 7 days and the other 2 for crushing tests at 28 days. The minimum concrete cube strength shall be 14 MPa and 20 MPa at 7 and 28 days respectively.

(i) Before any concrete is produced for use in the works, trial mixes shall be performed in accordance with the GS. The 28-day strength of each of the 3 cubes in the trial shall not be less than 26 MPa.

(j) Natural aggregates shall be used in lieu of the recycled aggregates in case of supply shortage of recycled aggregates.

Regulations, Ordinances, etc. **8.23** Comply with all relevant legislation, Codes of Practice and Practice Notes listed in Clause 2.1.

SECTION 9

BRICKWORK AND BLOCKWORK

GENERAL

Generally **9.1** Brickwork and blockwork to be in accordance with **PD 6697, BS EN 1996-1-2, BS EN 1996-2** and **BS EN 1996-3**.

MATERIALS

Bricks **9.2** Clay bricks shall be well burnt, hard, sound, square, clean and approved. Bricks with high sulphate content should be rejected. Bricks for fair faced works to be "selected", being picked for evenness, texture, sharpness of arrises and uniformity of colour. Any "cracked" bricks should be rejected.

Brick size to comply with National Annex of **BS EN 771-1,** Table NA.1 with Work size to be 215 x 102.5 x 65 mm and Coordinating size to be 225 x 112.5 x 75 mm, or other dimensions subject to approval by the SO.

The content of heavy metals or their compounds in the product shall not exceed below levels:

(a) Cadmium: 1 mg/L

(b) Lead: 5 mg/L

(c) Arsenic: 5 mg/L

(d) Mercury: 0.2 mg/L

(e) Hexavalent Chromium: 5 mg/L

Facing bricks **9.3** Facing bricks to have the following properties in accordance with **ASTM C216**:

(a) Compressive strength, the average compressive strength of 5 bricks must exceed 20.7 MPa; while the individual should not be less than 17.2 MPa;

(b) Saturation coefficient cannot exceed 0.78;

(c) Chippage, 85% to 100% of the brick can have chips that are measured from an edge that range between 0 to 7.9 mm and measured from a corner that range between 0 to 12.7 mm. No more than 15% of the brick can have chips that are measured from an edge that range between 7.9 to 11.1 mm and measured from a corner that range between 12.7 to 19.1 mm. The cumulative length of the chips around the perimeter edges of face cannot exceed 10% of the perimeter length;

(d) The faces shall be free of cracks or imperfections when viewed from a distance of 6 m.

Engineering bricks & loadbearing bricks **9.4** Engineering bricks and loadbearing bricks to be HD Type bricks to **BS EN 771-1** and comply with National Annex to **BS EN 771-1,** Table NA.6 (Class A: 125 N/mm^2 and Class B 75 N/mm^2, having absorption limits 4.5% and 7% respectively).

Fire bricks **9.5** Fire bricks to be fire clay refractory bricks of specified class of the best quality, light in colour, uniform in texture and of standard sizes to **BS 3056-1**. Testing, if specified, shall be to **BS 1902-3.13** or **ISO 12678-2**.

Concrete bricks and blocks **9.6**

Concrete bricks and blocks to be to **BS EN 771-3** & **BS EN 772-2.** The mean compressive strength to be not less than 7.0 MPa. Concrete bricks to be of the same size as clay bricks.

Concrete blocks to be of the thickness specified and other dimensions as approved.

Concrete bricks or blocks for fair face work to be "selected", being picked for evenness, texture and sharpness of arrises.

The content of heavy metals or their compounds in the product shall refer Clause 9.2.

Concrete hollow block **9.7**

Same as in Clause 9.6, except that the mean compressive strength to be not less than 5.0 MPa of the gross area.

Glass blocks **9.8**

Hollow glass blocks to be hermetically sealed hollow units made of clear, colourless glass with a polyvinyl butyral edge coating, manufactured strictly in accordance with **BS EN 1051-1**, to a single compressive strength value of not less than 6 N/mm² and an average value of not less than 7 N/mm².

Samples **9.9**

Submit samples of each type of brick or block, and obtain approval before placing orders with suppliers.

Damp proof courses **9.10**

Damp proof courses to be 2 layers of 2-ply bituminous paper, or of other types, to **BS 6398, BS 6515** and **BS 8215**. Do not use hessian based types of bitumen damp proof courses.

Wall ties **9.11**

Ties for cavity walls to be formed 20 x 3.2 mm galvanised steel flats and to be vertical twist type to **BS EN 845-1+A1**, except that the overall length of the ties shall be minimum 100 mm longer than the width of the specified cavity.

Ties between ends of walls and concrete to be one of the following:

(a) 6 mm diameter steel rods 350 mm long, painted with 2 coats of bituminous paint.

(b) 20 x 3 mm galvanised steel flats 350 mm long, fanged at both ends.

Strips of approved brickwork reinforcement 350 mm long of the following widths:

(i) For 100-105 mm walls, 60 mm
(ii) For 200-225 mm walls, 110 mm

Where strips are to be fixed by shot firing, the length may be reduced subject to approval.

Ties for walls built against face of concrete to be formed from 20 x 3 mm galvanised steel flats 150 mm long, fanged at both ends.

Cement **9.12**

Cement to be as Clause 6.27.

Water **9.13**

Water to be as Clause 6.35.

Sand **9.14**

Sand to be clean, hard, durable crushed rock or clean sand to conform to the grading limits set out in Table 9.1

TABLE 9.1
Grading

BS Sieve	% by weight passing BS sieves
5.00 mm	100
2.36 mm	90-100
1.18 mm	70-100
600 µm	40-100
300 µm	5-70
150 µm	0-15

Sand, other than the 5.00 mm size, whose grading falls outside the limits set out in Table 9.1 by a total amount not exceeding 5% may be accepted. The quantities of clay, fine silt and fine dust present when determined by the methods given in **BS EN 932-1, BS EN 932-6** and **BS EN 933-7** shall not exceed 10% by weight. Sand for fair faced works to be free from salt causing efflorescence.

Lime **9.15** Lime to be hydrated lime to **BS EN 459-1**, delivered in sealed bags bearing the manufacturer's name or brand.

Lime putty **9.16** Prepare lime putty as **PD CEN/TR 15123, BS EN 13914-2** and **BS 8481** by adding hydrated lime to water, and mix to a thick, creamy consistency. Leave undisturbed for 16 hours (minimum) before use.

Plasticiser **9.17** Plasticiser to be an approved proprietary brand to **BS EN 934-3**.

WORKMANSHIP

Handling **9.18** Unload and handle bricks and blocks without soiling, chipping or subjecting to other damage.

Storing **9.19** Stack bricks and blocks on level hard-standings, protect from damage and contamination.

Where blockwork to be used for acoustic wall, the concrete block to be cured for 28 days minimum after manufacturing before use.

Brickwork & blockwork reinforcement **9.20** Where specified, provide expanded metal lathing or mild steel rods of specific size, galvanised or painted with 2 coats of bituminous paint as brickwork reinforcement.

Provide galvanised expanded metal strip or other materials to the SO's approval, to blockwork at every 4 courses of the following widths:

(a) For 100 – 105 mm walls, 60 mm

(b) For 299 – 225 mm walls, 110 mm

Gauge boxes **9.21** Measure mortar constituents by volume, using clean gauge boxes made to sizes to suit volumes required.

Proportion **9.22** Mix constituents to the following proportions:

(a) Cement mortar to be: cement and sand 1:3.

(b) Cement/lime mortar to be: cement, lime putty and sand 1:1:6 for external walls and 1:2:9 for internal walls.

(c) Firebrick mortar to be:

(i) An approved proprietary brand of fire cement, used neat, or

(ii) High alumina cement to **BS EN 14647** and fine crushed firebrick 1:2, tested to **BS 4551+A2** if required by the SO.

Proportions given are for dry sand. Allow for bulking.

Where plasticisers are used, they shall be used strictly in accordance with the manufacturer's recommendations and the proportions of the mortar mix adjusted accordingly.

Mixing **9.23** Mix mortar by mechanical mixer, or, where approved, by hand on a clean, closeboarded platform. Mix thoroughly, but do not overmix mortar containing plasticisers.

Testing **9.24** The proportions of the materials used in Clause 9.22 with proper mixing shall have a mean compressive strength as Table 9.2.

TABLE 9.2
Strength of mortar

Type of mortar	Mean compressive strength at 28 days
(cement: lime: sand) 1: 0 to 0.25: 3 1: 1: 5 to 6 1: 2: 8 to 9	(site tests) 11 MPa 2.5 MPa 1.0 MPa

Testing on strength of mortar is normally not required. However, when specified, the testing to be in accordance with **PD 6697**, **BS EN 1996-1-2**, **BS EN 1996-2** and **BS EN 1996-3**.

Use of mortars **9.25** Mortars to be used as follows:

(a) Cement mortar for the following:

(i) Work below damp proof course, including basement walls.

(ii) Chimney stacks above roof level.

(ii) 70 and 105 mm brickwork.

(iv) Concrete blockwork not exceeding 150 mm.

(v) Load-bearing brick or block walls.

(vi) Brickwork in engineering brick.

(vii) Pointing where directed and where bedding is of cement mortar.

(b) Firebrick mortar for firebrick work.

(c) Cement/lime mortar as Clause 9.22 (b) for brickwork and blockwork generally, except as specified.

Samples of face brickwork and blockwork **9.26** Prepare sample panels of approximately 1 m^2 of faced brickwork and fair faced brickwork or blockwork, including pointing, and obtain approval before proceeding.

Dry weather **9.27** During dry weather, wet bricks and blocks as necessary to prevent premature drying out of the mortar.

Wet weather **9.28** During wet weather, protect freshly laid brickwork and blockwork at the completion of each day's work or in heavy rain.

Faced work **9.29** Protect faced and fair-faced work until practical completion.

Colour mixing of facing bricks **9.30** Distribute facing bricks, selected bricks and selected bricks for fair-faced work of varying colour, evenly throughout the work, so that no patches appear.

Uniformity **9.31** Carry out work with no portion more than 900 mm above another at any time, racking back between levels.

Dimension **9.32** Gauge brick courses with four courses to 320 mm including joints.

Joints **9.33** Lay bricks or blocks on a full bed of mortar with the joints filled solid to a consistent thickness of 10 mm.

In loadbearing walls, lay single frog bricks with the frog uppermost, and fill with mortar.

Accuracy **9.34** Keep courses level, and perpends vertically in line. Plumb quoins and other angles as the work proceeds.

Tolerances **9.35** Build brickwork and blockwork to the tolerances in Table 9.3.

TABLE 9.3
Tolerance (mm)

Position on plan	15
Length	15
Height	10
Level of bed joints (in any 5 m)	10
Straightness (in any 5 m)	15
Verticality (in any 3 m)	15

Cavity walling **9.36** Build cavity walls with cavities of the widths, and walling of the thicknesses required. Bond the two thickness of walling together with ties spaced 900 mm apart horizontally and 320 mm vertically, staggered, and with additional ties at reveals and openings. Carefully position ties so that they fall toward the outer thickness of the wall. Keep cavity clean by means of lifting battens. Leave openings at the base of the cavity to facilitate clearing out on completion and subsequently close up to match the surrounding work.

Bonding **9.37** Lay 70 mm and 105 mm brick walls in stretcher bond. Lay brick walls 225 mm and over in English bond, unless otherwise specified. Lay blockwork in stretcher bond. Lay bricks throughout the work with the perpends in any course not less than a quarter of a brick from those in the course below. Notwithstanding the above, lay faced brick walls and fair-faced brickwork or blockwork with joints to an even and regular pattern.

Ties to concrete **9.38** At junctions of walls with concrete structures cast in, cut and pin or shot fire ties to concrete at 320 mm centres vertically to project 250 mm into brick or block walls.

For brickwork or blockwork built against the face of concrete structure, cast in or out and pin ties to concrete at 900 mm centres horizontally, 320 mm centres vertically and staggered, to project 75 mm into brick or block walls.

Finishing of joints **9.39** Strike off joints not visible in the finished work as the work proceeds. Fill joints in fair-faced work as the work proceeds to provide a smooth surface flush with the brick or block face or with details as approved.

Finish joints in faced brickwork with either a trowelled weathered joint as the work proceeds, or rake out to a depth of 10 mm as the work proceeds and point with a weathered joint on completion. Rake out joints to a depth of 10 mm in brickwork to provide key for plaster or other wet applied finishes.

Damp proof course **9.40** Flush up brickwork to form a level and even bed with mortar used in the general brickwork to receive the horizontal damp proof course.

Lay damp proof course in continuous strip with 150 mm laps at end of length and at returns, and complete mortar joint to normal thickness.

Wedging and pinning **9.41** Pin up and wedge brickwork and blockwork to structural soffits, and fill solid with mortar.

Building in **9.42** Build in lintels and bed solid door and window frames and the like with mortar similar to that of adjacent walls.

Holes and chases **9.43** Leave, form or cut chases, holes, recesses and reveals in walls to receive frames, rainwater or other pipes, conduits, electric cables, sleeves and the like as required and subsequently make good with mortar similar to that of adjacent walls.

Raking out and pointing flashings **9.44** Rake out joints to a depth of minimum 25 mm for turn-in of flashings or skirtings. Point flashings and skirtings in mortar with plasticiser and similar to that in adjacent walls.

Glass block panels **9.45** Paint all sides of structural opening to receive glass block panels with two coats of bituminous paint or other types of paint approved by the SO.

Lay blocks in cement/lime mortar and point both sides. Provide 12 mm clearance at jambs and head of panels. Fill gap with movement joint filler and seal both sides, as Section 6.

Build in strips of blockwork reinforcement 64 mm wide at every fourth course. Carry ends of strips across the clearance gap and build into or secure to jambs of opening in an approved manner. Use proprietary fixing components supplied by glass block manufacturer, and follow all fixing details recommended by the manufacturer unless required to do otherwise by the SO.

Lintels **9.46** Construct concrete lintel for openings at brickwork and blockwork as per Clause 6.68. Alternative proprietary product may be accepted subject to approval by the SO.

SECTION 10

MASONRY

GENERAL

Stone **10.1** Stone, generally, shall be granite of consistent colour, free from defects and ferrous materials that will adversely affect strength or appearance, to **BS EN 771-6** and shall comply with **BS EN 1996-1-1, NA to BS EN 1996-1-1, BS EN 1996-1-2, NA to BS EN 1996-1-2, BS EN 1996-2, NA to BS EN 1996-2, BS EN 1996-3, NA+A1 to BS EN 1996-3** and **PD 6697** when applied to masonry structures. Test methods according to clause 2 of **BS EN 771-6.**

Micro conditions of exposure **10.2** Micro conditions of exposure of completed masonry, as in Clause 2.1.2.1 and Annex A of **BS EN 1996-2** shall be categorised into classes, as follows:

MX1 - In a dry environment;
MX2 - Exposed to moisture or wetting;
MX3 - Exposed to moisture or wetting plus freeze/thaw cycling;
MX4 - Exposed to saturated salt air or seawater;
MX5 - In an aggressive chemical environment.

Masonry units, mortar, concrete infill, ancillary components and reinforcement shall be selected according to Annex B and C of **BS EN 1996-2** based on the appropriate class of micro conditions of exposure of completed masonry.

MATERIALS

Approval of stone **10.3** Submit samples of stone for the SO's approval before ordering.

Mortar **10.4** Mortar shall be as Clauses 9.12 to 9.17 and 9.21 to 9.25.

Damp proof course **10.5** Damp proof course shall be as Clause 9.10.

Wall ties **10.6** Ties between walls and concrete shall be 20x3 mm stainless steel 316 flats 350 mm long, fanged at both ends and shall be to **BS EN 845-1+A1**.

"Ties for walls built against face of concrete to be formed from 20 x 3 mm stainless steel 316 flats 150 mm long, fanged at both ends and shall be to **BS EN 845-1+A1**."

WORKMANSHIP

Tolerances **10.7** Build masonry to the tolerances as follows:

TABLE 10.1
Tolerance (+ or - mm)

	Rubble Walling	Ashlar Walling
Thickness of bed joints	5 - 15	5 - 10
Position on plan	25	15
Length	25	15
Height	25	10
Level of bed joints (in any 5000 mm)	25	10
Straightness (in any 5000 mm)	25	15
Verticality (in any 3000 mm)	20	15

Mock up sample **10.8**

Provide stone works "mock up" samples, approximately 1 m^2 of stone works, including pointing on Site for the SO's approval if the stonework is extensive and/or as directed by the SO. All details including colour, finish, mortar type, pointing, wall ties, damp proof course and like matters for the source and type of each material shall be agreed before work commences.

Sample panels shall be used as means of comparison against which the SO shall determine the compliance or otherwise of the masonry in the permanent work. The sample panels shall be protected from damage and shall be left in a position until the SO instructs their removal.

If in the opinion of the SO the stone work in the sample panel does not comply with the specified requirements for the masonry, the proposed changes to materials and methods of construction shall be submitted to the SO; further sample panels shall be constructed until the sample panel complies with the specified requirements.

Types of walling **10.9**

Types of rubble and ashlar walling should be in strict accordance with the Manufacturer's instructions and standards, unless otherwise approved or instructed by the SO.

Preparation of stone for rubble stone walling **10.10**

Prepare stones to the following sizes, unless otherwise specified in the Drawings:

(a) Random rubble - Stones shall be irregularly shaped roughly cut 75 mm to 300 mm high, and 75 mm (minimum) deep and 75 mm to 600 mm long on bed. The length or depth on bed of each stone shall be greater than the height.

(b) Squared uncoursed rubble - Trim stones roughly square 75 mm to 300 mm high, varying in 75 mm stages. Each stone shall be 100 mm to 150 mm deep and 100 mm to 600 mm long on bed. Length or depth on bed of each stone shall be greater than the height.

(c) Squared coursed rubble - Trim stones roughly square as (b), but to suit courses of regular height varying from 150 mm to 250 mm.

Laying and jointing **10.11**

Rubble shall be laid dry on a full even bed of cement mortar. All joints shall be filled and shall be between 5 mm and 15 mm wide.

Random rubble **10.12**

Rubble of random shapes and sizes in random rubble walling shall be bonded together over each face of the wall. Rubble shall be selected and rough dressed to keep joint widths to a minimum. At least one bonding rubble of minimum size 450 mm x 150 mm (minimum) shall be provided and carried through the full thickness of the wall per square meter (see Diagram A). No more than 3 nos. rubble shall be adjacent to a vertical joint.

Squared uncoursed rubble **10.13**

Roughly squared rubble of random sizes in square rubble walling shall be bonded together with continuous straight horizontal joints. The numbers of vertical joints shall be kept to a minimum (see Diagram B).

Beds and joints to be rough punched so as to produce a joint not less than 10 mm and greater than 20 mm in thickness.

Squared rubble brought up to courses **10.14**

Roughly squared rubble in square coursed walling shall be laid as stated in Clause 10.12 but brought up to courses at centres not exceeding 750 mm to line up with quoin and jamb stones (see Diagram C).

Squared coursed rubble **10.15**

Roughly squared rubble of random size in squared rubble walling shall be bonded together in regular courses with continuous straight horizontal joints (see Diagram D).

Squared rubble walling exceeding 300 mm thick **10.16**

(a) Squared rubble walling exceeding 300 mm thick and faced one side shall be constructed (see Diagram E) in accordance with the following requirements:

(i) Roughly squared rubble at least 300 mm thick shall be provided with a backing of random rubble.

(ii) At least 2 bonding rubble per square meter shall be regularly spaced and carried through the full thickness of the wall or at least 450 mm into the backing, whichever is less.

(b) Squared rubble walling exceeding 300 mm thick and faced both sides shall be constructed in accordance with the following requirements:

(i) Roughly squared rubble at least 150 mm thick shall be provided with a core of random rubble.

(ii) Bonding stones shall be provided as stated in Clause 10.16 (a) but shall be carried through the full thickness of the wall or at least 450 mm into the core.

Pointing rubble walling **10.17** Joints in rubble walling shall be raked out to a depth of 15 mm as the work proceeds. The joints shall be pointed in cement mortar on completion with a flush, weathered or recessed joint as specified.

Preparation of stone for ashlar walling **10.18** The exposed faces and joint faces of each stone for ashlar stone walling shall be dressed squared and true free from hollows or rough areas. Finish exposed faces to a finely squared dressed surface. Stones shall be not less than 300 mm high. Each stone shall be clearly marked to indicate its position in finished work.

Laying and jointing ashlar walling **10.19** Stones in ashlar walling shall be laid on a full, even bed of mortar consisting of cement and fine crushed stone in proportions 1:3 by volume. All joints shall be filled and shall be 5 mm wide. Stones shall be laid to bond together throughout the wall, and to the backing, using projection bonding stones.

Pointing ashlar walling **10.20** Joints in ashlar walling shall be raked to a depth of 15 mm as the work proceeds and shall be finished with a weathered or recessed joint as specified on completion using bedding mortar.

Transportation, storage and handling **10.21** The transport of stone to the site should be so arranged with the minimised amount of handling. Precautions should be taken, by careful stacking and by packing in clean wheat straw or other suitable material, to guard against accidental damage to the stones. Particular care is needed in the transport of stone by sea, to ensure that it remains uncontaminated by salts throughout the journey. Store stone in stacks on battens, and protect from rain.

It should be stored clear of the ground to prevent the leaching of soil salt into it, or staining from moisture.

Provide adequate lifting plant to unload and handle stones into position.

Protection of newly erected stone work **10.22** Newly erected stone works shall be well protected from exposure to conditions which may adversely affect the masonry.

All stone arrises and projecting members should be protected immediately after fixing by wooden slats, strips or shields firmly fixed. Stone liable to stain should be coated over the whole face with a slurry of lime putty, plaster and stone dust as soon as possible after fixing.

When the scaffold is dropped, at the completion of the work, the coating and all mortar splashes should be removed; the face should be well scrubbed, and washed down with clean water.

Clean off, rub down and leave stonework perfect immediately before handover.

Walling built against concrete, etc. **10.23** Wall ties in masonry which is to face an existing or newly constructed wall shall be fixed at a rate of 5 m^2. Ties shall be fixed 100 mm into the wall and 75 mm into masonry.

Wall ties shall be fixed between the ends of walls and concrete to brickwork at centres of at least 450 mm vertically and shall project 250 mm into the masonry.

Upon the SO's instruction, the performance requirement testing on structural fixings in concrete and masonry should be to **BS 5080-1** and **BS 5080-2**.

Maintenance repair and cleaning **10.24**

Two copies of the "Methods of Repair and Cleaning Instruction/Guideline" shall be submitted to the SO, within 3 months after completion of the masonry works, for comment and approval.

Maintenance cleaning of stones shall be done by means of:

(a) Washing;

(b) Abrasive blasting;

(c) Mechanical; or

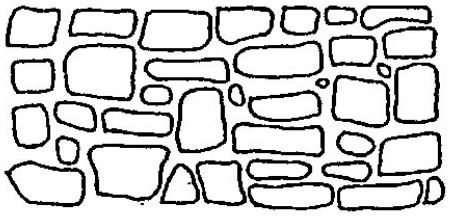
(d) Chemical.

Limestone should be cleaned by water and occasionally by steam, with or without mechanical aids.

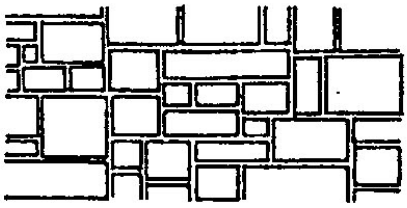
Before starting any maintenance repair and cleaning works, reference should be made to **BS 8221-2** and **BS 8221-1** respectively.

TYPES OF RUBBLE WALLING

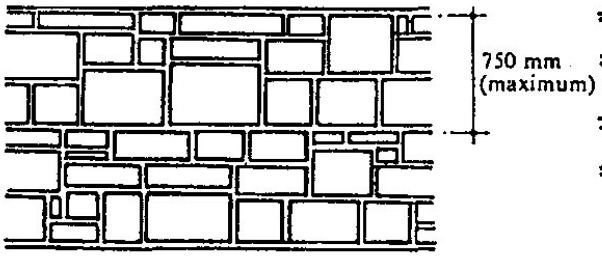
A. Random rubble



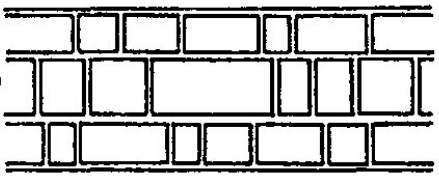
B. Squared uncoursed rubble



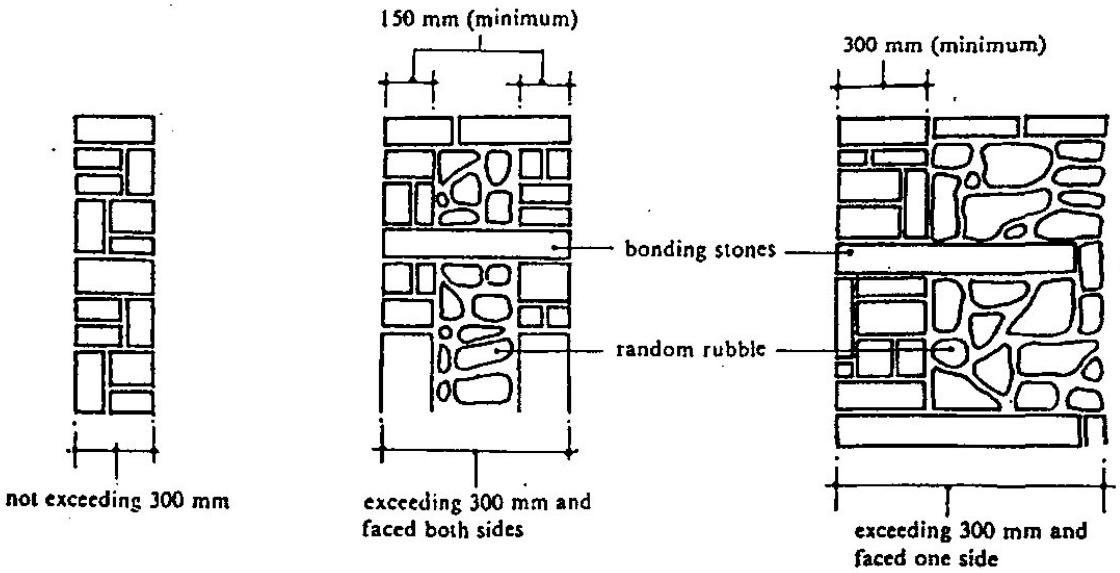
C. Squared rubble brought up to courses



D. Squared coursed rubble



E. Squared rubble walls--sections:--



SECTION 11

TANKING

GENERAL

Design **11.1** The design of tanking shall comply with **BS 8102** - protection of structures against water from the ground.

Specialist Contractor **11.2** For sheet membrane tanking, the work shall be executed by the manufacturers' approved specialist contractor.

MATERIALS

Mastic asphalt **11.3** Mastic asphalt for tanking shall comply with type T1097 to **BS 6925** (lime stone aggregate). All mastic asphalt blocks delivered to site must bear legible markings of:

(a) the name or trade mark of the manufacturer;

(b) the number and date of British Standard; and

(c) the type of number, e.g. T1097 to **BS 6925**.

Proprietary flexible sheet membrane **11.4** Proprietary flexible sheet membrane shall be capable of accommodating unanticipated cracks of up to 0.6 mm wide without losing its waterproofing properties, and the properties of the membrane in lap shear and lap peel shall not be less than 110 kN/m^2 and 3.3 kN/m respectively at site condition, unless otherwise approved by the SO. Certificates together with complete test reports to substantiate that the materials supplied meet the requirements specified shall be submitted when the material is delivered to the Site.

Liquid applied membrane **11.4A** Liquid applied, elastomeric waterproofing shall be made of a pitch modified polyurethane, and shall be submitted for approval by the SO. The membrane shall be capable of an elongation of not less than 400% to accommodate cracks up to 2 mm without losing its waterproofing properties, and its tensile strength shall exceed 1.6 N/mm^2, and the tear resistance and adhesion strength shall not be less than 12 N/mm and 2.6 N/mm respectively at site condition, unless otherwise approved by the SO. It shall be applied in strict accordance with the manufacturer's instructions.

Cementitious waterproofing **11.4B** Cementitious waterproofing shall be compatible with host concrete and all surfaces and materials, including ancillary materials, in contact with the waterproofing system. The material shall be non-toxic. It shall suit the situation on which it is to be used.

TESTING

Testing of mastic asphalt **11.5** Sampling and testing of mastic asphalt for composition and hardness number shall be carried out in accordance with **BS 5284**.

Prepare a bulk sample of not less than 6 kg by selecting at random from not less than 8 blocks, breaking them and taking portions from the inner part of each block. Deliver samples to the Public Works Laboratories (PWL) for testing as directed by the SO. If the test results of the samples do not comply with Tables 11.1 and 11.2, the SO shall reject the whole consignment from which the unacceptable samples have been selected, in which case the rejected consignment shall be removed from the Site.

TABLE 11.1
Composition by analysis of mastic asphalt: type T1097

Property	% by mass of mastic asphalt	
	T1097	
Grading of mineral aggregate using **BS ISO 3310-1** & **BS ISO 3310-2** test sieves	min.	max.
Retained on 3.35 mm mesh	0	2
Passing 3.35 mm mesh, retained on 600 µm mesh	4	17
Passing 600 µm mesh, retained on 212 µm mesh	8	26
Passing 212 µm mesh, retained on 75 µm mesh	8	26
Passing 75 µm mesh	38	50
Soluble bitumen	12	15

TABLE 11.2
Hardness number at 25ºC

Property	T1097
Remelted on site/laboratory	not less than 40
At the time of laying	not less than 40

Testing of membrane **11.6** Sampling and testing of sheet membrane shall be agreed with the SO and the results shall comply with the properties given in Clause 11.4. If the samples do not comply with the required properties, the SO may reject the whole consignment from which the unacceptable samples have been taken, in which case the rejected consignment shall be removed from the Site.

WORKMANSHIP

Workmanship **11.7** The work shall be carried out in accordance with **BS 8102, BS 8000-0** and **BS 8000-4**. Particular attention is drawn to the following before installation:

(a) The Works shall be supervised by a competent representative from the Contractor/manufacturer. Inspection shall be carried out and written approval given by this representative for each and every stage of work, from the surface preparation to the completion of the protection coating. Formal approval for each and every stage of work as mentioned shall be carried out by the SO.

(b) The Works shall only be carried out after the concrete has been properly cured for at least 7 days.

(c) Shop drawings shall be produced by the Contractor/manufacturer showing construction details including those at angles, corners, construction joints, pipe intrusions, etc. for approval and all Works shall be carried out as per the approved shop drawings.

Surface preparation for sheet membrane **11.8** Surfaces to which tanking is to be applied shall be level and free from irregularities such as ridges, dips, fins and concrete or mortar droppings. The horizontal surfaces of the concrete shall be given a wood-floated finish and be laid flat and true to allow

the specified thickness of the sheet membrane to be applied uniformly. Where vertical concrete is very smooth and in order to provide a satisfactory key for the sheet membrane, the Contractor shall remove the surface laitance by wire brushing and apply an approved proprietary high bond primer. Do not use excessive mould oil in the vertical form.

Surface preparation for liquid membrane **11.8A**

The concrete blinding layer and basement wall should be properly cured. All surfaces to be waterproofed should be clean, sound, smooth, dry and free of cracks, void and roughness, which may interfere the adhesion between the substrate and the waterproofing membrane. Porous concrete or other absorbent surfaces should be sealed and all surface defects revealed after the inspection should be repaired by appropriate method as recommended by the manufacturer prior to installation of base coat.

All critical right angle bends must have a cant strip or fillet installed prior to application. At vertical termination, 20 x 20 mm recess groove should be formed for the waterproofing membrane to be tucked into.

Remelting mastic asphalt on Site **11.9**

Break the blocks into pieces of suitable size, carefully stack in an approved cauldron or mechanical mixer and gradually heat to a temperature at no time exceeding 230ºC. Whilst heating, agitate the asphalt continuously to prevent local over-heating. Remove the asphalt from the cauldron or mixer by means of buckets which have been coated with a fine inert dust or cement. Do not use ashes or oil for this purpose.

The Contractor shall check with suitable thermometers to ensure that the asphalt is heated to the correct temperature.

To ensure proper heating and mixing, take samples during the remelting process for the composition and the hardness number tests.

Laying of mastic asphalt **11.10**

On horizontal surfaces, mastic asphalt shall be laid in three coats to a total thickness of 30 mm. On vertical surfaces, mastic asphalt shall be applied in three coats to a total thickness of not less than 20 mm, taken to a height of at least 150 mm above ground level. An angle fillet not less than 50 mm wide shall be applied in two coats at the junction of two planes forming an internal angle. Joints in successive coats of mastic asphalt shall be staggered at least 150 mm for horizontal work and 75 mm for vertical work. The top of vertical mastic asphalt shall be tucked into a chase not less than 25 x 25 mm unless the mastic asphalt is being continued horizontally.

Sampling during laying of mastic asphalt **11.11**

During laying, at least one sample shall be taken from the cauldron or mixer per day for control test.

Sample prepared for test shall not be less than 6 kg by taking three increments, from the discharge of the mixer or from the middle of the cauldrons when approximately half of the charge remains. In the case of hand stirred cauldrons the molten material shall be thoroughly stirred immediately prior to the samples being taken. Thoroughly mix the three increments together in a clean, wide-mouthed galvanized-iron bucket of approximate size 250 mm dia. x 150 mm.

Prepare two specimens for hardness number tests from the thoroughly mixed bulk sample as follows:

(a) Pour the mastic into two hardness moulds to a level slightly higher than the edge of the moulds;

(b) Tap with a spatula on the edge of the moulds for about 3 minutes so as to level the mastic and drive out entrapped air from the specimen; and

(c) Level off the surface with the spatula.

The moulds and spatula shall be warmed before use.

Pour bulk sample for testing composition into a wooden mould size 300 mm x 300 mm x 25 mm deep.

The composition and hardness number of the samples shall comply with Tables 11.1 and 11.2. If the sample failed to comply, the work on site represented by the sample may have to be completely removed and redone.

Laying of proprietary sheet membrane **11.12**

Proprietary flexible sheet membrane shall be primed, laid, lapped and finished in strict compliance with the manufacturer's recommendations.

Before commencing the Works, the Contractor shall demonstrate on the Site that all adhesive and materials are fully compatible. No work shall be undertaken when the surface moisture exceeds the permissible, as tested by the moisture testing equipment on the Site. The spreading of adhesive over large areas resulting in setting before placing of membrane shall be forbidden. Keep records of the adhesive used and check against the agreed spreading rate of membrane. Bubbles formed in the membrane shall be made good in accordance with the manufacturer's technical literature.

Application of liquid membrane **11.12A**

Liquid applied waterproofing membrane shall be applied in strict accordance with the manufacturer's instructions. It can be applied by roller, trowel or airless spray (only in well ventilated areas) in strict accordance with the manufacturer's specification and literature. Allow at least 24 hours of curing for the first coat before overcoating with the second coat. Allow another 24 hours minimum for curing before protection.

Protection of proprietary sheet membrane **11.13**

Apply protection within 2 working days on completion of each section of the Works. For horizontal work, the protection shall be a screed of cement and sand mortar 50 mm in thickness. For ease of placing, this horizontal protection coating shall be very workable, slump of less than 100 mm is not recommended. Temporary protection for the lapping area at the end of a working day shall be strictly in accordance with the manufacturer's recommendation. For vertical work, it shall be protected against damage by the erection of a masonry wall or protective boarding.

Protection of liquid applied membrane **11.13A**

The membrane must be protected from damage by future operations and other trades. Approved protection boards as recommended by the manufacturer shall be installed immediately after the membrane has cured.

SECTION 12

ROOFING

COVERINGS AND FLASHING

Lead **12.1** Sheet lead shall be to **BS EN 12588**, 1.8 mm thick, Colour Code Blue.

Copper **12.2** Sheet copper shall be to **BS EN 1172,** CW024A.

Aluminium **12.3** Sheet aluminium shall be to **BS EN 485-1, BS EN 515, BS EN 573-3,** AW-1199.

Workmanship

Lead **12.4** Fix sheet lead shall be in accordance with **BS 6915+A1.**

Flashings shall be let into walls a minimum of 25 mm, secured with lead wedges and pointed in cement mortar. Flashing shall be lapped a minimum of 100 mm and the lower edge secured with lead tacks at 750 mm centres.

Copper **12.5** Fix sheet copper shall be in accordance with **CP 143-12**.

Aluminium **12.6** Fix sheet aluminium shall be in accordance with **CP 143-15**.

Flashings shall be let into walls a minimum of 25 mm, provided with a turn back, secured with folded aluminium wedges and pointed in cement mortar. Flashings shall be lapped and single lock welted and the lower edge folded under for additional stiffness.

Aluminium in contact with mortar shall be coated with bituminous paint after bending.

Contact of dissimilar metals **12.7** Avoid contact in the completed work between the following metals:

(a) Aluminium alloys and copper alloys, nickel, lead or stainless steel.

(b) Iron or steel and copper alloys.

(c) Zinc (including galvanizing) and copper alloys or nickel.

Where unavoidable, coat contact surfaces with bituminous paint, protective tape or other approved means.

BITUMEN FELT BUILT-UP ROOFING

Materials

Bitumen felt **12.8** Bitumen felt shall be in accordance with **BS EN 13707**, and shall be as follows:

Underlayer to consist of one or more layers, as specified, of approved fine granule surface felt (nominal weight 1.8 or 2.5 kg/m^2).

Top layer shall be one of the following:

(a) Approved mineral surfaced felt, (nominal weight 2.8 kg/m^2).

(b) Approved fine granules surfaced felt (nominal weight 2.5 kg/m^2) with surface dressing.

Rolls shall be delivered to Site bearing the trade mark and certification as to BS type.

Bitumen primer **12.9** Bitumen primer shall be selected to suit the type of bonding compound.

Bonding compound **12.10** Bonding compound shall be bitumen based.

Dressing compound **12.11** Bitumen dressing compound shall be cut-back bitumen to **BS EN 12591, BS EN 13924-1** and **BS EN 15322** class 1.

Stone chippings **12.12** Stone chippings shall be light coloured, hard and free from brown or partially decomposed stone. Chippings shall be graded from 5 mm to 3 mm.

Nails **12.13** Nails for fixing felt to timber decks shall be galvanized steel or non-ferrous metal with 3 mm diameter shank and 11 mm diameter clout head and 20 mm long.

Workmanship

Generally **12.14** Lay bitumen felt roofing generally in accordance with **BS 8217**.

Laps **12.15** Lap felt 75 mm at joints and 100 mm at ends of length. Lay successive layers to break joint.

Bonding compound **12.16** Provide thermometers to check the work and do not heat any layers or material to more than 220°C. Lay evenly at a sufficiently high temperature to obtain a satisfactory bond (normally 180°C to 200°C).

Bonding compound shall be used in accordance with the manufacturer's recommendations. The Contractor shall ensure that workers are protected against the risk of exposure to substances considered to be hazardous to health. Toxicological information, exposure control, personal protection and first aid measures extracted from the manufacturer's material safety data sheets shall be kept in a register on the Site.

Preparation of base **12.17** Ensure that the base is clean and dry, before starting work.

Setting out **12.18** Rolls of felt shall be laid in the following directions.

(a) On flat roofs, lay the first layer of felt starting at, and parallel to, the lower edge or eaves. Lay subsequent layers in a similar manner to ensure that the laps in the built up roofing do not obstruct the flow of water.

(b) On sloping roofs, lay the felt in the direction of the slope. Lap sheets with the exposed laps away from the prevailing wind.

Laying **12.19** Lay bitumen felt roofing as follows:

(a) On concrete roofs, brush on a coat of bitumen primer, and allow to dry.

Partially bond the first layer to the base at the perimeter and in spots or strips, with hot bonding compound at the rate of 0.5 kg/m^2. Roll with a 70 kg (minimum) roller while the bonding compound is still hot. Remove any surplus compound squeezed out at the edge.

Fully bond subsequent layers with a continuous even coating of hot bonding compound applied to the previous layer at the rate of 1.5 kg/m^2. Roll and remove any surplus compound as specified above.

(b) On timber roofs, nail the first layer at 50 mm centres along the laps, 20 mm from the edges with additional nails in rows at 150 mm centres staggered at 300 mm centres.

Secure subsequent layers by full bonding as specified in Clause 12.19 (a).

Surface dressing **12.20** Dress surface with bitumen compound applied at the rate of 3 kg/m^2 dressed immediately with stone chippings, lightly rolled in at the rate of 15 kg/m^2. Remove any loose chippings.

Skirtings **12.21** Provide skirtings as follows:

(a) To concrete roofs, provide a triangular cementitious internal angle fillet at bottom 75 mm wide on splay. Carry up underlayers of felt to form skirting 150 mm (minimum) high above roof level. Cover with an approved mineral felt flashing with one edge tucked into 25 mm groove in wall, wedged at 600 mm centres and pointed with mastic and seal to face of skirting with bonding compound.

(b) To timber roofs, provide a 200 mm timber upstand with angle fillet at bottom fixed securely to roof deck and carry up roofing felt over it. Provide a lead apron flashing over. The lead flashing code and weight shall be confirmed by the SO.

Verges **12.22** At verges, gutters and the like:

(a) Provide and fix a non-ferrous trim fixed with compatible screws or nails, bonded between layers of built up roofing to form drip or dressed into gutter.

(b) Form a welted drip.

Outlets **12.23** All roof falls shall be aligned to direct water towards outlets:

(a) Dress all layers into proprietary roof outlets and seal with bonding compound.

(b) Provide and fix 1.8 mm lead slate size 450 mm x 450 mm perforated for and with a 150 mm long outlet soldered on to suit the bore of the pipe and dress between layers of built up roofing.

Pipe through roof **12.24** Cut and fit roofing around pipes passing through roof, dress flange or collar between second and third layers, and seal in hot bonding compound, using:

(a) Lead slate size 450 mm x 450 mm perforated for and with 150 mm high collar soldered on to suit bore of pipe.

(b) Proprietary moulded plastic or rubber collar.

BITUMINOUS EMULSION ROOFING

Materials

Bituminous emulsion **12.25** Bituminous emulsion for roofing shall be an approved compound. Use in accordance with the manufacturer's recommendations.

Glass fibre membrane **12.26** Glass fibre membrane shall be a woven material with a thread count of 8 x 8 mm per 10 mm^2 (minimum).

Workmanship

Preparation of base **12.27** Ensure that the base is clean and dry before starting work. Use a wire brush to remove rust patches on steel sheet roofing.

Application of bituminous emulsion **12.28** Apply bituminous emulsion evenly by brush. Ensure that previous coat is dry before applying the next coat.

Wash coat **12.29** Wash coat to consist of approved bitumen emulsion and water 1:1 by volume.

Prime coat **12.30** Priming coat to consist of approved bitumen emulsion and water 5:1 by volume.

Laying glass fibre membrane **12.31** Lap glass fibre membrane 75 mm at joints. Press into last coat of emulsion while still wet.

Concrete flat roof **12.32** Treat concrete flat roofs as follows:

(a) Apply wash coat and priming coat.

(b) Apply one coat of approved bitumen emulsion at the rate of 0.7 L/m^2.

(c) Apply one layer of glass fibre membrane.

(i) Apply three coats of approved bitumen emulsion at the rate of 0.5 L/m^2 per coat.

(ii) Apply two coats of approved bitumen emulsion at the rate of 0.5 L/m^2 per coat.

Existing felt roofs **12.33** Treat cracks in existing felt covered roofs as follows:

(a) Cut out cracks exceeding 5 mm wide, where ordered.

(b) Apply wash coat and primer to grooves.

(c) Fill grooves with compound consisting of approved bitumen emulsion and sand 1:3 by volume.

After making good cracks, treat the entire roof area as follows:

(a) Apply approved cover coating at the rate of 0.2 L/m^2.

(b) Apply two coats of approved bitumen emulsion at the rate of 0.7 L/m^2 per coat.

Waterproofing joints of steel sheet roofing **12.34** Treat joints of steel corrugated sheet roofing in a strip 150 mm wide to cover the joint, as follows:

(a) Point joint with approved bitumen emulsion.

(b) Apply approved cover coating at the rate of 0.14 L/m^2.

(c) Apply approved bitumen emulsion at the rate of 0.7 L/m^2.

(d) Apply one layer of glass fibre membrane.

(e) Apply two coats of approved bitumen emulsion at the rate of 0.7 L/m^2 per coat.

Surface finish **12.35** Finish surface with:

(a) A dressing of clean and sharp sand.

(b) Two coats of approved protective coating at the rate of 0.11 L/m^2 per coat.

(c) Two coats of approved coloured finish at the rate of 0.16 L/m^2 per coat.

(d) One coat of compound consisting of cement, approved bitumen emulsion and sand 1:8:32 by volume, trowelled on 3 mm or 5 mm thick, as specified.

CHINESE TILE ROOFING

Materials

Tiles **12.36** Tiles shall be sound, well-burnt unglazed clay, whole, and free from cracks and blemishes. Approximate sizes shall be:

Plain tiles 225 mm x 225 mm
Roll tiles 165 mm long, and tapered
Valley tiles 300 mm x 225 mm

Approval of tiles **12.37** A sample of the tiles shall be approved before ordering.

Mortar **12.38** Mortar shall be cement/lime mortar, as Clauses 9.15 to 9.25.

Nails **12.39** Nails shall be aluminium or galvanized steel nails at least 2 mm diameter 30 mm long and with plain heads.

Special tiles **12.40** Roll tiles to be left exposed shall be specially selected and semi-circular in section. Glazed tiles shall be obtained from an approved manufacturer.

Workmanship

Type of Tiling **12.41** Lay Chinese tiles to roofs as follows:

(a) A single layer of plain tiles to the gauge specified with roll tiles to 120 mm gauge.

(b) A double layer, each layer as (a) above.

Gauge **12.42** Lay plain tiles to a gauge exceeding 75 mm and not exceeding 115 mm.

Bedding **12.43** Bed corners of tiles in mortar dabs. Lay roll tiles to lap 50 mm, bed both edges in mortar, and cover with similar mortar 15 mm (minimum) thick, trowelled smooth.

On wood battened roofs, drive nails into battens and leave projecting 15 mm as key for mortar dabs and neatly point underside if exposed.

Verges **12.44** Finish with a mortar fillet, trowelled smooth.

Ridges and hips **12.45** Form ridge or hips with rows of inverted tiles, with rows of roll tiles over.

Valleys **12.46** Lay valley tiles up the valley to the gauge specified. Cut roof tiles to rake and finish both sides with mortar, trowelled smooth.

Eaves **12.47** Single layer tiling - finish eaves with double course of tiles where specified.

Double layer tiling - finish eaves with roll tiles or tile slips placed centrally between rolls to form weep hole, and fill edge with mortar, trowelled smooth.

Abutments, etc. **12.48** Cut and fit tiling at abutments and around pipes, etc., and finish with a mortar fillet, trowelled smooth.

Special tiles **12.49** Roll tiles to be left exposed shall be bedded and pointed in cement mortar. Glazed tiles shall be fixed in accordance with the manufacturer's recommendations.

MASTIC ASPHALT ROOFING

Generally

Restriction **12.50** Mastic asphalt roofing shall not be used for new works.

Mastic asphalt roofing **12.51** All asphalt roofing for repair works to existing asphalt roofs shall be laid and executed complete by an approved contractor for asphalt roofing or tanking.

Materials

Mastic asphalt **12.52** Mastic asphalt shall be as follows:

(a) Mastic asphalt (limestone aggregate) to **BS 6925**, type R988 manufactured with asphaltic cement specified under Table 1 column B (100% Bitumen).

(b) Mastic asphalt (limestone aggregate) to **BS 6925**, type R988 manufactured with asphaltic cement specified under Table 1 column T25 75% Bitumen and 25% Lake Asphalt.

Testing **12.53** Sampling and testing shall be carried out in accordance with **BS 5284**. Deliver samples to the Public Works Laboratories (PWL) as directed by the SO. Results shall be in accordance with **BS 6925**.

Isolating membrane **12.54** Black sheathing felt shall be to **BS EN 13707**.

Dressing compound **12.55** Bitumen dressing compound shall be cut back bitumen to **BS EN 12591, BS EN 13924-1** & **BS EN 15322** Class 1.

Sand finishing **12.56** Sand finishing shall be fine, clean and the particles of which must pass a 600 μm mesh BS sieve and be retained on a 300 μm mesh BS sieve.

Chipping finish **12.57** Granite chippings shall be best quality grey granite free from brown and partially decomposed stone graded to pass a 5.00 mm mesh BS sieve and be retained on a 2.36 mm mesh BS sieve.

Reflective paint **12.58** Reflective paint shall be an approved bituminous based aluminium paint or an approved paint compatible with bituminous surfaces.

Reinforcement **12.59** Reinforcement shall be bitumen coated "plain expanded" metal lathing to **BS EN 13658-1 & BS EN 13658-2**.

Workmanship

Code of practice **12.60** Lay mastic asphalt roofing in accordance with **BS 8217**.

Heating **12.61** Break the blocks into pieces of suitable size, carefully stack in an approved cauldron or mixer and gradually heat to a temperature at no time exceeding 230ºC. Whilst heating agitate the asphalt continuously to prevent local over-heating. Remove the asphalt from the cauldron or mixer by means of buckets which have been coated with a fine inert dust or cement. Do not use ashes or oil for this purpose.

The Contractor shall provide suitable thermometers to ensure that the asphalt is heated to correct temperature.

Cauldrons shall be sited so as to cause minimum inconvenience and nuisance to occupied premises considered to be air sensitive receivers as determined under EPD's guidelines for air quality assessment.

Isolating membrane **12.62** Lay black sheathing felt lapped 75 mm at joints, laid dry and not sealed to the structure on all surfaces not exceeding 30º from the horizontal.

Reinforcement **12.63** Skirtings, covering to curbs and the like on concrete exceeding 300 mm high sloping surface sand all finishes on timber shall be reinforced with metal lathing securely plugged and stapled.

Laying **12.64** Lay asphalt with coats breaking joint at least 150 mm, on a perfectly clean and dry base. Lay horizontal asphalt to wood or metal gauges to ensure the correct thickness of each coat. Thickness shall be as follows:

(a) Horizontal roof surfaces and on slopes not exceeding 30º - two coats of equal thickness to a total thickness of not less than 20 mm.

(b) Skirtings, upstands and drips and on slopes exceeding 30º - two coats of equal thickness to a total thickness of not less than 13 mm.

(c) Skirting, upstands and drips higher than 300 mm, three coats of equal thickness to a total thickness to a total thickness of not less than 20 mm.

Should "blows" be formed whilst laying, due to the entrapment of moisture or air, pierce the affected part and make good whilst the surrounding asphalt is warm.

Angles **12.65** Form internal angles between horizontal and vertical surfaces with stout asphalt fillets, in two coat work, not less than 50 mm on face and continuous with those surfaces.

Maintain the full thickness of asphalt specified at external angles between horizontal and vertical surfaces or between sloping surfaces.

Skirting **12.66** Unless otherwise required, form skirtings not less than 150 mm high above roof finish with top edge splayed and tucked into a groove not less than 25 mm deep.

Rainwater outlets **12.67** Neatly dress asphalt roofing into rainwater outlets including sealing as necessary. Prior to applying asphalt prime flanges of roof outlets with bitumen solution.

Flashings to rainwater outlets shall be carefully embedded in the first coat of the asphalt and the second coat dressed over it.

Pipes through roofs **12.68** Neatly dress asphalt reinforced as Clause 12.63 150 mm (minimum) high around sleeves to pipes passing through roofs with a stout asphalt angle fillet at bottom. Prior to apply asphalt thoroughly clean metal surfaces and prime with bitumen solution.

Expansion joints **12.69** Expansion joints shall be constructed strictly as indicated on the drawings.

Pointing shall be in accordance with the specification for "Movement Joints" in Clauses 6.61 and 6.62.

Flashings and coverings shall be in accordance with the specification for leadwork in Clauses 12.1 and 12.4.

Finishings **12.70** Immediately after the completion of laying, rub roof surfaces well with a clean wood float using fine clean sand.

Solar protection **12.71** Solar protection shall be provided as indicated.

(a) Dress surface with bitumen compound applied at the rate of 3 kg/m^2 dressed immediately with stone chippings lightly rolled in at the rate of 15 kg/m^2, remove any loose chippings.

(b) Apply two coats of reflective paint at rates recommended by the manufacturer.

(c) Lay precast concrete or insulating tiles in accordance with the specification for Rigid Tile or Slab Finishes in Clauses 18.87 to 18.112.

STEEL SHEET ROOFING AND CLADDING

Materials

Corrugated sheets **12.72** Steel corrugated sheets shall be hot-dipped galvanized corrugated sheets to **BS 3083** and to be at least 0.6 mm thick, with corrugations 76 mm wide and 19 mm deep.

Profiled sheets **12.73** Profiled steel sheets to **BS 5427-1+A1** shall be obtained from approved manufacturer of profile, thickness, finish and colour as specified.

Accessories **12.74** Accessories for steel sheets shall be made from 0.6 mm (minimum) thick galvanized steel sheet or to be approved proprietary fittings. Accessories for colour coated sheets shall be obtained from the approved manufacturer of the sheets.

Fixings **12.75** Hook bolts and nuts, drive screws, washers, self-tapping screws, roofing bolts, nuts and clips, roofing screws and sheeting clips shall be galvanized steel to **BS 1494**: Pt. 1 or electro-plated to **BS 7371-3** and of the sizes and finishes specified.

Alternatively, recommended specialist fixings from an approved manufacturer of the roofing sheets.

Bolts and screws shall be fitted with large washers compatible with sheets and shall be capable of withstanding up-lift under typhoon conditions.

Where coloured roofing sheets are used, fixing heads shall be covered with plastic caps to match the colour of the sheets.

Rivet fixings may only be used with the permission of the SO, and then only for vertical flashings.

Workmanship

Generally **12.76** Fix steel sheeting generally in accordance with **CP 143-12**.

Preparing sheets **12.77** Drill fixing holes in the crown of corrugations for roofing, and in the trough of corrugations for cladding. Drill holes 2 mm larger than bolts or screw, and not less than 40 mm from edges of sheets.

Remove all drilled cast material from around holes, leaving holes flat and smooth prior to any bolt or other fixing.

Make good damage to zinc coatings and galvanizing, treat cut ends of galvanized sections with two coats of metallic zinc-rich priming paint as Clause 21.3.

Laps **12.78** Lay sloping sheets with minimum end laps of 150 mm. Vertical sheets shall be fixed with minimum laps of 75 mm. All laps shall be located over a supporting member.

Lay sheets with side laps of one and a half corrugations.

Where specified, seal laps with approved lap sealant.

Fixing sheeting **12.79** Fix to steelworks with stainless steel self-tapping screws designed for fixing to steel. Fix to timber with self-tapping screws designed for fixing to timber.

Fixings for two rows around the perimeter of the roof, to any projecting areas, verges or open areas and at all end laps shall be at 300 mm (maximum) centres.

Fixing accessories **12.80** Cut, fit and dress steel sheet accessories to fit corrugations or profiles and fix with approved fixings in accordance with the manufacturer’s recommendations.

Movement joints **12.81** Provide movement joints in all lengths of roofing or cladding over 45 m, with one joint for lengths up to 75 m and one for every additional 30 m. Cover with a movement joint cover fixed to sheets at one side only.

Colour coated steel sheets **12.82** Fix sheets in accordance with the manufacturer's recommendations. Sheets shall be sheared and not cut with circular saws or abrasive wheels. Make good damages as Clause 12.22.

Sheets to curved roofs **12.83** Sheets required to be bent to a radius for use on curved roofs shall be bent by means of a proper profiling or crimping machine.

Waterproof joints of steel sheet roofing **12.83A** Treat joints of steel corrugated sheet roof according to Clause 12.34.

ALUMINIUM SHEET ROOFING AND CLADDING

Materials

Profiled aluminium sheets **12.84** Aluminium corrugated and profiled sheets shall be to **BS 4868**. Corrugated sheets shall be at least 0.6 mm thick with corrugations 76 mm wide and 19 mm deep. Profile sheets shall be of the profile, thickness, finish and colour as specified.

Accessories for profiled aluminium sheets **12.85** Accessories for profiled aluminium sheets shall be made from aluminium flat sheet at least 0.6 mm thick and of similar finish and colour to the profiled sheets or to approved proprietary fittings. Accessories for colour coated sheets shall be obtained from the approved manufacturer of the sheets.

Fixings **12.86** Fixings for aluminium profiled sheets as Clause 12.75.

Workmanship

Generally **12.87** Fixing of aluminium sheet shall be similar to that for steel sheeting. See Clauses 12.76 to 12.83A.

Compatibility **12.88** To prevent electro-chemical corrosion, direct contact with other metals (particularly copper) shall be avoided. Fixings must be of, or compatible with, aluminium. Where unavoidable, coat contact surfaces with bituminous paint, protective tape or other approved means.

PROFILED GLASS-FIBRE REINFORCED PLASTIC (GRP) SHEETS

Materials

Profiled glass-fibre reinforced plastic sheets **12.89** Profiled glass-fibre reinforced plastic (GRP) sheets shall be to **BS 4154-1** & **BS 4154-2**. The resin system, as regards physical properties, shall be to **BS 3532**. The profile, thickness, translucency and colour shall be as specified.

Where fire protection requirements apply, the GRP sheets shall be tested in accordance with **BS 476-3** and **BS 476-7** and the fire performances achieved by the samples shall be stated.

The sheets shall be marked with the name or trademark of the manufacturer, the BS number 4154 and the designation of the test samples of the translucent sheet in accordance with **BS 476-3**, where so claimed by the manufacturer.

Fixings **12.90** Fixings for glass-fibre reinforced plastic sheets as Clause 12.75.

Workmanship

Generally **12.91** Fixing of glass-fibre reinforced plastic sheets shall be similar to that for steel sheeting. See Clauses 12.76 to 12.83.

PROFILED UNREINFORCED RIGID PVC SHEETS

Materials

Profiled unreinforced rigid PVC sheets **12.92** Profiled unreinforced rigid PVC sheets shall be **BS 4203-1 & BS 4203-2**. The profile, thickness, colour and transparency shall be as specified. The sheets shall be marked with the name or trademark of the manufacturer, the date of manufacture and the number of the BS and the type.

Fixings **12.93** Fixings for PVC sheets as Clause 12.75.

Workmanship

Generally **12.94** Fixing of PVC sheets shall be similar to that for steel sheeting. See Clauses 12.76 to 12.83

Laps **12.95** Lay sloping sheets with minimum end laps of 225 mm. Vertical sheets shall be fixed with minimum laps of 75 mm. All laps shall be located over a supporting member.

Lay sheets with side laps of one and a half corrugations.

Where specified, seal laps with approved lap sealant.

PROFILED COMPRESSED PARTICLE SHEETS

Materials

Profiled compressed particle sheets and accessories **12.96** Profiled compressed particle sheets and accessories shall be as specified and not to contain asbestos materials of any kind.

Fixings **12.97** Fixings for compressed particle sheets as Clause 12.75.

Workmanship

Generally **12.98** Fixing of compressed particle sheets shall be similar to that for steel sheeting. See Clauses 12.76 to 12.83.

PROPRIETARY ROOFING SYSTEMS

Generally **12.99** Proprietary roofing systems shall be laid by specialist contractors approved by the manufacturers/agents.

Materials

Roofing system **12.100** All waterproof Roofing Covering Materials shall be materials of the proprietary roofing system and which are subdivided into four groups as follows:

(a) Type ‘AI’ Roofing Sheet Materials requiring Protection.

(b) Type ‘AII’ Roofing Sheet Materials with self finishes not requiring any protection finishing on top.

(c) Type ‘BI’ Liquid Applied Roofing Materials requiring Protection.

(d) Type ‘BII’ Liquid Applied Roofing Materials with self finishes not requiring any protection finishing on top.

Samples **12.101** Submit samples of the roofing materials which shall be installed and copies of the manufacturer's technical data and instructions to the SO for approval.

Compatibility **12.102** Before commencing work, the contractor shall demonstrate on the Site that all adhesives and materials are fully compatible and shall be certified by the suppliers/manufacturers in writing.

Workmanship

Generally **12.103** Lay the roofing system comprising the approved roofing material, insulation and roof finishes onto the roof, including priming, sealing, crack filling and other preparation where necessary all in accordance with the manufacturer's specification and recommendations, and in accordance with the details and sequence as approved by the SO.

Particular care shall be taken to ensure that all junctions, joints around pipes, rainwater outlets and the like are properly executed.

Take necessary measures when carrying out the works so that disturbances, including noise and vibration, to the occupants and users of the premises are kept to the minimum. Noisy works which, in the opinion of the SO, will affect the occupants and users will not be permitted.

Chutes for removal of Construction and Demolition waste shall be erected at approved locations, designed to withstand high winds, with hopper heads to ensure that no materials fall outside the chutes, and discharge at low level, preferably into skips or bunkers, to prevent the spread of debris and to minimize dust generation. Chutes shall be demolished and removed off the Site after use and all disturbed areas and surfaces shall be made good to match existing.

Prevent dust arising from debris generated by removal of existing roofing systems by approved dust control methods. Debris shall be regularly removed from the Site.

Surfaces preparation **12.104** Prior to laying of the roofing system inspect and repair as required to provide proper surfaces to receive waterproofing.

Remove all contaminants such as grease, oil, etc., from the surfaces. Clean surfaces to remove dust, dirt, loose stone and debris.

High pressure water cleaning of substrates shall not be permitted.

Existing membrane **12.105** When specified for repair or maintenance work, take up and remove existing tiles, existing layers of felt or other protective covering, to expose existing asphalt or roof membrane; lay a cement and sand screed, minimum 25 mm thick or self-leveling screed as approved by the SO, to produce an even surface to approved falls to receive the new roofing system. The Contractor shall take the responsibility for repairing and making good the existing roof slab.

Free of moisture **12.106** No work shall be carried out when there is surface moisture.

Protection of existing roof **12.107** The whole roof shall be left watertight when no work is in hand.

Where coverings have been removed and not yet replaced, the Contractor shall provide covering (ropes and hold-fasts to hold down the coverings) by means of tarpaulin or other sheeting to cover all areas of roofs. Overlaps must be sealed with tape and sheets effectively dressed into outlets.

Other methods of protection may be employed as approved by the SO.

During working hours, all roofing outlets shall be protected to prevent debris falling into rainwater pipes. The outlets shall be opened and cleared at the end of the working day and the roof swept clean to ensure effective drainage.

Protect all pipework, ducting and other services running on top of the existing roof, including provision of new pipe supports as necessary.

Any accidental damage to water supply pipes shall be reported to the SO immediately.

Adhesive **12.108**

Adhesive, if required, shall be applied strictly in accordance with the manufacturer's recommendations. All manufacturer's data about the shelf-life of adhesives shall be noted, and no attempt shall be made to use materials which are no longer fit for use. The spreading of adhesive over large areas and subsequent setting before placing of sheets shall be prohibited.

Ensure that workers are protected against the risk of exposure to substances considered to be hazardous to health. Toxicological information, exposure control, personal protection and first aid measures extracted from the manufacturer's material safety data sheets shall be kept in a register on the Site.

Bubbles **12.109**

If bubbles form in the membrane, the affected area shall be cut open and made good as far as the manufacturer's technical literature specifically allows. Otherwise, the whole area shall be stripped, cleared and the surface shall be prepared again and the work shall be re-executed.

Finishes (light reflective and/or UV resistant) to roofs **12.110**

When specified, apply a light-reflective and/or UV resistant paint or similar finish applicable to the particular roofing system.

Finishes to roofs (frequent foot traffic) **12.111**

When specified, the roofing system shall be designed to allow for increased wear due to frequent foot traffic or shall be protected by precast concrete tiles, (laid on cement and sand mortar) or other materials approved by the SO.

Do not allow traffic on roof until 4 days after completion of tiling and subsequently permit only light traffic for a further 10 days.

Roof vent **12.112**

When specified, position and fix approved proprietary roof vents in accordance with the manufacturer's recommendations and ensure that the roofing contractor or specialist makes good the roof covering up to and around them.

Insulation **12.113**

Insulation shall either have integrally bonded hard surfaces on both sides or be protected by inert hard sheeting or reinforced screed.

Moisture test **12.114**

Moisture testing equipment shall be available on Site to monitor the moisture content of the roof structure and the various elements of the roof system; all necessary precaution shall be taken to ensure the full integrity of the roofing system.

Records **12.115**

Records of tins of adhesive, liquid membrane or amount of sheeted membrane material shall be kept upon their arrival on site. The number consumed per day and the number cleared away shall be evaluated to check the actual spreading rate of the proprietary material against the manufacturer's technical data. Tins and packages may be marked on arrival and again when consumed.

Keep a register of all dangerous substances including those hazardous to health, which are delivered to and stored for use on the Works. The register shall include information on physical and chemical properties, hazards, safe handling and storage, precautionary measures to be taken, first aid measures, disposal of containers and surplus or waste materials, and measures to be taken in case of accidents.

Inspection **12.116**

Inform the SO upon the completion of each layer of the roofing system for an inspection before the execution of next layer.

NON-DESTRUCTIVE TEST

Flooding test **12.117** The test shall include sealing all outlets and if necessary constructing dams to compartmentalize large roofs. Flood the roof for 24 hours. After flooding, all outlet blockages and dams shall be removed to drain the roof. Do not permit any debris to enter into the drainage pipework. At a period between 24 and 48 hours from release of the water, an infra-red scan shall be carried out by an independent specialist contractor to establish if there has been penetration through the membrane. The report shall be sent directly by the infra-red scanning contractor to the SO. Carry out other test(s) with prior approval from the SO when flooding test cannot be conducted due to site constraints.

WARRANTY

Maintenance manual **12.118** Upon completion of the work, submit one maintenance manual, identified with project name, location and date; type of coating system applied and surface to which system was applied, and sketches where necessary. Recommendations for periodic inspections, care and maintenance shall also be included. Identify common cause of damage with instructions for temporary patching until permanent repair can be made.

Warranty **12.119** Duly executed warranty shall be submitted in accordance with the Contract. The completed installation shall be guaranteed against defects of materials and workmanship for a period of 10 years from the date of completion stated in the certificate of completion with respect to the Works for use in Hong Kong. The system shall be designed to withstand the conditions of the Hong Kong climate, which includes typhoons, monsoons and rainstorms. The warranty shall cover the roofing system in its entirety. The warranties shall be extended to cover all aspects of the roofing project executed including adhesion and structural integrity of materials used.

SECTION 13

CARPENTRY AND JOINERY

GENERAL

Generally **13.1**

Timber generally shall be to **BS EN 942** and to be of mature growth, properly seasoned and sawn square. Timber shall be free from wood wasp holes, large loose or dead knots, splits or other defects that will reduce its strength. Pin holes and worm holes may be permitted to a slight extent in a small number of pieces, subject to the acceptance of the SO, provided that there is no active infestation of the materials, that the strength of the member is not impaired and that they do not appear on the finished faces of joinery work.

Timber for external use **13.1A**

(a) Species : Timber shall be either hardwood or softwood suitable for external use.

Approved softwood may be Radiata Pine, and Red or White Pine or those cited in Table NA.1 of **BS EN 942**. Approved temperate hardwoods may be Beech or Oak or those cited in Table NA.2 of **BS EN 942**. Submit the species to be used to the SO for approval.

(b) Source of Supply : Obtain timber either softwood or hardwood from a responsibly managed forest or plantation that is preferably Forest Stewardship Council (FSC) certified; where this is not available, ensure that the timber is at a minimum from a Known Licensed Source.

Submit FSC certificates and invoice copies that clearly show the FSC chain of custody number against the purchase product. Where FSC is not available, submit certificates, invoice copies and other paperwork from other systems that shows the product is either Known Licensed Source or Source in Progress to Creditable Certification.

(c) Seasoning : Moisture content to be in accordance with Clause 13.3.

Maintain the specified moisture content of the timber until preservative treatment described below is applied.

(d) Preservative : Preservatives shall be environmentally friendly, healthy and safe, acceptable preservatives include Alkaline copper quaternery (ACQ) preservatives to American Wood Protection Association (AWPA) Standards or other suitably approved preservatives. Chromate copper arsenic (CCA) is not allowed to be used subject to approval by the SO.

(e) Tropical hardwoods : Tropical hardwoods, which include species such as Meranti, Iroko, Sapele, Angre, Mahogony, Teak and Ramin, should not be used unless they originate preferably from a forest that is Forest Stewardship Council (FSC) certified or where this is not available, from a forest participating in a system designed to progress that forest towards FSC certification or equivalent authorized certification.

Source in Progress to Creditable Certification **13.1B**

Source in Progress to Creditable Certification are forest certification systems that assist managers to achieve FSC certification. Systems including WWF Global Forest and Trade Network (GFTN) Producer Groups, the Tropical Forest Trust, Smart Step, and SGS Malaysia (Certification Support Programme) are considered as sources in progress to creditable certification.

Known Licensed Source **13.1C**

The minimum acceptable status of a timber source is "Known Licensed Source". It refers to forest certification systems (except FSC) that include a chain of custody system covering the timber being purchased (be aware that not all forest systems have this element). A list of acceptable forest certification system with a chain of custody system include the followings:

(a) Programme for the Endorsement of Forest Certification Schemes (PEFC) – General

(b) PEFC – United Kingdom

(c) PEFC – Germany

(d) PEFC – Sweden

(e) Canadian Standards Association (CSA)

(f) Cerflor (Brazil)

(g) Malaysian Timber Certification Council (MTCC)

(h) PEFC – China

Storage **13.2**

Store timber in a dry, well ventilated place, and protect from the weather. Stack timber in such a manner as to prevent distortion.

Moisture content **13.3**

Calculate moisture content at the time of fabrication by the following formula:

$$\frac{\text{Wet (or supplied) Mass} - \text{Dry Mass}}{\text{Dry Mass}} \times 100 = \text{Moisture Content (percentage)}$$

The dry mass shall be determined by drying in an oven at a temperature of 103ºC ± 2ºC until the weight is constant.

The maximum permissible moisture content in timber to be incorporated into the work shall be as follows:

(a) Internal timber for use in Air Conditioned space 12%

(b) Internal timber generally 16%

(c) Timber with one face to the exterior of the building and one face to the interior (e.g. window frames) 18%

(d) External timber (e.g. fencing etc.) 20%

If these percentages cannot be attained due to local circumstances of supply and availability, the SO's attention must be drawn to the fact.

Moisture Test **13.3A**

Moisture testing equipment shall be provided by the contractor for on-site checking and monitoring of required moisture content of the timber. The tested timber shall be marked and its records shall be kept on site.

MATERIALS

Samples **13.4**

Submit samples of timber for joinery for approval where the grain shall be left exposed or where the surfaces shall be varnished or similarly treated.

Softwood **13.5**

Softwood for carpentry to be Pine, Cedar, Spruce or China fir or other species approved by the SO. All timber shall be appropriately stamped or marked to identify origin and grade. All timber shall be kiln dried and treated according to Clause 13.1A (d), or as directed otherwise by the SO.

All softwood and softwood products shall be from a verifiable sustainable forest and shall be accredited with a certificate from the Forest Stewardship Council (FSC) or other Approved Authority. While a certificate from FSC is preferable, certificates, invoice copies and other paperwork from other systems that shows the product is either Known Licensed Source or Source in Progress to Creditable Certification are considered as acceptable certificates from Approved Authority.

Hardwood **13.6**

Hardwood and hardwood products shall only be used in special circumstances under the direction of the SO, and shall be certified as originating from a sustained resource or managed plantation as certified by the Forest Stewardship Council (FSC) or other Approved Authority.

While a certificate from FSC is preferable, certificates, invoice copies and other paperwork from other systems that shows the product is either Known Licensed Source or Source in Progress to Creditable Certification are considered as acceptable certificates from Approved Authority.

Density of hardwood shall be 720 kg/m^3 (minimum) at 15% moisture content.

Submit to the SO the following information:

(a) The species and country of origin.

(b) The name of the concessions or plantations from which these timbers originate.

(c) Copies of the forestry policies implemented by these concessions or plantations which confirm that the management of the timber resource is sustainable.

(d) Shipping documents which confirm that the supplier in Hong Kong has obtained the timber from the stated concessions or plantations.

(e) Certificate from the Forest Stewardship Council (FSC) or other Approved Authority

Hardwoods of unknown species or from unidentified sources are expressly prohibited.

Teak **13.7**

Teak, which is only permitted to be specified in special circumstances, shall have a density of 650 kg/m^3 (minimum) at 15% moisture content. They shall be accredited with a certificate from the Forest Stewardship Council (FSC) or other Approved Authority.

Flooring **13.8**

Softwood or hardwood species used for timber flooring shall be obtained from a sustainable source as previously specified.

Boarded or strip flooring shall be selected and approved hardwood, as specified, or as submitted to the SO for selection. Finished thickness shall be 20 mm (minimum).

Emission of formaldehyde from the approved proprietary products shall not exceed 0.13 mg/m^3 air.

Wood block flooring **13.9**

Wood block flooring shall be approved high density resin bonded fibreboard flooring or other approved hardwood as specified. Resin shall conform to Class E1 under **BS EN 13986**. Finished thickness shall be 20 mm (minimum). Blocks shall be 300 mm x 50 mm in size and colour matched.

Parquet flooring **13.10** Wood parquet flooring shall be obtained from a sustainable source as previously specified. Each block shall be 120 mm x 25 mm in size and 8 mm thick, and shall be tongued & grooved.

Weather boarding **13.11** Hardwood weather boarding shall be 150 mm wide and tapering from 25 mm to 10 mm thick and shall be:

(a) Sawn boarding or boarding wrot on one face and two edges with horizontal joints lapped 30 mm.

(b) Boarding as (a) but with wider edge rebated with joints lapped 20 mm.

Plywood **13.12** Plywood shall be of the following grades, as specified:

(a) "Grade 1 veneer" - hardwood faced, as specified, for natural finish.

(b) "Grade 2 veneer" - lauan faced for painting.

Generally the bonding adhesive between veneers shall be resin adhesive of durability class H2 in accordance with **BS 1203**. Adhesive shall conform to the requirement in Clause 13.29.

Nominal standard thicknesses of plywood shall be 3, 4, 5, 6, 9, 12, 15, 18 and 25 mm.

Plywood containing hardwoods of unknown species or from unidentified sources are expressly prohibited from use. Use only plywood and plywood products made from softwoods or temperate hardwoods that originate from the Forest Stewardship Council (FSC) certified forests or other Approved Authority.

While a certificate from FSC is preferable, certificates, invoice copies and other paperwork from other systems that shows the product is either Known Licensed Source or Source in Progress to Creditable Certification are considered as acceptable certificates from Approved Authority.

Marine plywood **13.13** Marine plywood shall be to **BS 1088** bonded with durability class of D3 or D4 in **BS EN 204** adhesive between plys as in Clause 13.29.

Blockboard **13.14** Blockboard shall be Grade 2 veneer for painting, and bonded with adhesive as in Clause 13.29.

Hardboard **13.15** Hardboard shall be to **BS EN 316**, **BS EN 622-1** and **BS EN 622-2**.

Insulating board **13.16** Insulating board (Softboard) shall be to **BS EN 316**, **BS EN 622-1** and **BS EN 622-4**.

Wood chipboard **13.17** Wood chipboard shall be unsanded or sanded board to **BS EN 309** and **BS EN 312**. Veneered chipboard shall be an approved proprietary brand to **BS EN 309** and **BS EN 312**. All wood chipboards shall be low formaldehyde emission chipboard (Class E1) unless permitted otherwise by the SO, or polyurethane - based chipboard with zero formaldehyde emission. Any boarding shall be used in wet areas such as kitchens or bathrooms shall be High Moisture Resistant board to **BS EN 31**6 and **BS EN 321**.

Medium Density Fibreboard (MDF) **13.17A** Board type shall be moisture resistant grade (MDFMR) with density in excess of 600 kg/m^3 to **BS EN 316** and **BS EN 622-5**.

Glass fibre **13.18** Glass fibre insulating quilt shall be light-weight bonded mat weighing 12 kg/m^3 uncompressed.

Semi-rigid resin bonded glass fibre slab **13.19** Glass fibre insulating board shall be semi-rigid resin-bonded glass fibre weighing 45-48 kg/m^3.

P.V.C. or acrylic sheet **13.20** PVC or acrylic sheet shall be clear, translucent or coloured, as specified, and to be approved by the SO.

Laminated plastic sheet **13.21** Laminated plastic sheet less than 2 mm thick shall be to **BS EN 438** Part 3. Class HDS (horizontal heavy-duty standard), HDF (horizontal heavy-duty flame-retardant), HDP (horizontal heavy-duty postforming), HGS (horizontal general-purpose standard), HGF (horizontal general-purpose flame-retardant), HGP (horizontal general-purpose postforming), VGS (vertical general-purpose standard), VGF (vertical general-purpose flame-retardant), VGP (vertical general-purpose postforming) as specified.

Acoustic tiles **13.22** Acoustic tiles shall be of an approved proprietary brand meeting the requirements of **BS EN 13964** manufactured from the following materials:

(a) Wood or other organic fibre insulating board to BS EN 622, 12 mm (Minimum) thick for 300 mm x 300 mm tiles and 15 mm (minimum) thick for 400 mm x 400 mm tiles.

(b) Mineral fibre or wool insulating board 12 mm (minimum) thick for 300 mm x 300 mm tiles and 15 mm (minimum) thick for 400 mm x 400 mm tiles.

(c) Approved multi-purpose, dimensionally stable building board 6 mm (minimum) thick.

Tiles shall have a plain, perforated or fissured surface with a factory applied decorative finish. The edges shall be square, bevelled, or bevelled and grooved to suit the suspension system.

Provide a certificate from the manufacturer confirming that the tiles are asbestos free.

Tiles shall be manufactured with low emission materials conforming to European E1 emission standard.

The acoustic tiles shall be accompanied with relevant test certificates or reports regarding the acoustic performance, issued by an accredited laboratory.

Proprietary suspended ceiling systems **13.23** The suspended ceiling system shall be an approved proprietary system meeting the requirements of **BS EN 13964** and of one of the classes of exposure to be determined by conditions set out in Table 13.1.

TABLE 13.1

Classes of exposure

Class	Conditions
A	Building components generally exposed to varying relative humidity up to 70% and varying temperature up to 25ºC but without corrosive pollutants.
B	Building components frequently exposed to varying relative humidity up to 90% and varying temperature up to 30ºC but without corrosive pollutants.
C	Building components exposed to an atmosphere with a level of humidity higher than 90% and accompanied by a risk of condensation.
D	More severe than the above.

The suspension system shall be manufactured from one of the following materials:

(a) Galvanized mild steel.

(b) Aluminium.

(c) A combination of galvanized mild steel and aluminium.

Metal framing components, suspensions and connecting elements shall be protected against corrosion according to Table 13.2.

TABLE 13.2

Classes of corrosion protection of metal substructure components and membrane components

Class according to Table 13.1	Profiles, suspensions[a], connecting elements[a] and membranes	
	Components made of steel	Components made from aluminium
A	Products with a continuously hot-dip metal coating Z100, ZA095 or AZ100 according to **BS EN 10346**[b c]. Products with electroplated zinc coating flat ZE25/25 according to **BS EN 10152**[c]. Continuously organic coated (coil-coated) products of corrosion protection (interior) category CPI2 for the exposed side according to **BS EN 10169:2022**[f] (e.g. coating system ZE15/15-HDP25-2T-CPI2).	No additional corrosion protection required
B	Products with a continuously hot-dip metal coating Z100, ZA095 or AZ100 according to **BS EN 10346**[b c]. Products with electroplated zinc coating flat according to **BS EN 10152** with or without an additional organic coating[d] as follows[c]: ZE25/25 + 40 µm per face[e], ZE50/50 + 20 µm per face[e] or ZE100/100 without OC. Continuously organic coated (coil-coated) products of corrosion protection (interior) category CPI2 for the exposed side according to **BS EN 10169:2022**[f] (e.g. coating system ZE15/15-HDP25-2T-CPI2).	No additional corrosion protection required or coil coating according to **BS EN 1396**: corrosion index 2a
C	Products with a continuously hot-dip metal coating Z100, ZA095 or AZ100 according to **BS EN 10346**[b c] with an additional organic coating[d] of 20 µm per face. Products with electroplated zinc coating flat according to **BS EN 10152** with an additional organic coating[d] as follows[c]: ZE25/25 + 60 µm per face[e] , ZE100/100 + 40 µm per face.	Anodising[c] (15 µm < s < 25 µm) or coil coating according to **BS EN 1396**: corrosion index 2a
D	Special measures depending on use and corrosion action. Minimum corrosion protection according to Class C. Additional measures as required.	Anodising[c] (s > 25 µm) or coil coating according to **BS EN 1396:**corrosion index 2b

a Round steel wires used as suspensions or part of a suspension shall meet the requirements of **BS EN 10244-2** (Zinc or Zinc alloy coating on steel wire).
b **BS EN 10346** replaces **BS EN 10327.**
c Any equivalent corrosion protection leading to a similar level of protection is permitted.
d Coating of exposed parts with zinc compatible organic coating according to **BS EN ISO 12944-3** applied by a post-painting process or equivalent coil coating according to **BS EN 10169:2022**.
e Applies only to membrane components.
f Applies only to "capping" material for substructure components.

The substructure (suspension system) shall be classified in accordance with its deflection limits as given in Table 13.3. See para. 4.3.2 of **BS EN 13964** for testing criteria and methodology.

TABLE 13.3

Class of deflection

Class	Maximum deflection in mm[A]
1	L^B / 500 and not greater than 4.0
2	L^B / 300
3	No limit

A The maximum deflection is the accumulative value of the deflection of the substructure component and the deflection of the membrane component
B *L* is the span in mm between the suspension components or the suspension points

Aluminium sections shall be anodised where exposed. The panel grid shall be constructed of exposed tee or concealed 'T', 'Z' or other approved sections. Hangers shall be steel wires not less than 2 mm diameter, or straps, rods or combination of sections designed to facilitate the adjustment of grid levels, support the weight of the ceiling and all fittings and attachments. Fixing to soffits shall be by means of approved sockets, anchors or other fixing devices cast into the slab or approved proprietary plugs or drill-anchors.

The system shall be so designed to facilitate the removal of at least 10% of the tiles without disturbing the remainder.

Provide matching edge trim to the perimeter of suspended ceilings.

Submit samples of the panel grid complete with acoustic ceiling tiles for approval.

Nails **13.24** Nails shall be steel nails to **BS 1202**: Pt. 1, with "bright" finish, unless otherwise specified. The nail and its coating shall not contain Arsenic, Cadmium, Copper, Lead or Mercury.

Nail lengths shall be not more than the total thickness of sections to be joined less 5 mm, or not less than twice the thickness of section through which nails are driven.

Where the thickness of the outer section through which nails are being driven is less than half that of the section to which nailing is being done, the depth of penetration of the nails into the latter shall be not less than 10 diameters of the nails being used.

Screws **13.25** Wood screws shall be brass, stainless steel, alloy or other non-corroding metal with countersunk heads, unless otherwise specified. Steel screws shall only be used for temporary work. The proper dedicated screws shall be used for all Particle-board fixing.

Screw lengths shall be not more than the total thickness of sections to be joined, less 5 mm, or not less than one and a half times the thickness of section through which screws are driven.

Where the thickness of the outer section being screwed is less than half that of the section to which screwing is being done, the depth of penetration of the screwing into the latter shall be not less than the thickness of the outer section.

Screw cups shall be brass cups or stainless steel.

Masonry nails **13.26** Do not use masonry nails or drive pins without approval.

Explosive cartridge fixings **13.27** Obtain approval before using explosive cartridge operated fixings. All fixings shall be in accordance with the Factories and Industrial Undertakings (Cartridge-Operated fixing tools) Regulations. Use tools, normally of the indirect acting type, plus pins and cartridges which correspond with the manufacturer's specifications for that tool. A tool shall only be used by a person holding a certificate of competency specifying the maker and model of the tool on which he has been successfully trained.

Plugs **13.28**

Plugs for fixing to hard materials shall be proprietary plugs of plastic, soft metal, fibre or similar.

Fixing to friable materials, plasterboard and the like shall be proprietary fixings specially designed for that situation.

The use of wood plugs shall not be permitted.

Adhesive **13.29**

Adhesive for wood shall be as follows:

(a) For internal use: thermoplastic resin wood adhesives classified as durability class of D1 or D2 in BS EN 204 in accordance with moisture content of timber as given in Clause 13.3.

(b) For external use or internal use under very damp conditions: thermoplastic resin wood adhesives classified as durability class of D3 or D4 in BS EN 204.

(c) Formaldehyde Emission shall be of Class E1 under BS EN 13986.

Where the temperature exceeds 25°C, a "warm-setting" grade of adhesive shall be used.

The use of animal glues shall not be permitted.

The following requirements shall be complied with:

(a) VOC content limits on regulated adhesives stipulated in the Air Pollution Control (VOC) Regulation of Hong Kong.

(b) Shall not contain the following substances regulated in the Montreal Protocol on Substances that Deplete the Ozone Layer (particularly CFCs, HCFCs, 1,1,1- trichloroethane and carbon tetrachloride).

(c) Shall contain no more than 0.01% by wet weight of formaldehyde.

(d) Shall contain no more than 0.5% by wet weight of the sum total of aromatic compounds, which include benzene, toluene, xylenes, and ethylbenzene.

Resin for MDF panels **13.29A**

All urea formaldehyde bonded MDF panels and MUF mouldings shall be manufactured with low emission resins conforming to Class E1 of **BS EN 13986** emission standard.

Wood preservative **13.30**

Wood preservative shall be an approved proprietary brand exterior grade where completely concealed, or not decorated and colourless, coloured or suitable for overpainting where likely to be exposed or in contact with a painted finish.

Wood preservative to external timber **13.30A**

Wood preservative to external timber shall be applied as follow:

(a) Preparation : Timber shall be free from dirt and surface moisture.

(b) Application of Preservative: Apply by pressure impregnation in accordance with **BS 8417.**

Apply preservative in a manner that is not hazardous to health. Adhere strictly to the manufacturer's instructions.

(c) Cutting and Machining : Whenever possible, all cutting, planning, boring, drilling, notching or any other machining or manual operation shall be completed prior to preservative treatment.

(d) Incising : For certain timbers such as Douglas Fir which are difficult to impregnate, make 20 mm deep incisions coverage of 650 per m^2 in the direction of the grain all in accordance with **BS 144.** This method shall only be used on timber sections exceeding 80 mm thickness.

(e) Creosote Application : For timber where impregnation is not suitable and a paint finish is not required, when approved apply 2 coats of creosote in accordance with the manufacturer's instructions.

(f) Guarantee : Obtain a guarantee of 30 years for timber components against rot, insect attack and fungal decay.

(g) The product shall not contain any heavy metals or their compounds as listed below:

(i) Arsenic
(ii) Cadmium
(iii) Copper
(iv) Lead
(v) Mercury

Mosquito gauze **13.31** Mosquito gauze shall be one of the following:

(a) Plastic covered glass fibre 7 x 7 mesh per 10 mm^2.

(b) Stainless steel wire 11 x 11 mesh per 10 mm^2.

(c) Copper wire 11 x 11 mesh per 10 mm^2.

WORKMANSHIP

Generally **13.32** Workmanship generally shall be to **BS 1186**:Pt. 2.

Timber **13.33** Cut timber to required sizes and lengths as soon as practicable after the Works are begun, and store dry under cover so that the air can circulate freely around it.

Stack cut timber off a levelled, well-drained and maintained hard-standing ground and in such a manner as to prevent distortion.

Dimensions **13.34** Dimensions of sections shown on the drawings are finished sizes. Allow for planning and sanding faces to finished sizes.

Check site dimensions before prefabricating joinery fittings.

Framed joinery generally **13.35** Plane timber for joinery on all faces. Finish exposed faces to a fine glasspapered surfaces and round arrises to 1 mm radius.

Framed joints **13.36** Faces of framed joints shall be square and shall be driven together to give a close, accurate fit.

Prepare and frame up joinery work with dry joints and store until required for fixing. Before fixing open up all joints, put together with approved glue and wedge up. Replace any sections that have warped or developed shakes or other defects.

Running bonded joints **13.37** Running bonded joints shall be cross-tongued, using approved tongues. For work over 40 mm thick, use double tongues.

Joinery with clear finish **13.38** Protect from damage or discolouration joinery shall be left with clear finish. Submit proposals for protection for approval.

Prototypes **13.39** Prepare prototypes and obtain approval for repetitive fittings before starting fabrication.

Fixing **13.40** Plug and screw or secure timber sections to the backing by approved means.

Check location of buried services before fixing to walls and other surfaces.

Nailing **13.41** Nail timber sections securely to the backing and ensure that the nails do not split the timber. Split timbers shall be removed and replaced.

Punch nail heads below timber surfaces visible in completed work.

Nail weather boarding to wood framing with not less than two corrosion proofed nails in the width of each board at each framing member.

Screwing **13.42** When specified, screw timber sections to the backing including drilling pilot holes and countersinking heads flush with timber surfaces.

Screws shall be inserted full depth with a screwdriver and not hammered.

Countersink screw heads 5 mm (minimum) below timber surfaces shall be left with natural finish. Glue in colour and grain matched pellets cut from matching timber. Finish off flush with face.

Wood preservative **13.43** Apply wood preservative to all unexposed surfaces of timber including framing fillets etc. and backs of frames, skirtings etc., except surfaces with additional finishes such as laminated plastic sheet or painting.

Fixing plastic sheet **13.44** Do not fix laminated plastic sheet to timber with moisture content of more than 16%.

Acoustic tiles **13.45** Fix acoustic tiles and the like to timber battens or direct to sub-base by means of an approved adhesive used in accordance with the requirements of Clause 13.29 and manufacturer's recommendations.

Suspended ceilings **13.46** Construct suspended ceilings in accordance with **BS EN 13964**. Fix proprietary systems in accordance with the manufacturer's recommendations. Ensure that ceiling tiles and grids are properly set out and that all cutting is done at the perimeter unless required to be otherwise in Particular Specification. Fix all cover strips, edge trims and the like.

Boarded or strip flooring **13.47** Heading joints shall be cross-tongued, and staggered not less than two board widths apart.

Cramp flooring, to ensure a tight and accurate fit along the whole length of the joint.

Fix flooring with galvanized, sherardized or cadmium-plated wire nails.

Face nail square edged flooring not more than 100 mm wide, use two nails. Stop nail heads and finish flush.

Secret-nail tongued and grooved flooring at each support with one nail placed just above the tongue and driven on skew. Punch nail heads flush.

Fixing battens **13.48** On concrete, cast in or lay at 350 mm centres 50 mm x 40 mm twice splayed fixing battens pre-treated with wood preservative.

Door & panel **13.49** Softwood or hardwood species used for timber doors and panels shall comply with the following:

(a) Formaldehyde Emission: All wood panels shall be of Class E1 under **EN 13986** in respect of formaldehyde emission.

(b) The approved proprietary products shall not contain any heavy metals or their compounds as listed below:

(i) Arsenic

(ii) Cadmium
(iii) Copper
(iv) Lead
(v) Mercury

(c) The following substances shall not be added during manufacturing: elemental chlorine, fluorine, PCP (pentachlorophenol) and tar oils containing benzo(a)pyrene.

(d) The approved proprietary products shall have no flame retardant of polybrominated biphenyls (PBBs), polybrominated diphenyl ethers (PBDEs) or short-chain chlorinated paraffins added as formulated components.

The following requirements shall also be complied with for wood panels:

(a) The content of free formaldehyde in adhesives used in the product shall not exceed 0.5% by weight of the adhesive.

(b) Requirements of wood or wooden materials: the approved proprietary products shall meet one of the following requirement:

(i) 40% of the wood material is from recycled/waste wood;

(ii) The wood material obtains sustainable forest management certification such as Forest Stewardship Council (FSC), PEFC (Programme for the Endorsement of Forest Certification schemes) or equivalent.

Wood block flooring **13.50** Ensure that the base is clean and dry. Fix blocks to screed with an approved cold bitumen/rubber emulsion adhesive as in Clause 13.29. Lay to herringbone or basket pattern, as specified, with straight border two blocks (minimum) wide.

Provide 5 mm expansion gap at perimeter of areas of wood block flooring, and fill with one of the following:

(a) Cork strip

(b) Foam rubber strip

Sand surface of wood block flooring with an electric surfacing machine using sequentially graded abrasive paper to obtain a smooth surface ready to receive sealer or polish.

Machine shall be fitted with dust bag to control the release of dust.

Parquet flooring **13.51** Ensure the base is clean and dry. Lay blocks on one coat of an approved cold bitumen rubber emulsion adhesive applied to the screed with a serrated trowel. Leave flooring ready to receive sealer or polish. Sand surface of parquet flooring as Clause 13.50.

Door & frames general **13.52** Door frames shall not be used as formers for door opening construction unless with the permission of the SO, and never when proprietary door sets are required in the Contract. In all such circumstances, templates or formers must be used. The adoption of timber doorsets may be accepted subject to the approval of the SO.

Door with board finish **13.53** Construct hardwood ledged doors with 20 mm (minimum) vertical tongued and grooved boarding in about 150 mm widths. V-jointed on face side with ledges 5 mm thicker than boarding thickness and 100 mm wide for top ledge and 175 mm wide for middle and bottom ledges. Nail boarding to ledges and screw ends of ledges to boarding.

Ledged and braced **13.54** Construct hardwood ledged and braced doors as Clause 13.52 but with 100 mm wide diagonal braces of similar thickness to ledges. House braces to ledges and screw ends to boarding.

Framed, ledged and braced doors **13.55** Construct framed, ledged and braced doors of 45 mm (minimum) thickness with 115 mm wide stile and top rail, 225 mm wide middle and bottom rail, and 100 mm wide braces. Fill in with vertical boarding as Clause 13.52.

Panelled doors **13.56** Construct hardwood panelled doors 40 mm (minimum) thick, with 100 mm wide stiles, top rail and muntins and 200 mm wide middle and bottom rails. Flat panels shall be 20 mm thick. Groove rebate or leave open framing, as specified, for panels or glass.

Flush doors **13.57** Stiles and rails generally shall be 75 mm wide. For doors exceeding 900 mm side or 2000 mm high stiles to be 100 mm wide.

Infill for hollow core doors shall be 20 mm horizontal battens at 150 mm centres. Block out for lock fixing, door closers, or other ironmongery as specified, or composition board core approved by the SO.

Infill for solid core doors shall be 25 mm vertical battens tightly cramped together with the covering fully bonded both sides.

Cover both sides of the door with the following as specified:

(a) 3.2 mm standard hardboard

(b) 5 mm Plywood for painting

(c) 5 mm selected Hardwood faced plywood for clear finish

(d) Class HG laminated plastic bonded to 5 mm plywood

(e) Other board finish accepted by the SO.

Provide 12 mm selected hardwood lipping pinned and glued to all edges.

Lipping to meeting edges of folding doors and meeting edges and heels of swinging doors shall be 25 mm thick, rebated or rounded.

When specified, fit the bottom edge of doors with a 12 mm selected hardwood removable carpet strip screwed to the lipping.

Cupboard doors **13.58** Construct cupboard doors shall be one of the following:

(a) plywood or blockboard doors in maximum 500 mm wide each lipped on all edges with selected hardwood faced with laminated plastic sheet or prepared for painting,

(b) melamine faced and lipped chipboard doors in maximum 500 mm wide each as Clause 13.17, or

(c) hollow core doors as Clause 13.56.

Hanging cabinets **13.58A** Construct hanging cabinets with 18 mm (minimum) thick plywood or hardwood back and sides. Fix on wall by anchor bolts. Anchor bolt system shall be submitted to the SO for approval.

Openings in flush doors **13.59** Frame openings with 12 mm (minimum) selected hardwood lipping. Rebate lipping for glazing, if required.

Glazing beads **13.60** Provide glazing beads to match surrounding timber. Mitre at angles. Fix with screws and cups, where specified. Glazing beads shall not be less than 12 mm thick.

Fire resisting timber door **13.61** Fire resisting timber doors should be flush door as described above, including frames, hinges door closers and any other hardware and shall comply with **BS 476** Part **20-23** or Classification I1 of **BS EN 1634-1**.

		Proprietary fire doors should be tested in accordance with **BS 476** Part **20-23 or** Classification I1 of **BS EN 1634-1** and to the approval of the SO. Test report shall be provided to indicate that the material, product or construction is capable of resisting the action of fire for the specified period. The test shall be carried out and the test report shall be prepared by an Accredited Laboratory.
Smoke and intumescent seals	**13.62**	Folding or swing fire doors shall incorporate proprietary smoke seals and intumescent strips where necessary to attain the requirements of **BS EN 1634-3, BS EN 14600, ISO 5925-1, UL 1784, AS 1530:Part 7; or BS 476 Pt. 20-23**.
Acoustic doors	**13.63**	Acoustic doors shall be either solid core doors or composite core doors with air-tight seals to all junctions with frames and recessed threshold. Seal types shall be submitted to the SO for approval unless specified in the Contract. Airborne sound insulation shall be tested to **BS EN ISO 10140-1, 2 & 5** or **ASTM E413** and **ASTM E90.** Field ratings shall be tested to **ASTM E336** and **ASTM E413.** The Contractor shall guarantee both laboratory and field performance. The doors shall be accompanied with relevant test certificates or reports regarding the acoustic performance, issued by an accredited laboratory.
Doors and window frames	**13.64**	Construct doors and window frames with properly framed joints and fix using cramps or bolts as Clauses 14.108, 14.109, 14.116 and 14.117 and secure the bottom of door frames with dowels as Clauses 14.107 and 14.115. Lippings, particularly lippings at the closing & meeting stiles shall be profiled to ensure correct operation gaps to the satisfaction of **BS 4787-1.**
Door sub frames	**13.64A**	All door sub frames shall be pre-treated with wood preservative as Clause 13.43 with bedding as Clause 13.67. Shop drawings shall be produced by the Contractor/manufacturer showing construction details of door sub frame including setting out of fixing, method of fixing and plug details, etc. for the SO's approval. All works shall be carried out as per the approved shop drawings.
Bedding and pointing	**13.65**	Bed frames in cement mortar, leaving no gaps. For external doors, rake out external face 10 mm deep, and point with an approved sealant.
Architraves	**13.66**	Architraves shall be one length between angles. Mitre architraves at angle joints.
Drawers	**13.67**	Construct drawers with 20 mm thick front, as specified, 15 mm thick back and sides, as specified, dovetailed and framed together or alternatively with other types of joints with the approval of the SO, and 5 mm thick bottom housed on three sides. Set drawers to slide on proprietary runners. Submit ironmongery for approval.
Destructive test	**13.68**	Open-up inspection for each door construction type (hollow / solid) shall be carried out in 1 per batch of doors delivered to site as selected by SO, if the quantity of such type of doors exceeds 5 for the whole project.
Glued laminated timber	**13.69**	Glued laminated timber shall be to **BS EN 14080**.
Cross laminated timber	**13.70**	Cross laminated Timber shall be to **BS EN 16351**.
Engineered bamboo products	**13.71**	Engineered Bamboo products shall be to **BS ISO 23478**.

SECTION 14

IRONMONGERY

GENERAL

Source **14.1** Standard items of ironmongery may be supplied by the Employer except when it is specified that ironmongery shall be supplied by the Contractor.

Contractor's supply **14.2** Supply ironmongery in accordance with the Contract documents. All ironmongery shall be approved before orders are placed and shall be obtained from an approved manufacturer for that item and for the use intended.

Specification by name **14.3** Contractor's attention is drawn to Clause 1.15.

Standard **14.4** Unless more stringent standards are specified, all architectural ironmongery shall comply with the current editions of following British/European/National Standards:

Standard	Title
BS EN 179*	Building hardware. Emergency exit devices operated by a lever handle or push pad, for use on escape routes. Requirements and test methods.
BS EN 485-1+A1	Aluminium and aluminium alloys - Sheet, strip and plate - Part 1: Technical conditions for inspection and delivery
BS EN 485-2	Aluminium and aluminium alloys - Sheet, strip and plate - Part 2: Mechanical properties
BS EN 485-3	Aluminium and Aluminium alloys - Sheet, strip and plate - Part 3: Tolerances on dimensions and form for hot rolled products.
BS EN 485-4	Aluminium and aluminium alloys - Sheet, strip and plate - Part 4: Tolerances on shape and dimensions for cold-rolled products.
BS EN 515	Aluminium and aluminium alloys - Wrought products - Temper designations.
BS EN 573-1	Aluminium and aluminium alloys. Chemical composition and form of wrought products. Part 1: Numerical designation system.
BS EN 573-2	Aluminium and aluminium alloys. Chemical composition and form of wrought products. Part 2: Chemical symbol based designation system.
BS EN 573-3	Aluminium and aluminium alloys. Chemical composition and form of wrought products. Part 3: Chemical composition and form of products.
BS EN 573-5	Aluminium and aluminium alloys. Chemical composition and form of wrought products. Codification of standardized wrought products
BS EN 912	Timber fasteners. Specifications for connectors for timbers.
BS EN 1125*	Panic exit devices.
BS EN 1154*	Door closing devices.
BS EN 1155*	Electrically powered door holders.
BS EN 1158*	Door co-ordinators.
BS EN 1172	Copper and copper alloys. Sheet and strip for building purposes.
BS EN 1303	Cylinders for locks.
BS EN 1403	Corrosion protection of metals. Electrodeposited coatings. Method of specifying general requirements.
BS EN 1461	Hot dip galvanized coatings on fabricated iron and steel articles, specifications and test methods.
BS EN 1527	Sliding door gear.

BS EN 1634-1	Fire resistance and smoke control tests for door and shutter assemblies, openable windows and elements of building hardware. Fire resistance test for door and shutter assemblies and openable windows.
BS EN 1634-2	Fire resistance and smoke control tests for door, shutter and openable window assemblies and elements of building hardware. Fire resistance characterisation test for elements of building hardware.
BS EN 1634-3	Fire resistance and smoke control tests for door and shutter assemblies, openable windows and elements of building hardware. Smoke control test for door and shutter assemblies.
BS EN 1652	Copper and copper alloys. Plate, sheet, strip and circles for general purposes.
BS EN 1654	Copper and copper alloys. Strip for springs and connectors.
BS EN 1670	Corrosion resistance.
BS EN 1906	Building hardware. Lever handles and knob furniture. Requirements and test methods.
BS EN 1935*	Single axis hinges.
BS EN 2284	Specification for sulfuric acid anodizing of aluminium and wrought aluminium alloy.
BS EN 10029	Hot-rolled narrow steel strip. Tolerances on dimensions and shape.
BS EN 10048	Hot rolled narrow steel strip. Tolerances on dimensions and shape.
BS EN 10051	Continuously hot-rolled strip and plate/sheet cut from wide strip of non-alloy and alloy steels. Tolerances on dimensions and shape.
BS EN 10095	Heat resisting steels and nickel alloys.
BS EN 12051	Door and window bolts.
BS EN 12163	Copper and copper alloys - Rod for general purposes.
BS EN 12164	Copper and copper alloys - Rod for free machining purposes.
BS EN 12166	Copper and copper alloys - Wire for general purposes.
BS EN 12167	Copper & copper alloys - Profile and bars for general use.
BS EN 12168	Copper and copper alloys - Hollow rod for free machining purposes.
BS EN 12209	Building hardware. Locks and latches. Mechanically operated locks, latches and locking plates. Requirements and test methods.
BS EN 12320	Padlocks and padlock fittings.
BS EN 12365	Gaskets and weather stripping.
BS EN 12476	Phosphate conversion coatings of metals. Method of specifying requirements.
BS EN 13724	Letter plates.
BS EN 15338 + AI	Hardware for furniture strength and durability of extension elements and their components.
BS EN 15570	Hardware for furniture strength and durability of hinges and their components.
BS EN 15706	Hardware for furniture strength and durability of slide fittings for sliding doors and roll fronts.
BS EN 15828	Hardware for furniture: strength and durability of hinges prorating on a horizontal axis.
BS EN 16014	Hardware for furniture: strength and durability of locking mechanism.
BS EN 61558-1+A1	Safety of power transformers, power supplies, reactors and similar products. Part 1 - General requirements and tests.
BS EN ISO 1456	Metallic and other inorganic coatings - Electrodeposited coatings of nickel, nickel plus chromium, copper plus nickel and of copper plus nickel plus chromium.
BS EN ISO 1461	Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods.

BS EN ISO 2081	Metallic and other inorganic coatings. Electroplated coatings of zinc with supplementary treatments on iron or steel.
BS EN ISO 2082	Metallic coatings. Electroplated coatings of cadmium with supplementary treatments on iron or steel.
BS EN ISO 2931	Anodizing of aluminium and its alloys. Assessment of quality of sealed anodic oxidation coatings by measurement of admittance.
BS ISO 3864-1 & 4	Graphical symbols. Safety colours and safety signs.
BS EN ISO 7010	Graphical symbols. Safety colours and safety signs. Registered safety signs.
BS EN ISO 9445-1	Continuously cold-rolled stainless steel - Tolerances on dimensions and form - Part 1: Narrow strip and cut lengths.
BS EN ISO 9445-2	Continuously cold-rolled stainless steel - Tolerances on dimensions and form - Part 2: Wide strip and plate/sheet.
PD CEN/TR 15349:2006	Hardware for furniture strength and durability of hinges and their components. Terms for extension elements and their components.
PD CEN/TR 15588:2007	Hardware for furniture strength and durability of hinges and their components. Terms for hinges and their components.
PD CEN/TR 15709:2008	Hardware for furniture strength and durability of hinges and their components. Terms for slide fittings for sliding doors and roll fronts.
PD CEN/TR 16015:2010	Hardware for furniture: Terms for locking mechanism.
BS 476	Fire tests on building materials and structure.
BS 1449-1.1/1.8/ 1.14	Steel plate, sheet and strip.
BS 3621	Thief resistant locks.
BS 5499-2,4,6 & 10	Safety signs, including fire safety signs.
BS 5839 Pt. 3	Fire detectors and automatic release mechanisms.
BS 6100-1	Building and civil engineering - Vocabulary - Part 1: General terms.
BS 6100-6	Building and civil engineering - Vocabulary - Part 6: Construction parts.
BS 6496	Powder organic coatings for application and stoving to aluminium alloy.
BS 8220	Guide for security of buildings against crime.

* Products manufactured to these standards should meet the requirements of CE marking and carry the mark where they are intended for use on fire/smoke and locked doors on escape routes.

Other National Standards:

AAMA 611-98	American Architectural Manufacturer Association Voluntary Specification for Anodized Architectural Aluminum
ANSI/BHMA A156.18-2006	American National Standard for Materials and Finishes
AS 1476-1974	Australian Standard Specification for metric wood screws

DOOR IRONMONGERY

Certification **14.5** Fully detailed catalogues, certificates of compliance or other documentary evidence from recognised testing laboratories accredited by UKAS or HKAS under the HOKLAS, or equivalent accreditation schemes, of the specified proprietary products shall be supplied to the satisfaction of the SO that the ironmongery complies with the GS.

Certification for fire door **14.6** Individual independent fire test/assessment certificates to **BS EN 1634** specific to each fire rated door assembly proposed for the Works shall be submitted to confirm compliance with required fire resistance ratings.

Fire and smoke control assemblies **14.7** Ironmongery to fire rated and/or smoke control assemblies must satisfy the requirements of relevant statutory and regulatory bodies and the relevant sections hereof.

Samples **14.8** Samples of all items of ironmongery shall be submitted for approval before placing order.

Ironmongery schedule **14.9** A door-by-door ironmongery schedule, including all other separate ironmongery items shall be supplied when samples have been approved. All components shall be identified by manufacturers' name and reference number and country of origin and cover the requirements of smoke stop and fire-rated doors, detail door thicknesses, handing, suiting and master keying. Upon approval, this schedule shall form the basis for confirming the requirements for ironmongery. No alteration to this schedule shall be permitted without prior approval.

Compatibility **14.10** Ironmongery shall be properly matched, fully coordinated suite, of consistent design and finish, and obtained from approved reputable source.

Manufacturer's instructions **14.11** One complete set of manufacturer's fixing and maintenance instructions shall be provided prior to delivery.

Packing **14.12** Ironmongery, complete with fixings and fixing instructions shall be supplied, suitably boxed and delivered in sets where appropriate and marked in a manner to suit site installation requirements. When ironmongery is delivered in sets, each set shall be bagged and labelled with the door number to which it shall be fixed. All items with appropriate fixing screws of a length and pattern shall be supplied to suit the construction to which the items shall be fixed.

Keys **14.13** A minimum of two keys for each lock shall be provided, each fitted with a stainless steel split ring and a 25 mm diameter x 1.5 mm thick plastic disc engraved with the number of the lock or room number in figures a minimum of 5 mm high.

Arrange with the SO for the safe storage and handling of keys and ensure their receipt by the SO on completion of the Contract. When master keying is specified, the master keys shall be forwarded direct to the SO.

Materials **14.14** Materials as specified shall comply with the following standards:

Aluminium: Refer to in Clause 17.7.

Stainless Steel: Grade 316 (18/10/3 molybdenum bearing grade) referred to in Clause 17.9. Lower grades will not be accepted for accessories such as lock strike plates, rebate components, etc.

Brass: Plate, sheets, strips and circles: **BS EN 1652** No. CW 612N R420 or H120.

Profile, rod, hollow rod, wire and bars: **BS EN 12163, BS EN 12164, BS EN 12166, BS EN 12167** and **BS EN 12168** No. CW 614N R430 or H110.

Real Bronze**:** Solid cast bronze of suitable copper-tin alloy according to **BS EN 1412, BS EN 12163, BS EN 12164, BS EN 12166, BS EN 12167** and **BS EN 12168** or **ANSI/BHMA A156.18.**

The product shall not contain any heavy metals or their compounds as listed below:

(a) Arsenic
(b) Cadmium
(c) Lead
(d) Mercury

Finishes

14.15 Finishes as specified shall comply with the following standards:

Stainless Steel shall be to **BS EN 10095**.

Electroplated coatings of nickel and chromium shall be to **BS EN ISO 1456**.

Anodic oxidation coating on aluminium shall be to **AAMA 611-98.**

Electroplated coatings of cadmium and zinc on iron or steel shall be to **BS EN ISO 2081** and **BS EN ISO 2082.**

Phosphate treatment of iron and steel shall be to **BS EN 12476**.

14.16 Finished surfaces of one material whether extruded, rolled, cast or stamped, shall match exactly in colour and texture and all finishes visible on a door face shall be visually identical, unless otherwise specified.

14.17 All concealed components including lock bodies shall be protected by the manufacturer's standard finish which shall, where applicable, comply with the above standards.

14.18 Iron or steel surfaces shall be protected by galvanizing to **BS EN ISO 1461**, zinc or cadmium plating to **BS EN ISO 2081** or **BS EN ISO 2082** or other approved methods, to **BS EN 1670** Class 3 corrosion resistance.

Fixings

14.19 Suitable, matching, metric, positive drive fixings (e.g. Allen key, 'Supadriv' or 'Pozidriv') of correct types and lengths shall be provided for background constructions, with visible finishes to match the item fixed.

Hinges and pivots

14.20 Hinges and pivots shall be to **BS EN 1935** of the appropriate class for the door size, weight and duty, with heavy-duty, maintenance free, concealed bearings.

14.21 Where door closers incorporating hold-open devices or a backcheck facility, hinges with a minimum Grade 12, 13 or 14 to **BS EN 1935** shall be used.

14.22 Hinges shall be stainless steel, all finished to match other hardware on the door face, including plating to match brass, bronze or other finishes, where required.

14.23 Hinges with nylon bearings shall not be permitted in fire-resisting door assemblies.

14.24 Hinges shall be countersunk drilled, fixed with matching screws and of the following types:

(a)	For timber doors and frames:	Jig drilled, with staggered drilling pattern and 12 screw gauge (SG) x 32 mm wood screws
(b)	For pressed steel doors and frames:	ANSI template drilled with M5 or M6 x 12.5 mm machine threaded screws
(c)	For timber doors with steel frames:	Different drilling patterns for leaf and frame as appropriate to timber and metal substrate

14.25 Outward opening external and/or security doors shall be provided with hinges with integral security studs.

14.26 Unless otherwise specified, two hinges shall be provided per leaf up to 1800 mm high and one extra hinge for each additional 450 mm height (or part thereof).

14.27 Conductor hinges or concealed fixing, flexible metal cable loops shall be provided to transfer wiring for electromagnetic fire hold closers, solenoid locks and the like between frame and door leaf.

14.27A The centre hung top pivot hinge used for door installation shall comprise the top pivot hinge assembly fixed onto the door frame and the bottom strap fixed onto the top rim of door leaf. The retractable pin of the top pivot hinge assembly shall be inserted into the bottom strap with adequate depth in accordance with the manufacturer's requirements. Insertion depth indication marker of conspicuous colour shall be set up on the retractable pin of top pivot hinge during installation of door for ease of routine inspection in future.

Overhead door closers

14.28 Door closing devices shall be hydraulic controlled closing types, from matching suites, with a full range of optional functions, including adjustable power, adjustable backcheck, mechanical and electromagnetic stand open and delayed closing. Uncontrolled devices (e.g. spring hinges) are unacceptable, due to noise of operation and potential for damage to doors, frames, ironmongery, etc.

14.29 All door closing devices used on metal fire rated doors shall incorporate fire retardant fluid.

14.30 Overhead door closers shall be capable of being fitted on either hand of the door and shall close the door positively. Regulation of the closing and latching speed shall be undertaken by independent control valves.

14.31 Closers for fire rated doors shall be tested to and comply with **BS EN 1154** Category of Use 4, to close a door from up to 180 degrees. In accordance with the Door and Hardware Federation (DHF), Code of Practice “Hardware for Fire and Escape Doors” (Clause 3.3.1), Certified, Approved and CE Marked. No closer for use on a fire rated door shall be less than power Size 3.

14.32 All products to have been incorporated in successful fire tests and assessed to **BS 476-22** (30, 60 and 120 minutes) and **BS EN 1634** (30, 60 and 120 minutes).

14.33 In addition to the corrosion test requirements of **BS EN 1154**, which relate to performance only, the visual requirements for significant surfaces shall be identified according to **BS EN 1670** Clause 4.7 Grade 3 to **BS EN 1154** shall apply.

14.34 Overhead surface closers shall suit doors of either hand and have 50 mm maximum projection, plain, rectangular, solid bodies of aluminium, brass or stainless steel construction, with visible surfaces, including arms, finished identically to other items on the door and with no permanent visible markings (except as required by relevant standards).

14.35 Overhead surface closers, except to plant rooms and pipe ducts shall be equivalent to **BS EN 1154** Class 4-8-2/4-1-1-3, power adjustable for doors from 400 mm to 1100 mm wide and 40 kg to 80 kg mass, or equivalent grade to Table 14.1 for doors of greater width/mass. They shall incorporate adjustable, hydraulic backcheck.

14.36 Overhead surface closers to plant rooms and pipe ducts shall be equivalent to universal arm (push- or pull-to) type, to **BS EN 1154** Class 4-8-2/4-1-1-3, for doors up to 1100 mm wide and 80 kg mass or equivalent grades to Table 14.1 for doors of greater width/mass.

14.37 To avoid reductions in efficiency which may result when fixing surface mounted closers on the pull side of a door, test data for all closers specified with parallel (pull-to) or universal (push- or pull-to) arms shall be provided to show that the closer achieves the specified power classification(s) when mounted on the pull side of the door.

14.38 Where universal (push- or pull-to) arms are specified, the closers shall be fitted on the least visible face of the door.

14.39 Door mounted overhead concealed closers shall be equivalent to the **BS EN 1154** Class 4-8-2/4-1-1-2, adjustable for doors from 500 mm to 1100 mm wide and 40 kg to 80 kg mass, or equivalent grades to Table 14.1 for doors of greater width/mass. The minimum door thickness shall be 45 mm.

14.40 Transom mounted overhead concealed closers shall be to **BS EN 1154** Class 4-8-4-1-1-3, for doors from 850 mm to 1100 mm and 80 kg mass, or equivalent grades to Table 14.1 for doors of greater width/mass.

Floor springs

14.41 Floor mounted concealed closers shall be heavy duty, adjustable, hydraulic check types, with thermo-constant stabilising fluid. All floor springs shall be non-handed (i.e. they are reversible). Single action straps are to be Grade 316 stainless steel, double action straps shall be forged steel, both with full intumescent protection. Also refer to Clause 14.27A.

14.42 All floor springs for double swing doors, including plate glass assemblies, shall have micro-adjustable toe-in and positive centring, to ensure that leaves can be fully aligned in closed position.

14.43 Single and double action floor springs shall be hydraulic check spring mechanisms sealed into an oil or hydraulic fluid box complete with a loose protected steel box for fixing within a concrete floor, a detachable cover plate with waterproof seal. Adjustment within the box shall provide full horizontal movement for door alignment, final positioning and height adjustment. The position of the floor spring within the loose box shall be adjustable after installation. The non-adjustable bottom strap shall be designed to suit the type, size and weight of the door but shall not be less than 160 mm long with holes for four screws. The top centre for double action floor springs shall be adjustable. If specified, a hydraulic back check shall be incorporated effective for the opening angle of the floor spring.

14.44 On single action floor springs, the bottom strap and top centre shall be suitably offset to suit the frame details, projection of pull handles, adjoining wall layout and other aesthetic aspects.

14.45 Where floor springs are fitted to a fire rated door, the floor springs shall have been tested in conjunction with an appropriate fire rated door and passed the integral fire test in accordance with **BS 476-22** or **BS EN 1634**.

In the event that the springs are fitted to metal doors, the specification shall be the same except that a non-ferrous strap shall be provided to suit the profile of the bottom rail of the door and the top centre shall suit the top rail of the door.

14.46 Exposed parts shall be finished to the same standard as the rest of the ironmongery unless stated otherwise in contract requirements. The top plate shall be satin finish stainless steel, 18/10/3 quality unless stated otherwise in contract requirements.

14.47 Floor springs for main circulation routes, auditorium and other heavy use locations shall be equivalent to **BS EN 1154** Class 4-8-2/6-1-1-3, power adjustable for doors from 300 mm to 1400 mm wide and 20 kg to 120 kg mass, or equivalent grade to Table 14.1 for doors of greater width/mass. They shall incorporate adjustable, hydraulic or mechanical backcheck, built-in levelling device and complete with Grade 316 stainless steel covers.

14.48 Floor springs for other locations shall be equivalent to **BS EN 1154** Class 4-8-1/4-1-1-3, adjustable power for doors up to 1100 mm wide and 100 kg mass, or equivalent grades to Table 14.1 for doors of greater width/mass. They shall incorporate hydraulic or mechanical backcheck, built-in levelling device and complete with Grade 316 stainless steel covers.

TABLE 14.1
BS EN 1154

1	2	3	4	5	6	7	8	9
Door closer power size	Recommended door leaf width	Test door mass	Closing moment				Opening moment between 0° and 60°	Door closer efficiency between 0° and 4°
			between 0° and 4°		between 88° and 92°	any other angle of opening		
	mm max.	kg	Nm min.	Nm max.	Nm max.	Nm min.	Nm max.	% min.
1	<750	20	9	<13	3	2	26	50
2	850	40	13	<18	4	3	36	50
3	950	60	18	<26	6	4	47	55
4	1100	80	26	<37	9	6	62	60
5	1250	100	37	<54	12	8	83	65
6	1400	120	54	<87	18	11	134	65
7	1600	160	87	<140	29	18	215	65

NOTE 1: The door widths given are for standard installations. In the case of unusually high or heavy doors, windy or draughty conditions, or special installations, a larger power size of door closer should be used.

NOTE 2: The test door masses shown are only related to door closer power sizes for the purpose of the test procedure. These test door masses are not intended to indicate maximum values for actual use.

Barrier Free Access **14.49** Door closing devices shall be designed to allow exterior and interior doors to be opened with forces of not more than 30 N and 22 N respectively. Closers for interior doors shall have a closing period of at least 3 seconds measured from an open position of 70° to a point 75 mm from the closed position measured from the leading edge of the door. Door closing devices include door closers and floor spring.

Electromagnetic fire-hold closers **14.50** Electromagnetic fire-hold closers shall be to **BS EN 1155** and of the same design, finish and standards as other closers. Surface type fire-hold closers and floor-mounted concealed type shall be equivalent to Class 3-5-4-1-1-3. They shall allow the door to:

(a) Hold open electro-magnetically when set and, on receipt of a signal from a central fire alarm or other device, automatically release and properly close.

(b) Close immediately if physically pushed to, if an integral fire officer test button is pressed, or if power fails.

14.51 Power sources for fire hold closers shall be Class II Safety Isolated Transformers to **BS EN 61558-1+A1**. If fire alarm systems do not incorporate clean contacts, transformers shall incorporate relay control interfaces.

Automatic door operators **14.52** Automatic door operators shall be approved, high quality devices to **BS 7036**, to suit the door construction, configuration, location and frequency of use and operate at 230/240 vAC 50 Hz. Finishes shall match other hardware on the door and units shall be frame mounted wherever possible, on the door face least susceptible to weather and/or tampering.

14.53 Operators for fire rated doors shall be of suitable types which will not compromise the fire resistance rating, linked to fire alarm systems to close automatically in case of fire.

14.54 Operators shall allow adjustment of opening and closing speed, hold open time, backcheck and power and allow manual override, in case of power failure.

Door selectors **14.55** Where one leaf of a pair of self-closing doors must close before the other, due to rebated styles, latch bolts, suitable matching selectors to **BS EN 1158** Class 3-5-*-

1-1-3 (where "*" denotes the appropriate door mass from Table 14.1), of types which do not obstruct ironmongery or affect fire resistance ratings, shall be supplied. Use sprung-arm, under-frame fixing selectors for outward opening doors and gravity face fixing types for inward opening doors.

Locks

14.56 Mortice lock suites shall be to **BS EN 12209** with:

(a) Forends and strike plates and rebate components if for rebated meeting edges, of materials to match door furniture, with no exposed sharp edges or corners.

(b) Piercing for bolting through of single sided lever or knob furniture, if required.

(c) Facility for full reversal of handing, without opening the case.

(d) If to receive lever handles, special, heavy springing against progressive lever droop (levers with sprung roses or back plates are unacceptable due to potential for damage and corrosion).

(e) If to receive knob handles, soft springing, with two-way action and 100mm minimum backset.

14.57 Cylinders shall be easily removable when the door is open, without dismantling trim but non-removable when closed.

14.58 Heavy duty, modular, security locks shall be obtained from an approved reputable source with 60 mm minimum backset and 72 mm centres. Latch bolts shall be 11 mm (minimum) low friction type, and deadbolts shall have 20 mm (minimum) throw (except for privacy function lock) with griptight 8 mm followers for noise reduction, closing efficiency, security and improved durability.

14.59 Heavy duty, high security locks and electrical solenoid locks shall have equivalent of 19 mm (minimum) throw stainless steel, three part, low friction, guided latch bolts with anti-thrust devices and/or 25 mm (minimum) throw deadbolts with hardened steel rollers, as appropriate. They shall be certified by an approved security body and shall have been tested in conjunction with an appropriate fire rated door and passed the integral fire test in accordance with **BS 476-22** or **BS EN 1634**.

14.60 General duty locks shall have equivalent of 11 mm (minimum) plated brass latch bolts and 13 mm (minimum) plated brass deadbolts, with hardened steel rollers. WC cubicle locks shall be mortice type, with inside thumbturn and coin operated, outside emergency release. Emergency releases shall incorporate red/white outside indicators.

Security locks

14.61 Security locks shall be to **BS 3621**.

14.62 Security locks shall have minimum of five levers or, if pin or disc, mechanisms shall have a minimum of six pin or disc tumblers or more than one row of pins and rollers, such rows shall not be in the same plane.

14.63 Forends shall be of double thickness and each lock shall be capable of being fitted to fully rebated doors with 12.5 mm or 25 mm deep rebate by the addition of a rebating set.

14.64 Keys shall be registered in the name of the Government and duplicates only obtainable through the manufacturer. Prior to ordering, agree with the SO the method of ordering, supplying and fixing to ensure the maintenance of security. Master keying shall not be permitted.

14.65 Exposed parts shall be satin finish stainless steel 18/10/3 quality. Rebating set shall be nickel plated brass to match.

Mechanical locking cylinders and keying

14.66 Cylinders shall be to **BS EN 1303** to match door furniture (including coloured finishes).

14.67 Standard cylinder lengths shall suit doors up to 55 mm thick, when used with the specified roses or back plates, with other lengths available as required.

14.68 Lock cylinders shall be capable of achieving required master keying systems, with adequate provision for future expansion, without compromise to security and without the need to cut keys to depths at which they become susceptible to breakage.

14.69 General lock cylinders shall be of five-pin, integrated keyway types, with double paracentric keyways, mushroom drivers, triple grooved, anti-pick pins, hardened anti-drill pins, off-centre cams and three keys per cylinder as standard to **BS EN 1303** Grade 3.

14.70 High security lock cylinders shall be equivalent of six-pin, double-locking types, offering practically infinite differs, with double paracentric keyways, mushroom drivers, triple grooved, anti-pick pins and multiple side pins, hardened anti-drill pins, off-centre cams and three keys per cylinder as standard to **BS EN 1303** Grade 5.

14.71 Padlocks shall be of appropriate grades to **BS EN 12320**, and capable of master and construction keying together with other locks.

14.72 Unless otherwise stated, locks and panic exit devices shall be keyed to a system of Grand Master, Master and Sub-Master suites without compromise to security standards and shall be construction keyed, with ten keys provided for site use. On completion, operation by a master key shall exclude all construction keys.

Door furniture and plates

14.73 Lever assemblies shall be non-sprung, to **BS EN 1906** incorporating four heavy duty captive, maintenance free, self lubricating and corrosion resistant bearings. Roses shall be concealed bolt through fixings type.

14.74 Spindles for furniture shall be corrosion proofed, high tensile steel. Standard spindles shall suit 35 - 55 mm thick doors.

14.75 Where half sets of furniture are to operate locks, special spindles requiring no piercing of the opposite door face shall be used.

14.76 For pairs of dummy levers or knobs “Rigidisers” shall be provided. For single sided dummy levers or knobs “Rigidisers” and special spindles requiring no piercing of the opposite door face shall be provided. Face fixed, fix dead spindles are unacceptable, due to vulnerability to forcible damage.

14.77 Pull handles shall be supplied with bolt through fixings and seating cups, concealed by push plates on the reverse face, or back-to-back fixings as appropriate. Face fixed pulls are acceptable only if unavoidable.

14.78 Protection plates shall be minimum 3 mm thick if aluminium and 1.6 mm thick if stainless steel or brass, with edges softened and radiused corners, to prevent injury. Fix plates with suitable countersunk screws located 5 mm from edges, at each corner and equally spaced, at 225 mm maximum centres. Clearance from the edge of the door or door frame shall not be more than 4 mm.

14.79 Furniture for privacy locks shall incorporate inside thumbturn and coin operated, outside emergency release. In public areas, emergency releases shall incorporate red/white outside indicators.

Panic exit devices

14.80 Panic exit devices shall be provided en-suite to match the door hardware.

14.81 All panic exit devices shall comply with **BS EN 1125** with the activating bar horizontally across the inside face of the door operating when pushed anywhere along its effective length in the direction of the exit and/or moved in a downwards arc. Where panic exit devices have vertical shoots, they shall have an automatic catch holding the bolts in a withdrawn position when the doors are opened and automatically releasing the bolts on the closing of the door.

14.82 Horizontal bar operated panic exit devices to single leaf doors in front of house and area accessible to the public shall be easily reversible, low projection, touchbar type to **BS EN 1125** Grade 3-7-6-1-1-3-2-2-B, with secret "hold unlocked" facility and photo-luminescent "in bar" signage to **BS 5499-2, 4, 6 & 10** and/or **BS ISO 3864-1 & 4**. Standard units shall suit doors 800 - 1380 mm wide and up to 3000 mm high, with options for other sizes as required.

14.83 Horizontal bar operated panic exit devices to single leaf doors in service areas accessible only to maintenance staff may be standard projection, push bar type to **BS EN 1125** Grade 3-7-5-1-1-3-2-2-A.

14.84 Panic exit devices to pairs of doors shall not allow escape to be prevented by padlocking a chain around crossbars or other components.

14.85 In addition to the corrosion test requirements of **BS EN 1125**, which relate to performance only, the equivalent visual requirements for significant surfaces of **BS EN 1670**, Clause 5.7 Class 3 shall apply.

14.86 Panic exit devices shall accept an outside cylinder and/or lever or knob handle operators, local alarms, remote monitoring and/or motor operation as required.

Bolts

14.87 Bolts shall be to **BS EN 12051** and of the following minimum classifications:

(a) Flush bolts: Class 3-4-0-1-1-3-3, comprising keep and easy clean floor socket in wet areas or dust-excluding floor socket in other areas. Bolts shall have a 9.5 mm (minimum) diameter and shall be suitable to secure the inactive leaf of locking pair of doors.

(b) Barrel, tower and mortice bolts: Class 3-4-0-1-1-3-3.

(c) Foot drop, square spring of garage door bolts and padlock bolts: Class 3-4-0-1-1-4-4.

14.88 Unless otherwise stated:

(a) Bottom bolts shall be 150 mm minimum long.

(b) Top bolts to doors up to 2000 mm high shall be 150 mm long. For taller doors, increase bolt length by 150 mm for each 150 mm of additional height, or part thereof. For very tall doors, automatic flush bolts may be substituted.

14.89 Bolts shall be of a high quality, lever action, flush type, with dovetail returns to resist forcing and/or frame damage. Mount lever action flush bolts to door edges, wherever practical, for concealed fixing.

14.90 Bolts to duct doors shall be of a good quality and anodised aluminium, surface type. Where doors open outwards, top bolts shall be necked to allow proper fixing.

Door stops

14.91 Door stops for the protection of doors, ironmongery or surfaces shall be of concealed fixing types with robust holders matching other ironmongery on the door and rubber inserts, which are easily replaceable.

Sliding gear

14.92 Sliding gear shall be high quality, proprietary units of suitable type and capacity, to **BS EN 1527**.

Flush pulls

14.93 Flush pulls and sliding door locks shall be from the same suite as other architectural ironmongery.

Sundries

14.94 Ironmongery sundries hardware shall suit the location and function and match architectural ironmongery in quality, design and finish.

Hat and coat hooks

14.95 Where hat and coat hooks are vulnerable to abuse, heavy-duty hooks independently certified to withstand 1000 N applied load without deformation with the fixings supplied, shall be used. In psychiatric or detention facilities, units which collapse if improperly used and can be subsequently reset, shall be used.

Door guard **14.96** Door guard shall be of brass, alloy or other metallic construction, complete with No. 10 x 30 mm wood screws, properly anchored and capable to withstand substantial impact load when engaged. Finish shall match other ironmongery on the door.

Door viewer **14.97** Door viewers shall have viewing angle not less than 180°.

Indicating sign plates **14.98** Indicating sign plates shall be as for push plates, but satin anodised aluminium plates shall not be less than 1.6 mm thick. Self-luminous exit signs to comply with **BS 5499- 2.**

14.99 Fire safety signs, notices and graphic symbols shall be as for push plates, manufactured to the standards laid down in **BS ISO 3864-1**.

FURNITURE IRONMONGERY

Fittings to drawers and cupboards **14.100** Fittings to drawers, cupboards and other joinery fittings shall be of a quality to match the door hardware in a co-coordinated range.

(a) Hinges shall be stainless steel or chromium plated brass.

(b) Standard drawer locks shall be cast zinc with a brass, or chromium plated brass cap approximately 22 mm diameter with a four tumbler cylinder and a 4 mm thick brass bolt. Locks for cash drawers shall be fitted with a brass spring loaded bolt.

(c) Flush or surface bolts shall have a minimum of a 6 mm diameter shoot.

(d) Ball catches shall have a 9.5 mm diameter ball mounted in a face plate complete with matching striking plate.

(e) Magnetic door catches shall have a plastic casing with overall length not less than 45 mm.

(f) Flush pulls shall be 100 x 50 x 18 mm deep fixed with four countersunk screws.

(g) Drawer pulls shall be 7.5 mm diameter rod twice bent to form handle 100 x 25 mm overall length each leg fitted with 3 mm threaded rod one end drilled and tapped at least 15 mm into the leg and the other end fitted with two flat washers and a nut.

(h) Drawer slides shall be heavy-duty rust proofed enamelled steel, with nylon cages and steel bearings able to bear the required load at full extension and with positive closing action

Finishes **14.101** Fittings shall be finished as follows:

(a) Stainless steel.

(b) Satin anodised aluminium.

(c) Chromium plated brass.

Workmanship **14.102** Ironmongery shall be fitted and fixed in accordance with the manufacturer's recommendations, where applicable, manufacturer’s fixing templates shall be used.

14.103 All morticing of doors and frames shall be carefully done to ensure that mortices are not oversize and that items are securely fitted, especially items morticed into half hour doors and frames where their fire-rated performance may be invalidated. Items morticed into one hour doors and frames must be protected by intumescent materials. For locks and latches, this protection shall comprise a layer of approved intumescent sheet on each side of the lock or latch case; any other morticed items shall be painted with intumescent paint before being fitted.

14.104 Screws shall be properly inserted to drilled pilot holes with a correctly sized screwdriver. Screws must not be hammered even part of the way in.

14.105 Items when fixed where the screw head is burred shall have the screws replaced. Where required, screw or bolt threads shall be plugged to suit the construction to which the item is fixed.

14.106 Ironmongery shall be oiled and adjusted where required and left in perfect working order.

IRONMONGERY SUNDRY

Materials

Dowels for fixing door frames **14.107** Dowels shall be 16 mm diameter galvanised steel rod 75 mm long.

Fixing cramps **14.108** Fixing cramps for door frames, and the like fixed in brick or block walls shall be 30 mm x 3 mm galvanised steel flat 250 mm girth, turned up at one end and twice drilled to suit No. 12 gauge screws and flanged at the other end.

Fixing bolts **14.109** Unless otherwise specified, fixing bolts for door frames, and the like fixed to concrete shall be not less than 10 mm diameter proprietary expanding anchor bolts 120 mm long overall, with nut and washer.

Water bar **14.110** Water bar shall be galvanised steel, stainless steel, aluminium plate or brass flat bars as specified.

Curtain track **14.111** Curtain track shall be an approved proprietary brand complete with matching fittings of the same make, as follows:

(a) Rigid UPVC ‘T’ box section track with nylon slides.

(b) Regular of double duty enamelled steel ‘C’ section track with nylon runner.

(c) Regular of double duty enamelled steel ‘C’ section track complete with cord operation.

Curtain rail **14.112** Curtain rail shall be stainless steel heavy duty hollow tube with matching purpose-made end flanges, all to the dimensions specified.

Towel rail **14.113** Towel rail shall be stainless steel heavy duty hollow tube with matching purpose-made end flanges.

Timber connectors **14.114** Steel connectors for timber shall be galvanised, round, tooth-plate type to **BS EN 912**.

Workmanship

Metal dowels **14.115** Fix dowels 40 mm into bottom of door frame jambs, etc., with a tight push fit, and bed the other end in floor in cement mortar.

Fixing cramps **14.116** Fix cramps to frames at 900 mm (maximum) centres with the upper and lower cramps 300 mm (maximum) from the end of the jamb, using two 12 SG screws and build-in the other end.

Fixing bolts **14.117** Secure frames to concrete walls with bolts at 900 mm (maximum) centres with the upper and lower bolts 300 mm (maximum) centres from the ends of the jamb as fixed in accordance with the manufacturer's recommendations.

Water bar **14.118** Bed water-bar in waterproofing cement mortar leaving no gaps.

Curtain track	**14.119**	Fix curtain track in accordance with the manufacturer's recommendations including runners at the rate of 13 Nos/m and all other accessories including bracket, stopped ends and overlap set. When specified, install cord sets and leave in proper working order.
Curtain rail	**14.120**	Plug and screw end flanges of curtain rail to brick or concrete wall with stain less steel screws.
Towel rail	**14.121**	Plug and screw end flanges or brackets of towel rail to brick or concrete wall with stainless steel screws.

SECTION 15

STRUCTURAL STEEL WORK

GENERAL

Generally **15.1** The use of structural steelwork shall be to the **Code of Practice for the Structural Use of Steel** including its latest amendments and revisions issued by the Buildings Department except otherwise stated.

MATERIALS

Mechanical properties and chemical composition **15.2** Unless specified otherwise, all structural steel shall be Grade S275JR or S355JR, hot-rolled or hot-finished structural steel complying with **BS EN 10025** or **BS EN 10210** respectively, except that hot-finished hollow sections shall be Grade S275J0H, S275J2H, S355J0H or S355J2H complying with **BS EN 10210-1**.

Dimensions and tolerances of hot-rolled or hot-finished sections and plates **15.3** Dimensions and tolerances shall comply with the standards shown in Table 15.1:

TABLE 15.1

Section	Dimensions	Tolerances
Universal Beams and Columns	**BS 4-1**	**BS EN 10034**
Joists	**BS 4-1**	**BS EN 10024**
Channels	**BS 4-1**	**BS EN 10279**
Angles	**BS EN 10056-1**	**BS EN 10056-2**
Split Tees	**BS 4-1**	**BS EN 10034**
Rolled Tees	**BS EN 10055**	**BS EN 10055**
Plates (reversing mill)	-	**BS EN 10029**
Plates (cut from coil)	-	**BS EN 10051**
Wide flats	-	**UNI EU 91**
Hollow Sections	**BS EN 10210-2**	

Cold-formed open sections and profiled steel sheets **15.4** Cold-formed open sections and profiled steel sheets shall comply with **BS 5950-7** or equivalent. Proprietary products may be used with prior approval of the SO.

Cold-formed hollow sections **15.5** The mechanical properties, chemical composition, dimensions and tolerances of cold-formed structural hollow sections shall comply with **BS EN 10219-1** and **BS EN 10219-2**.

Ordinary bolts, nuts and washers **15.6** Ordinary bolts, nuts and washers shall comply with the standards given in Table 15.2, unless specified otherwise:

TABLE 15.2

Grade	Bolt	Nut	Washer
4.6	**BS 4190**	**BS 4190** (Grade 4)	**BS 4320**(1)
8.8	**BS 4190**	**BS 4190** (Grade 8) (2)	**BS 4320**(1)
10.9	**BS 4190**	**BS 4190** (Grade 10) (3)	**BS 4320**(1)

(1) Black steel washers to section 2 of **BS 4320**, normal diameter series.
(2) Nuts for galvanized or sherardized 8.8 bolts should be grade 10 to **BS 4190**.
(3) Nuts for galvanized or sherardized 10.9 bolts should be grade 12 to **BS 4190**.

High strength friction grip bolts nuts and washers **15.7** High strength friction grip bolts and associated nuts and washers shall be to **BS EN 14399-1** to **BS EN 14399-8** and **BS EN 14399-10,** unless specified otherwise.

Drill anchor bolts **15.8** Unless specified otherwise, all drill anchor bolts for external environment shall be in Grade A4 stainless steel to **BS EN ISO 3506-1** to **BS EN ISO 3506-4**, and electroplated anchors and hot-dip galvanized anchors shall not be allowed.

Holding down bolts **15.9** Unless specified otherwise, holding down bolts and associated nuts and washers shall comply with Table 15.3:

TABLE 15.3

Grade	Bolt	Nut	Washer
4.6	**BS 7419**	**BS 4190** (Grade 4)	**BS 4320**(1)
8.8	**BS 7419**	**BS 4190** (Grade 8) (2)	**BS 4320**(1)

(1) Black steel washers to section 2 of **BS 4320**, normal diameter series.
(2) Nuts for galvanized or sherardized 8.8 bolts should be grade 10 to **BS 4190**.

Shear studs **15.10** Proprietary shear studs for composite construction shall be the headed type and shall be in accordance with **BS EN ISO 13918** with the following minimum properties after being formed:

(a) Yield strength of 350 MPa;

(b) Ultimate tensile strength of 450 MPa; and

(c) Elongation of 15% on a gauge length of $5.65\sqrt{A_o}$, where A_o is the original cross section area of the test specimen.

The minimum diameter and the minimum depth of the head of a headed stud shall be 1.5*d* and 0.4*d* respectively, where *d* is the nominal shank diameter of the stud.

Turnbuckles and other elements **15.11** Obtain approval for specially made elements and components such as turnbuckles.

Non-availability of specified materials **15.12** Obtain approval for any variation required when the specified material is not available and bear any additional cost arising therefrom.

Manufacturer's certificates **15.13** Provide the manufacturer's certificates for all steel sections, plates, sheets, bolts, nuts and washers delivered to the Site.

Markings **15.14** Clearly mark all steelwork in an approved manner. Individual pieces shall be capable of positive identification at all stages of fabrication.

Materials for grouting of base plates and end plates **15.15** Unless specified otherwise, grout around foundation bolts, under column base plates and behind connection end plates shall be one of the following types:

(a) Fluid cement mortar not leaner than 1:1 cement to fine aggregate by volume and be mixed as thickly as possible consistent with fluidity. The minimum amount of water is to be added to provide a viscosity suitable for the voids to be filled without bleeding or segregation of the fresh grout mix; or

(b) An approved proprietary non-shrink polymer modified cementitious or resin based grout that does not contain high alumina cement.

Grout shall have at least the same grade strength as the surrounding concrete.

TESTING OF MATERIALS

Generally **15.16** Allow sufficient time for the testing of specimens. Do not incorporate materials until relevant tests have been carried out and approval obtained.

Testing of sections and plates **15.17** Provide one test specimen for every 40 t or part thereof of each section or plate of same thickness from the same cast. For the purpose of this clause "same thickness" means similar sections with a variation in thickness not exceeding + 5 mm. Test specimens shall be taken from sections selected at random by the SO on the Site, or at such other place or places as agreed by the SO.

Prepare the test specimens to **BS EN 10002-1** as directed and appropriately label, mark and deliver them to Public Works Laboratories, as directed by the SO. Unless specified otherwise, the test specimens shall be subjected to tensile test in accordance with **BS EN 10002-1**.

Subject to the approval of the SO, manufacturer's certificates may be accepted as proof of quality in lieu of sampling on site when all steel sections are prefabricated prior to shipment.

Through thickness properties **15.18** Ensure that where appropriate the steel material has adequate through thickness properties to satisfy the design, the method of fabrication, welding procedures and non-destructive inspection regime such that the material at, or adjacent to, welds is free of laminations, centreline segregation or other crack like indications on completion of welding.

Any material, which is specified or proposed by the Contractor to have enhanced through thickness properties, shall comply with the requirements of **BS EN 10164**. The Contractor shall, not less than three weeks prior to ordering the steel, submit a report to the SO which documents the strategy that will be adopted (in terms of material selection, weld procedure, procedure trials, weld sequence, shrinkage control and inspection regime) to ensure that the above criteria are satisfied.

If valid test reports issued by the manufacturer are not available, carry out the following additional tests by Public Works Laboratories or an Accredited Laboratory:

(a) Ultrasonic grading to **BS EN 10160** Class S1 and **BS EN 10306** Table 2 Class 2.3 for flat products and sections respectively; and

(b) Through-thickness tensile tests to **BS EN 10164**.

Testing of bolts and nuts **15.19** Provide test specimens and carry out testing of bolts and associated nuts in accordance with the relevant BS EN / BS in the Public Works Laboratories when so directed by the SO. Rate of sampling shall be as Table 15.4 unless specified otherwise. Submit test results as soon as they are available. Unless specified otherwise, test specimens for bolts shall be subjected to tests to **BS EN ISO 898-1** to determine their tensile strength and for nuts shall be subjected to proof load tests to Annex A.1 of **BS 4190**.

TABLE 15.4
Sampling of bolts and nuts

Diameter of Bolts	Rate of Sample
not exceeding 16 mm	1 in 15000 or part thereof
exceeding 16 mm but not exceeding 24 mm	1 in 5000 or part thereof
exceeding 24 mm	1 in 2500 or part thereof

Security - general **15.20** Provide security measures for test specimens in accordance with Clauses 15.20A to 15.20D.

Security – sampling **15.20A** Collect or cut test specimens under the direction and supervision of the SO who shall put his signature on the specimens in indelible ink.

Security – before delivery for laboratory **15.20B** Keep the specimens with the SO's signature securely under lock with the key keep in the SO's office before delivery to the laboratory for testing or to the workshop for grinding preparation.

Specimens delivered to workshop for grinding shall be returned to the SO for verification of signature and keep securely under lock before delivery to the laboratory for testing.

Security – delivery **15.20C** Deliver specimens to the laboratory under close supervision of the SO.

Security – stock management **15.20D** Submit for approval by the SO at the commencement of the Contract a stock management system to preclude unauthorized use of structural steel materials prior to receipt of test results as well as swapping of materials of different testing status. The followings shall be included:

(a) Provide identification marks to different specimens arriving on the Site which are uniquely traceable to the record of each batch.

(b) The record of a batch of structural steel materials shall include date of arrival to the Site, quantities delivered of different types, grades and sizes, delivery note, mill certificate and the supplier's certificate.

(c) Establish and maintain a record system, such as colour coding or other approved systems, for identifying and showing clearly specimens that are under different testing status (awaiting test results, approved for use, non-compliant, re-test, omitted for testing, etc.).

(d) Keep separately specimens of different testing status at different locations.

Failure of tests **15.21** Should the result of any test on steel sections, plates, bolts or nuts specified in Clauses 15.17, 15.18 and 15.19 respectively fail to comply with the relevant BS EN /BS, two further test specimens may be taken from the same batch of steel, sections, plates, bolts or nuts for re-test. Provided the results of these further tests both comply with the relevant BS EN / BS, the batch of steel sections, plates, bolts or nuts represented by the specimens shall be deemed to comply with the GS. If the result of either of these additional tests does not comply with the relevant BS EN / BS, the batch of steel represented by the specimens shall be deemed not to comply with the GS.

Remove non-compliant structural steel, bolts and nuts from the Site as soon as possible under the supervision of the SO.

FABRICATION SHOP DRAWINGS

Submission **15.22** Prior to construction and fabrication, submit to the SO for approval Fabrication Shop Drawings to show all necessary details and dimensions. Fabrication Shop Drawings shall not be reproductions of contract drawings without providing information required.

Acceptance by the SO of the Fabrication Shop Drawings shall not relieve the Contractor of his responsibility for accuracy of his detail dimensions on the drawings, nor the general fit-up of parts to be assembled on site.

Welding **15.23** Requirements on edge preparation for welds shall be indicated on the Fabrication Shop Drawings.

Packings and clearance **15.24** When preparing Fabrication Shop Drawings, make provision for:

(a) Packings which may be necessary to ensure proper fit-up of joints.

(b) The need for clearances between the fabricated components so that the permitted deviations in fabrication shall not be exceeded.

Holes sizes **15.25** Holes in steel sections and plates shall be formed to the following sizes:

(a) For ordinary bolts and high strength friction grip bolts:
Not exceeding 24 mm diameter - 2 mm greater than the bolt diameter
Greater than 24 mm diameter - 3 mm greater than the bolt diameter

(b) For holding down bolts:
6 mm greater than the bolt diameter or with sufficient clearance to ensure that a bolt, whose adjustment may cause it to be out of perpendicular, can be accommodated through the base plate.

Details of holes and fittings in components necessary for safety or to provide lifting and erection aids shall be included in the Fabrication Shop Drawings.

Holding down bolt covers **15.26** Holding down bolt details shall include provision of loose cover plates or washers with holes 3 mm greater than the holding down bolts.

Machining note **15.27** Any machining requirements shall be clearly noted on the Fabrication Shop Drawings.

WORKMANSHIP – GENERALLY

Handling, transportation and storage **15.28** Bundle, pack, handle and transport steelwork in a safe manner that shall prevent damage to the steelwork and any protective coating, and to avoid permanent distortion. Particular care shall be taken to stiffen free ends and all machined surfaces.

Take precautions to minimize exposure of steelwork to atmospheric or chemical pollution before and after fabrication. Prior to fabrication, steel shall not be more heavily pitted or rusted than Grade C of **Swedish Standard SIS 05 59 00**.

Store steelwork awaiting erection clear of the ground and keep different members separate. Lay or stack to avoid accumulation of water or dirt on or against any of the surfaces. Provide suitable packings between layers of stacked steelwork. Ventilate covered steelwork sufficiently to preclude condensation.

Store and stack steel members in such a manner that markings are clearly visible.

Cutting, sawing, drilling and forming holes **15.29** (a) Cutting, sawing and drilling

Cut members to size. Guide and control flame cutting, plasma cutting or laser cutting by machine. Use hand-held cutting only where it is impracticable to use machine cutting. Finish cut edges as follows:

(i) Remove burrs, sharp arrises and slag from edges of all cut members.

(ii) Dress machine sheared or cropped edges to a neat finish, free from distortion.

Grind stiffeners, plates and the like to fit the profile of the parent member with diagonal cuts to clear the root radius.

Machine stanchion splices and butt joints of compression members true and square.

(b) Forming holes

(i) Drill round holes for fasteners or pins to tolerance on hole diameter in accordance with Clause 14.2.5.2 in the **Code of Practice for the Structural Use of Steel**. Form slotted holes by drilling two holes and complete by cutting. Dress holes as required to remove burrs and protruding edges. Holes or slotted holes can be plasma cut only after satisfactory demonstration and to the approval of the SO that the tolerances and distortion control that stated in Clause 15.32 can be met.

(ii) Punching full size shall not be permitted for steel grade with design yield strength greater than 460 MPa. Punching full size shall only be permitted when all the following conditions are satisfied:-

(1) The tolerance on distortion of the punched hole does not exceed that stated in Clause 15.32.

(2) The holes are free from burrs that should prevent solid seating of the parts when being tightened.

(3) The thickness is less than 25 mm for steel not higher than Grade S355 and not greater than 10 mm for higher grade steel.

(4) The thickness is also not greater than the diameter of the hole being punched.

(5) In spliced connections, the holes in mating surfaces shall be punched in one direction in all members.

(iii) Punching and reaming

If the conditions stated in (b)(ii) above are not satisfied, punching may be used provided that the holes are punched at least 2 mm less in diameter than the required size and the hole is reamed to the full diameter.

(iv) Drifting

Drifting of holes to align the components shall only be permitted with the approval by the SO, but must not cause any damage or distortion to the final assembly.

(v) Holes in hollow sections

Seal bolt holes or other holes in hollow sections to prevent the ingress of moisture unless approved otherwise by the SO. Show the proposed method on the Fabrication Shop Drawings.

Curving, straightening, heating, shaping and forming **15.30**

Carry out curving, straightening, heating, shaping or forming only if it does not result in material properties that do not conform to the specified requirements for the as-supplied material.

Submit to the SO for approval curving, straightening, heating, shaping or forming procedures before commencement of the work.

Installation and testing of drill anchor bolts **15.31**

All drill anchor bolts shall be coordinated such that they do not clash with any reinforcing steel bars of the concrete structure. Any deviation from the specified positions shall be reported to the SO before installation.

Installation of drill anchor bolts shall strictly follow the manufacturer's specifications. Any installation procedures or details that deviate from the manufacturer's specifications shall be appended by a written statement from the

manufacturer to confirm strength of the anchors.

Where specified, carry out loading test of drill anchor bolts in accordance with **BS 5080-1** and **BS 5080-2** at a sampling rate of at least 1% of the anchors or 5 numbers, whichever is more, of each type and size of the anchors installed. Each sample anchor shall be tested for tensile load by pull-out test and/or shear load by shear load test, as appropriate, to not less than 1.5 times the recommended working load of the anchor as specified by the manufacturer and with a minimum holding time of 60 min under maximum test load. The sample anchor shall not show any signs of separation, plastic deformation or deleterious effect, and shall have at least 80% recovery of the total deformation upon removal of the test load. If the loading test of any sample anchor fails, the failure mode shall be recorded and the cause shall be determined and reported to the SO. Propose remedial measures, including justification calculations for any alternate design and method statement, for agreement with the SO prior to carrying out any remedial works. The sample anchor shall not be used for permanent work unless agreed by the SO.

Employ an Accredited Laboratory to carry out the testing of drill anchor bolts, and provide any necessary labour and attendance. The Accredited Laboratory shall submit test reports directly to the SO in sealed envelopes within 3 days after the testing.

WORKMANSHIP – ACCURACY OF FABRICATION

Permitted deviations **15.32**

Fabricate all steelwork components to an accuracy that will enable erection within the specified limits to take place without inducing excessive stresses, deflection or distortion into the structure. Permitted deviations in cross section, length, straightness, flatness, cutting, holing, position of fittings, and lattice components shall be within the tolerance stated in Clauses 15.3 to 15.9 in the **Code of Practice for the Structural Use of Steel**.

WORKMANSHIP – ERECTION

Generally **15.33**

Unless approved otherwise by the SO, erect fabricated steelwork only after all welded joints and specified protective coatings have been inspected, tested where required, and approved.

Do not load any part of the structure without prior approval.

Method statement **15.34**

Prepare and submit details of the proposed method of erection for approval. Details submitted shall include type of plant and equipment to be used and, if necessary, drawings and calculations of any temporary work. Approval shall not in any way relieve the Contractor of his responsibility for safe erection of permanent work, or the safe erection and subsequent dismantling of temporary work. Design, construct and dismantle falsework to **BS 5531** when specified.

Method statement for grouting under column base plates and connection end plates shall be submitted for approval. Grouting trial shall be conducted on site to verify the proposed method statement under site conditions and compressive strength before approval. Make two cubes using 100mm cube moulds for testing of compressive strength of the grout. Strength compliance requirements shall follow Clauses 6.55 and 15.15.

Temporary bracings or restraints **15.35**

(a) Design and provide sufficient temporary bracings or restraints to ensure that the structure can withstand all loadings during construction without inducing excessive stresses, deflection or distortion in the structure. Include the design and details of the temporary bracings or restraints in the proposed method of erection.

(b) Do not remove the temporary bracings or restraints until the fabricated structure has been completed and permanent bracings have been erected to ensure stability in all directions.

(c) Any connections for the temporary bracings or restraints shall not weaken the permanent structure or impair its serviceability.

Lining and levelling **15.36**

Align each part of the structure as soon as practicable after it has been erected. Do not make permanent connections between members until the structure has been aligned, levelled, plumbed and temporarily connected to ensure that members will not be displaced during the subsequent erection or alignment of the remainder of the structure.

Take due account of the effects of temperature on the structure and measuring equipment when measurements are made for setting-out, during erection, and for dimensional checks carried out subsequently.

Packings and grouting **15.37**

Bed column bases and connection end plates or grout anchor bolts only after the steelwork has been plumbed, levelled, aligned, and adequately braced.

Steel packings and wedges of sufficient strength and stiffness shall be used to plumb and level columns before grouting, and shall be of sufficient size to avoid local crushing of the concrete. They shall be placed so that they do not prevent subsequent grouting to completely fill all spaces directly under the column base plates or behind connection end plates. Grout shall be applied under a suitable head and tamped or vibrated to remove air pockets.

Where packings are to be left in position and subsequently grouted, they are to be placed such that they will be totally embedded in the grout with adequate cover.

Immediately before grouting, the space under column base plates or behind connection end plates shall be clean and free of all extraneous matter.

Material for sealing the perimeters around the column base plates or connection end plates for grouting shall be removed after grout has been cured to expose the grout surface for inspection.

If grouting were carried out without approved method statement or without agreement by the SO, demonstrate to the satisfaction of the SO that approved grouting materials have been used and the grouted space is free from void pocket.

WORKMANSHIP – BOLTING

Preparation of joints **15.38**

Prepare and prime the contact surfaces at bolted joints. If the contact surfaces are specified to be coated or otherwise treated, e.g. machined surface finish, the joint shall be approved before assembly.

Bolts and nuts **15.39**

(a) Length of bolts and threads

For ordinary bolts, the length of bolts shall be chosen such that, after tightening, at least one clear thread shall show above the nut. At the same time, at least one complete thread in addition to the thread run-out shall remain clear between the nut and the unthreaded shank of the bolt, except for Grade 10.9 bolts, where at least five clear threads shall remain.

For high strength friction grip bolts, the length of bolts shall be chosen such that, after tightening, at least one clear thread shall show above the nut. For general grade (Grade 8.8) high strength friction grip bolts, at least three clear threads in addition to the thread run-out shall remain clear between the nut and the unthreaded shank of the bolt. For higher grade (Grade 10.9) high strength friction grip bolts, at least five clear threads shall remain.

(b) Galvanized nuts

Nuts shall be checked after being galvanized for free running on the bolt and re-tapped if necessary to ensure a satisfactory tightening performance.

(c) Locking of nuts

Secure nuts used in connections subjected to vibration or reversal of stresses to prevent loosening. Show the proposed method in the Fabrication Shop Drawings.

Washers **15.40**

(a) Generally

When the members being connected have a finished surface protective treatment which may be damaged by the nut or bolt head being rotated, place a washer under the rotating part

Provide taper washers to give the bolt heads and nuts a satisfactory bearing when the bolt head or nuts is in contact with a surface which is inclined at more than 3^{o} from a plane at right angles to the bolt axis.

(b) Spring washers

Tighten bolt assemblies containing spring washers until the spring washer is completely flattened.

Fit-up with ordinary bolt assemblies **15.41**

Draw parts to be connected firmly together. Use shims to adjust the fit, if necessary. For thicker gauge material (thicker than 4 mm for plates and 8 mm for sections), leave residual gaps up to 2 mm, if necessary, between contact faces unless full contact bearing is specified. Bring each bolt assembly into a snug-tight condition without overloading the bolts. In large bolt groups, carry out this process progressively from the middle of the group to the outside. Carry out additional cycles of tightening, if necessary, to achieve a uniform snug-tight condition. Take sufficient precautions so as not to overload short bolts and M12 or smaller bolts during tightening. The snug tight tension in the bolt should not exceed the value at which bolt shear capacity reduces.

High strength friction grip bolts **15.42**

(a) Preparation of surfaces

Clean the interface of members to be jointed with high strength friction grip bolts to the specified surface preparation and leave unpainted. Protect the surface before and after bolt assembly from weather so that the slip factor is not adversely affected. Prepare sample surface preparation for the prior approval of the SO.

(b) Slip factor

The slip factor shall be in accordance with **the Code of Practice for the Structural Use of Steel.** Remove all mill-scale from the faying surfaces of friction grip bolted connections. The faying surfaces of friction grip joints are to be free of distortion, deformities or contaminants. Use masking to keep the surfaces free of protective treatments. Where specified carry out tests in accordance with **BS EN 1090-2** to determine the slip factor.

(c) Tightening

Use high strength friction grip bolts in accordance with **BS EN 1090-2**. Plate washers shall be used for connections with long slotted and oversized holes. Tightening may be by one of the following methods :

(i) The torque-control method using a calibrated power-operated or a hand-operated torque wrench to the minimum preloading force in Table 15.5.

TABLE 15.5
Minimum preloading force

Nominal size and thread diameter	Minimum preloading force (kN)	
	General Grade (Grade 8.8)	Higher Grade (Grade 10.9)
M 12	47	59
M 16	88	110
M 20	137	172
M 22	170	212
M 24	198	247
M 27	257	321
M 30	314	393
M 36	458	572

Calibrate the wrench regularly in accordance with **BS EN 1993-1-8** as follows:

(1) At the commencement of each new working day or shift,

(2) With each change of bolts diameter, and

(3) With each change of bolts grip length in excess of 1/5th of the length used in the calibration of the wrench.

Reapply the wrench to bolts previously tightened in a multi-bolt connection to ensure all bolts have the correct torque.

(ii) The HRC (High Resistance Calibrated) method using a specific shear wrench equipped with two co-axial sockets for tightening the HRC system bolt and nut assemblies with calibrated preload to **BS EN 14399-10.** The specified preload requirement is controlled by the HRC bolt itself by means of the geometrical and torsion mechanical characteristics together with the lubrication conditions. The equipment does not need calibration.

(d) Fit-up

Draw parts to be connected firmly together with all bolts partially tightened. Check if there is any remaining gap which may affect the integrity of the joint. If so, take the joint apart and insert a pack before recommencing the tightening procedure.

Where parts cannot be brought together by drifting without distorting the steelwork, rectify by reaming, provided that the design of the connection will allow the use of larger diameter bolts. Submit calculation to demonstrate that the connection remains adequate for the forces in the connection.

(e) Discarded bolt assemblies

If, after complete tightening, a bolt or nut has to be slackened off, discard the whole bolt assembly.

WORKMANSHIP – WELDING

Welding **15.43** Welding shall be a metal arc process in accordance with **BS EN 1011-1** together with other clauses contained in this GS, unless specified otherwise. Choose welding consumables to ensure that the mechanical properties of the weld metal are not less

than those required for the parent metal. Execute welding in a flat or horizontal position wherever possible.

Welders and testing of welders **15.44**

Provide an experienced and competent operator to supervise welding. Welders shall be tested to meet the requirements of **BS EN 287-1** or approved equivalent standards.

Test on welders shall be witnessed by a qualified welding inspector and certificates are to be endorsed by an independent inspection authority. The certification shall remain valid providing it complies with the conditions for re-approval of certification specified in **BS EN 287-1**.

Welding record **15.45**

Keep a record on the Site when specified to identify welders responsible for major welds.

Preparation of welding procedure specifications **15.46**

Submit preliminary Welding Procedure Specification (pWPS) which shall be prepared in accordance with **BS EN ISO 15609-1** and certified by a qualified welding inspector for the approval of the SO. The approved pWPS shall be qualified in accordance Clause 15.47 prior to commencing production welding. More than one qualified Welding Procedure Specification (WPS) may be needed to cover the scope of the actual production, and each WPS shall at least address:

(a) Welding process,

(b) Parent metal specification, thickness and other relevant dimensions,

(c) Classification, type and size of electrodes and other consumables,

(d) Welding current, arc voltage and travel speed/ wire feed speed,

(e) Sketch showing edge preparation, fit-up and approximate number and arrangement of runs in multi-run welds,

(f) Whether shop or site welding,

(g) Welding positions,

(h) Welding sequence,

(i) Minimum preheating temperature and interpass temperature range,

(j) Post-weld heat treatment if required.

Do not depart from the approved welding procedure without prior agreement of the SO.

Qualification testing of welding procedure **15.47**

Carry out qualification testing of approved pWPS by Welding Procedure test to **BS EN ISO 15607** and **BS EN ISO 15614-1** strictly in accordance with the approved pWPS and using representative samples of the materials. The qualification testing including welding and testing shall be examined by an Accredited Laboratory approved by the SO. Allow for the SO's inspection of the qualification testing.

Subject to the approval of the SO, qualification testing of pWPS need not be carried out if the same procedures have been tested and approved by the Accredited Laboratory.

Strictly follow the qualified WPS for the works. Carry out further qualification tests if either the material or procedure changes.

Based on the qualified WPS, prepare appropriate work instructions for all sizes of butt welds and fillet weld where leg length equals to or exceeds 10 mm. Submit the work instructions for the SO's approval prior to the commencement of welding. Work instructions shall include cross-reference to the qualified WPS upon which

they are based, and shall indicate clearly all essential information including their acceptable range for the specific weld size.

Welding consumables **15.48**

Consumables shall be to **BS EN ISO 2560**, **BS EN ISO 14341**, **BS EN ISO 14171** or **BS EN ISO 17632** as appropriate and strictly in accordance with the manufacturer's recommendations.

Submit delivery notes of welding consumables to the SO. Maintain a log book for welding consumables on site which shall contain the date, types and quantities of welding consumables delivered on site, and the updated balance. Submit daily record to the SO on the names of welders engaged, welding joints under preparation, types and quantity of welding consumables used.

Storage of welding consumables **15.49**

Consumables for use in welding (including electrodes) shall be kept and handled in a controlled manner in accordance with **BS EN 1011-1**. Any drying or baking of electrodes before issue shall be carried out in accordance with the manufacturer's recommendations.

Distortion control **15.50**

The sequence of welding a joint or a sequence of joints shall be such that distortion is minimized.

Preparation of joints for welding **15.51**

Prepare fusion surfaces to **BS EN ISO 9692-1** and qualified WPS. Surfaces must be dry, clean and free from paint or metal coating. Warm the surfaces if required to remove condensation. Weld runs that were not performed on the same day shall have the inter-pass surface treated and properly dressed to the approval of the SO. The first three runs of a welded joint shall be completed within one day.

Slag **15.52**

Remove welding slag by chipping before depositing subsequent runs.

Tack welds **15.53**

Tack welding may only be used with express approval by the SO, and shall be carried out as follows:

(a) Tack welds shall be made using the same procedures as for the root runs of main welds. The minimum length of the tack welds shall be the lesser of 4 times the thickness of the thicker part being joined or 50 mm, unless demonstrated by a weld procedure qualification.

(b) Tack welds, which are not defective, may be incorporated into main welds provided that the welder is qualified as in Clause 15.44. However, where joints are welded using an automatic or mechanised process, the suitability of the tack weld used for incorporation into automatic processes shall be demonstrated in the weld procedure qualification.

(c) Remove all tack welds made in circumstances other than those identified above.

Butt welds **15.54**

Butt welds shall be full penetration welds between prepared fusion faces, unless specified otherwise. Partial penetration butt weld shall be subject to the approval of the SO but the bevel depth shall at least be 70% thickness of the jointing plates. Carry out back chipping, grinding or gouging of the deposited weld as required to obviate imperfections in the root run. Grind butt welds flush without loss of parent metal.

Fillet welds **15.55**

Deposit fillet welds to the required length, throat thickness and with partial or full penetration as specified.

Temporary attachments **15.56**

Do not weld temporary attachments to principal joints. Obtain approval of the position of welds for temporary attachments and time slot for removal, and shall be made in accordance with the requirements for a permanent weld.

Remove temporary attachments by flame cut or gouged at a point not closer than 3 mm from the surface of the parent material. If affected area deeper than 3mm, remedial proposal shall be submitted to the SO for approval and the repaired surface shall be subjected to both magnetic particle inspection and ultrasonic examination.

Ground flush the residual material and visually inspect the affected area. When the base material thickness exceeds 20 mm (or carbon equivalent > 0.43%), it shall also in any case be checked by magnetic particle inspection. The standard of acceptance for welds shall be in accordance Clause 15.58. Do not remove attachments by hammering.

Shear stud welding **15.57**

(a) Method

Weld shear studs by automatic stud welding gun strictly in accordance with the manufacturer's recommendations for materials, procedures and equipment unless approved otherwise. Provide adequate earth return connections local to area being stud welded. The local area around where the stud is to be welded shall be free of standing water before commencement of welding.

(b) Trial Welding

Before commencement of the work, carry out trial welding of studs on samples of material and studs representative of those to be used in the work to demonstrate the suitability of the proposed welding system and equipment. Test a minimum of ten studs in the trial. During the work, at the commencement of each shift, a minimum of two trial welds is to be undertaken by each welder. Visually inspect all trial welded studs and they shall show a full 360^{o} collar. Subject trial welded studs to a bend test. The stud weld shall not show any signs of cracking or lack of fusion.

The bend test shall be made by bending the head of the stud towards the nearer end of the beam, by means of a steel tube placed over the stud, until it is displaced laterally a distance of one quarter of the height of the stud. Studs subjected to the bend test shall not be straightened.

(c) Test and Inspection

Visually inspect all stud welds. Subject any stud weld that does not exhibit full 360^{o} collar to a bend test such that the area of 'no flash' is put in tension. Under this test the weld is to show no visible signs of cracking.

Subject a minimum of 5% of the studs, but not less than two studs per beam, which have satisfied the visual inspection to a bend test.

Where bend test reveals an unsatisfactory stud weld, three welds made before and, where appropriate, after the defective weld shall also be subjected to bend test. If one of these studs fails to satisfy the requirements in the test, appropriate testing shall be carried out on all studs on the same work piece. The Contractor shall submit remedial proposal of corrective actions for all non-conforming stud welds, either by removal of the defective stud, where necessary, and repeat stud welding, or by repair welding with a suitable welding process for the SO's approval. All repaired or replaced studs shall be retested.

(d) Removal of Slag

Remove slag by light hammering, wire brushing or other methods that do not deform the surface of the weld.

Acceptance of welds **15.58**

Employ an Accredited Laboratory to carry out and interpret the inspection and testing of welds, and provide any necessary labour and attendance. Submit evidence proving that operators carrying out the inspection and testing have been trained and assessed for competence in the inspection and testing of welds. In addition, submit certificates of competence from a recognised authority for operators carrying out ultrasonic examination.

Arrange for the Accredited Laboratory to submit a testing programme for the approval of the SO. Any welds that shall be rendered inaccessible by subsequent

work shall be examined prior to the loss of access.

Visually inspect all welds in accordance with **BS EN ISO 17637**, and after visual inspection, carry out non-destructive testing in accordance with Table 15.6:

TABLE 15.6

Weld Type	Frequency of Non-destructive Testing
Full penetration butt welds with maximum thickness of the parent material exceeding and including 10 mm	100% ultrasonic examination and magnetic particle inspection
Full penetration butt welds with maximum thickness of the parent material not exceeding 10 mm	100% magnetic particle inspection
Partial penetration butt welds with depth of penetration exceeding and including 8 mm	20% ultrasonic examination and magnetic particle inspection
Partial penetration butt welds with depth of penetration not exceeding 8 mm	20% magnetic particle inspection
Fillet welds with leg length exceeding and including 15 mm	10% ultrasonic examination and magnetic particle inspection
Fillet welds with leg length not exceeding 15 mm	10% magnetic particle inspection

The standard of acceptance for welds shall be in accordance with Table 14.3b in the **Code of Practice for the Structural Use of Steel**.

Carry out surface flaw detection by magnetic particle inspection (MPI) in accordance with **BS EN ISO 17638**. If MPI is impractical, dye penetration inspection (DPI) may be used, subject to the approval of the SO, in accordance with **BS EN ISO 3452-1**.

Carry out ultrasonic examination in accordance with **BS EN ISO 17640** Level B. Make printout results available during ultrasonic examination on site at 3 specified locations per weld (such as at both ends and in the middle of the weld) and at positions in question.

The Accredited Laboratory shall submit test reports directly to the SO in sealed envelopes within 3 days of the completion of the testing. Tests revealing discontinuity shall be reported separately from the subsequent repair and re-test.

Unless approved otherwise by the SO, carry out all non-destructive testing not less than 16 hr from the time of completion of the weld to be inspected, and not inferior to the requirements in Table 14.2b in the **Code of Practice for the Structural Use of Steel**. Should test results indicate that welds are below the standard of acceptance, carry out at the Contractor's own expense approved remedial measures and further acceptance tests.

WORKMANSHIP – ACCURACY OF ERECTED STEELWORK

Permitted deviations 15.59 Erect steelwork within the permitted deviations stated in Clauses 15.10 to 15.12 in the **Code of Practice for the Structural Use of Steel**. Make all necessary allowances and adjustments to achieve this accuracy.

Buttering shall not be used for closing up the construction deviation/tolerance unless approved otherwise by the SO. WPS for buttering, if adopted, shall be submitted and qualified in accordance with Clause 15.46. The buttering thickness shall not exceed 20 mm and the buttered surface shall be properly dressed for subsequent welding, if needed.

WORKMANSHIP – PAINTING AND CORROSION PROTECTION

Painting in general **15.60** Painting shall be as Section 21 in general. All painting shall be applied in strict compliance with approved paint manufacturer's recommendation, and shall be compatible with each other.

Preparation and painting of new surfaces **15.61** Prepare new surface to receive protective coatings in accordance with one of the following :

(a) Manually clean metal surface thoroughly to remove all dirt, weld spatter, grease and the like. Chip, scrape and wire-brush to remove mill scale and rust. The surface so prepared shall not be inferior to **Swedish Standard SS EN ISO 8501-1** St2. Painting shall be as Table 15.7, Type A.

(b) Degrease metal surface, mechanically remove all millscale, rust and weld spatter with power driven tools such as carborundum grinding discs, chipping hammers and needle guns. Clean off all loosened particles by wire brushing or vacuum cleaning. The surface so prepared shall not be inferior to **Swedish Standard SS EN ISO 8501-1** St3. Apply the protective coating within 4 hours to the cleaned surface. Painting shall be as Table 15.7 Type B.

(c) Blast-clean steel so that the prepared surface is not inferior to **Swedish Standard SS EN ISO 8501-1** Sa 2.5. Unless approved otherwise by the SO, blast-cleaning to steelwork shall not be carried out until all welds for steelwork have been completed. Clean the blasted surface by vacuum and do not touch the surface by hand or contaminate it in any other way. Apply the protective coating within 4 hr to the cleaned surface. Submit a sample of blast cleaned steel not less than 150 x 150 x 6 mm adequately protected in sealed clean polythene wrapping for approval before any work is carried out. This approved sample shall be retained for comparison with the subsequent prepared steelwork. Painting shall be as Table 15.7 Type C or Type D as specified in the Contract and the zinc rich primer shall be applied directly on the blast cleaned metal surface.

Redecoration of existing painted surfaces **15.62** For redecoration of existing painted surfaces of structural steelwork, clean the existing paint coat with an approved detergent, remove loose and flaking portions with wire brush and grind rusted areas back to bare metal as instructed by the SO, care being taken to avoid producing a smooth surface by excessive grinding. Where the existing coating is intact after cleaning, apply the proposed paint coating over a trial panel and examine for adherence after the curing period as recommended by the paint manufacturer. Do not use the paint until the trial is passed. Where bare metal is exposed, apply primer, undercoat and finishing coat as directed by the SO.

Hot-dip galvanizing **15.63**

(a) Unless approved otherwise by the SO, galvanizing to steelwork shall not be carried out until all welds for steelwork have been completed. Prior to galvanizing, the following requirements have to be satisfied :

(i) All welding slags and paints on the steel surface shall be removed.

(ii) All cut surfaces shall be ground smooth.

(iii) Adequate number of vent and drainage holes in accordance with **BS EN ISO 14713** shall be provided for closed end hollow sections. The position of the holes and any requirements for subsequent sealing shall be agreed by the SO.

Apply hot-dip galvanized coatings to **BS EN ISO 1461**. The name and location of the galvanizing factory shall be submitted to the SO for approval. Provide the approved galvanizing factory's certificate showing that the galvanized coatings comply with the requirements including the test results carried out for thickness of coating.

(b) Small areas of galvanized coating damaged by welding, cutting or by rough treatment during transit or erection shall be made good by:

(i) The use of at least one coat of zinc rich primer to **BS 4652**. Thoroughly clean all areas affected by welding with abrasives or mechanical driven tools before applying the zinc rich paint; or

(ii) If specified, by blast cleaning to not inferior to **Swedish Standard SS EN ISO 8501-1** Sa 2.5 and followed by one coat of 2-packed epoxy based zinc rich primer to **BS 4652**.

(c) Painting to galvanized structural steel shall be as Table 15.7 Type F or Type G as specified in the Contract.

(d) For galvanized or zinc rich primer coated surface, submit method statement on checking and removal of zinc salt for the SO's approval prior to application of painting.

Painting, stripe coats to joints and sharp edges and damaged painting **15.64**

Unless as required in 15.61(c), there shall be no paint at the time of welding, other than suitable prefabrication primer, within 50 mm of the weld. As soon as possible after joints have been completed and approved, the parent and the joint material, exposed parts of bolts, nuts and washers and weld affected areas shall be brought up to the same standard of preparation and painting as the adjoining surfaces.

All damaged painting shall be brought up to the same standard of preparation and painting as the adjoining surfaces.

Immediately after the primer of the painting system has dried, apply a stripe coat of primer by brush to edges, corners, crevices, exposed parts of bolts, nuts and welds to ensure that all these areas have a similar dry film thickness to that of any adjacent surface. Subsequent undercoat and finishing coat of paint shall be applied similarly, but with the stripe coat for the undercoat and finishing coat be applied beforehand.

Paint **15.65**

Paint shall be supplied in sealed containers. Each container shall be marked on the side to show the following:

(a) The name of the manufacturer,

(b) The paint manufacturer's reference number,

(c) Intended purposes, type of pigment and binder,

(d) Batch number, date of manufacture, expiry date and pot life, and

(e) Colour, gloss, drying times and flash point.

TABLE 15.7
Surface Protection to Structural Steel

Surface Preparation	Painting system	Details of Painting System	
As Clause 15.61 (a)	Type A	Primer :	Drying oil based zinc phosphate primer, applied in 1 coat Dry film thickness = 40 µm
		Finishing coat :	Drying oil based finishing coat, applied in 2 coats Dry film thickness = 80 µm
		Minimum overall dry film thickness = 120 µm	
As Clause 15. 61 (b)	Type B	Primer :	2-pack surface tolerant epoxy based aluminium paint Dry film thickness = 80 µm
		Finishing coat :	2-pack recoatable polyurethane finishing paint, applied in 2 coats Dry film thickness = 80 µm
		Minimum overall dry film thickness = 160 µm	
As Clause 15.61 (c)	Type C	Primer :	2-pack epoxy based zinc rich primer, applied in 1 coat, to **BS 4652** (except that the content of zinc metal in the dry film shall not be less than 80% (by weight) of the cured paint film) Dry film thickness = 60 µm
		Undercoat :	2-pack epoxy based micaceous iron oxide paint Dry film thickness = 100 µm
		Finishing coat :	2-pack recoatable polyurethane coats finishing coat, applied in 2 coats Dry film thickness = 100 µm
		Minimum overall dry film thickness = 260 µm	
As Clause 15.61 (c)	Type D	Primer :	2-pack epoxy based zinc rich primer, applied in 1 coat, to **BS 4652** (except that the content of zinc metal in the dry film shall not be less than 80% (by weight) of the cured paint film) Dry film thickness = 60 µm
		Undercoat :	2-pack epoxy based micaceous iron oxide paint Dry film thickness = 100 µm
		Finishing coat :	2-pack epoxy based finishing coat Dry film thickness =100 µm
		Minimum overall dry film thickness = 260 µm	
	Type E	NOT USED	
Hot-dip galvanized to Clause 15.63	Type F	Primer :	Nil
		Pretreatment :	Degrease and rinse. Apply British Rail T-Wash or equivalent. Excess etchant to be thoroughly rinsed.
		Undercoat :	Nil
		Finishing coat :	2-packed recoatable polyurethane finishing paint applied in 2 coats recommended as suitable by paint manufacturer for direct application to etched surface. Etched surface shall be overcoated within 24 hours or the time limit by the manufacturer Dry film thickness = 80 µm
Hot-dip galvanized to Clause 15.63	Type G	Primer :	Nil
		Pretreatment :	Degrease and rinse. Apply British Rail T-Wash or equivalent. Excess etchant to be thoroughly rinsed.
		Undercoat :	2-pack epoxy based micaceous iron oxide paint recommended as suitable by paint manufacturer for direct application to etched surface. Etched surface shall be overcoated within 24 hours or the time limit by the manufacturer Dry film thickness = 80 µm
		Finishing coat :	2-packed recoatable polyurethane finishing paint applied in 2 coats Dry film thickness = 80 µm
		Minimum overall dry film thickness = 160 µm	
Note : Drying oils dry (or cure) in the presence of atmospheric oxygen; they include linseed oil, urethane oil, alkyd, modified alkyd, phenolic varnish or epoxy ester.			

FIRE PROTECTION FOR STRUCTURAL STEEL

Generally **15.66** Fire protection system shall comply with the requirements of the **Code of Practice for Fire Safety in Buildings** including its latest amendments and revisions issued by the Buildings Department and shall provide the structural steelworks with the required Fire Resistance Rating (FRR) as specified in the Contract or as required by the **Code of Practice for Fire Safety in Buildings**. In case that specified proprietary products are used, they shall still comply with the requirements in Clauses 15.66 to 15.72.

Fire protection system **15.67** When specified, provide fire protection to structural steel by one of the following materials or system:

(a) Sprayed mineral coating to **BS 8202-1**;

(b) Intumescent coating system to **BS EN 16623**; or

(c) Proprietary fire protection board.

The fire protection system including its construction shall have been tested and assessed to the requirements of **BS 476-20** and **BS 476-21** as being capable of resisting the action of fire for the specified periods. The tests and assessment shall be carried out by an Accredited Laboratory, or one of the assessing organizations listed in **APP-118** issued by the Buildings Department. The assessment report shall be within its validity period.

Details of application of the materials such as surface preparation, application of primer and fixing details shall be strictly in accordance with the approved tests and assessment report; no deviation can be made except for specific situations where some minor variations may be necessary. Such minor variations must be tested or assessed against established standard fire testing that the construction elements and the structural members are capable of resisting the action of fire for the specified period. The assessment should be carried out and the assessment report prepared and endorsed by a HOKLAS accredited laboratory or other accredited laboratory which has mutual recognition agreements / arrangements with the HOKLAS.

Submittals **15.68** The proposed fire protection system shall meet the design intent, the required performance criteria and other requirements specified in the Contract. The fire protection system must be approved by the SO before use. Submit to the SO for approval all relevant information including but not be limited to the following:

(a) Product data: Data identifying performance characteristics and properties of the fire protection material.

(b) Tests and assessment report prepared by an Accredited Laboratory as specified in Clause 15.67 above, together with job references and information of whether the product has been accepted by the Buildings Department, Association for Specialist Fire Protection (ASFP), Underwriters Laboratories Inc. or other international recognized organizations.

(c) Details of the fire protection system including the thickness of coating/board to be applied for each structural steel with calculation on section factor (Hp/A or A/V) to substantiate that the required fire rating can be achieved.

(d) Details of the surface preparation requirements and application technique including fixing details of the material.

(e) Certification from the fire protection coating manufacturer on the compatibility of the coatings with the corrosion protection coating/paints.

(f) Name of installation contractor qualified for the works and acceptable to the fire protection coating/board manufacturer.

(g) Samples of the materials.

(h) Quality control and field test procedures.

(i) Installation, safety and protection procedures including those for repair work.

Sprayed mineral coating **15.69**

(a) Sprayed mineral coating can only be used for interior structural steelwork and shall not be used for exterior environment unless specified otherwise.

(b) For steel in an interior dry environment, all steel surfaces shall be blast cleaned to **Swedish Standard SS EN ISO 8501-1** Sa2 and shall be thoroughly cleaned of oil, grease, dirt or other foreign substances which may impair the proper adhesion of the fire protection to the substrate.

Should sprayed mineral coating not be applied within 4 hr to the cleaned surface, the cleaned steel surfaces shall receive one coat of drying oil based zinc phosphate primer with a dry film thickness of 35 μm. A bond coat shall be applied, unless approved otherwise by the SO in writing, to the primed surface prior to the application of the sprayed mineral coating and the bond coat must be compatible with sprayed mineral coating.

(c) For interior area with high humidity, e.g. toilet, bathroom, changing rooms or similar areas, or where specified, the steel shall receive the following corrosion protection:

All steelwork and welded connections shall be blast cleaned to **Swedish Standard SS EN ISO 8501-1** Sa 2.5 and shall receive a corrosion protection system using two-pack epoxy based zinc rich primer to **BS 4652** with a dry film thickness of 80 μm. Before application of subsequent coating, all zinc salts on the surface shall be removed.

A bond coat shall be applied to the primed surface prior to the application of the sprayed mineral coating and the bond coat must be compatible with sprayed mineral coating.

(d) Dry density and cohesion/adhesion properties of sprayed material:

(i) For general area:
Dry density of the sprayed material shall not be less than 240 kg/m^3
The cohesion/adhesion of the sprayed material shall have a minimum 0.01 MPa onto primed steelwork under site tests in accordance with **ASTM E736**.

(ii) For mechanical rooms, plant rooms, areas subjected to vibration, or specified areas:
Dry density of the sprayed material shall not be less than 640 kg/m^3
The cohesion/adhesion of the sprayed material shall have a minimum 0.35 MPa onto primed steelwork under site tests in accordance with **ASTM E736**.

Submit to the SO the test data on the density and cohesion/adhesion.

(e) Provide mechanical retention for the sprayed mineral coating by means of mesh reinforcement in accordance with **BS 8202-1** unless:

(i) There is evidence from fire resistance tests to show that there is adequate bond between the spray and the substrate (including primers or other coatings); or

(ii) The spray is locked in position by virtue of the shape of the element

Mechanical retention shall be provided for sprayed mineral coating in mechanical rooms, specified areas or areas where the substrate is subjected to vibration.

(f) Application of the spray material:

(i) Prior to application of spray material to the underside of steel decking, concrete works above shall be complete. No floor traffic shall be allowed during application and during 7-day minimum curing period.

(ii) Spray material shall be applied prior to the installation of ductwork, piping and conduits which would interfere with uniform application of the spray material.

(iii) Prior to application of spray material, clips, hangers, support sleeves and other attachments required to penetrate the spray material shall be in place.

(iv) Any void space between the slab soffit and the top of the steel beams shall be filled with the spray material.

(v) Cover the surfaces not to receive spray material to prevent contamination by splatter, rebound and overspray

(g) The specified or design thickness of the sprayed mineral coating shall be the minimum thickness when measurement is carried out on site. Conduct the measurements in accordance with **BS 8202-1**.

(h) Demonstrate, using a site trial prior to commencement of site spray work, that the proposed materials, system and application method are adequate for the design intent. Site tests such as the density and adhesion tests should also be carried out at the trial panel to ensure that the sprayed coating meets the required performance.

Intumescent coating system **15.70**

(a) The coating system shall be designed, taking into account the environmental conditions during construction phase and throughout the life of the building.

(b) For exterior environment, the material shall have a weathering and ageing test.

(c) All interior structural steelwork including fasteners and welded connections shall be blast cleaned to **Swedish Standard SS EN ISO 8501-1** Sa 2.5 and shall receive the protective coating as follows:

Primer:	2-pack epoxy based zinc rich primer, applied in 1 coat, to **BS 4652** (except that the content of zinc metal in the dry film shall not be less than 80% (by weight) of the cured paint film) with dry film thickness = 60 μm
Basecoat:	Protective fire coating with thickness depends on Hp/A, and fire rating
Finishing coat:	Compatible finishing coat, dry film thickness = 50 μm

(d) For specified area or external steelworks, all steelworks including fasteners and welded connections shall be hot-dip galvanized to **BS EN ISO 1461**. Before application of the intumescent coating, the galvanized steelworks shall be treated with etchant such as T-Wash followed by a compatible primer recommended by the fire protection manufacturer as follows:

Pretreatment:	Degrease and rinse. Apply British Rail T-Wash or equivalent. Excess etchant to be thoroughly rinsed.
Primer:	Thickness and type to be recommended by the fire protection coating manufacturer.

Basecoat:	Fire protection coating with thickness depends on Hp/A, and fire rating	
Finishing coat:	Compatible finishing coat, dry film thickness = 50 μm	

(e) The primer for corrosion protection must be compatible with the steel substrate and the basecoat, and must provide excellent adhesion at all times. All zinc salt on the surface shall be removed prior to the application of the basecoat. If adequate removal of the salt cannot be guaranteed, a suitable tie coat shall be applied prior application of the base coat.

(f) The fire protection coatings shall not become softened, flow, or flake off in a fire.

(g) All primer, tie coat if any, base coat and finishing coat shall be compatible with each other.

(h) The dry film thickness of the basecoat must be recorded at locations of steel sections as follows:

Web:	One reading per metre length on each face
Outer Flanges:	One reading per metre length on each face
Inner Flanges:	One reading per metre length on each face
Hollow Sections:	One reading per metre length on each face
Circular Hollow Sections:	Four readings per metre length around section

(i) Dry film thickness reading shall be taken when the intumescent basecoat is sufficient hard to prevent the probe indenting the surface. Individual thickness reading less than 90% of the specified thickness is not acceptable. The average thickness shall be equal or greater than the specified thickness.

(j) The average measured dry film thickness shall not exceed by more than 10% the manufacturer's maximum test thickness for the particular steel shape and orientation.

(k) The finishing coat shall not be applied until the basecoat thickness has been checked and verified.

(l) The limits of temperature, humidity and curing time must be strictly adhered to coating manufacturer's recommendations such that bubbles and blisters within coating shall not happen.

(m) Submit a method statement showing the proposed specification of the coating system, application procedures for off-site and on-site activities, curing, handling and protection during transportation and the repair method for the approval of the SO.

Proprietary fire protection board **15.71**

(a) Proprietary fire protection board shall only be used for interior structural steelwork and shall not be used for exterior environment unless specified otherwise.

(b) The board shall be made of a suitable material and asbestos free.

(c) Submit test report to show that the material is resistant to moisture and will not rot, disintegrate, warp, swell, sag or dimensional change under humidity.

(d) If approved by the SO, application technique, fixing, jointing and the use of the fire protection board shall be in strict compliance with the manufacturer's technical specifications and recommendations.

(e) Before installation of the fire protection board, all structural steelwork including fasteners and welded connections shall receive one of the following corrosion protection as specified:

Hot-dipped galvanized to **BS EN ISO 1461**; or

Blast cleaned to **Swedish Standard SS EN ISO 8501-1** Sa 2.5 and receive the protective coating as follows:

Primer:	2-pack epoxy based zinc rich primer, applied in 1 coat, to **BS 4652** (except that the content of zinc metal in the dry film shall not be less than 80% (by weight) of the cured paint film) with dry film thickness = 60 μm
Basecoat:	2-pack epoxy based micaceous iron oxide paint, dry film thickness = 80 μm

(f) Apply finishes/painting to the board when specified in the Contract.

Manufacturer's Inspection **15.72** The manufacturer of the fire protection system shall inspect the fire protection works after it is completed, including testing and repair if necessary, and shall certify that the work complies with the manufacturer's criteria and recommendations. Obtain and submit to the SO the manufacturer's Inspection Report and certifications of approval.

SECTION 16

CURTAIN WALLS

Generally **16.1** For details regarding glass and glazing materials, such as gaskets and setting blocks, refer to the relevant parts of Section 20 – Glazing.

The use of glass in curtain walls shall be to **Code of Practice for Structural Use of Glass** including its latest amendments and revisions issued by the Buildings Department, except otherwise stated.

Scope of the Works **16.2** The Works comprise the design, fabrication, transportation, assembly and installation of the curtain walls as specified. Provide full-scale testing to show compliance. Testing must conform to Buildings Department Practice Note **APP-37** as a minimum. Other testing as specified herein must conform to relevant recognized International Standards. (e.g. **ASTM, AAMA, BS, JIS** or **AS/NZS** to demonstrate the acceptability of the curtain wall system.)

Works included **16.3** The Works include, but shall not be limited to:

(a) Aluminium/stainless steel framing members.

(b) Galvanized mild steel sections as reinforcement.

(c) Fixings, connections and provision of anchorages. Concrete embedments shall be provided under the Works but set by others.

(d) Glass and glazing materials including glass spacers, setting blocks, gaskets, sealants etc.

(e) Operable windows, spandrels, dressings to roofs/abutments, integral louvres and screens to A/C intakes/exhausts.

(f) Stone panels and their support systems including anchorages to the main structure.

(g) Ironmongery and fittings including all fasteners.

(h) Sills, copings, water bars, flashings, seals and other attachments.

(i) Insulation against fire between storeys and designated compartments including all necessary support and retention materials.

(j) Isolation of dissimilar metals and moving parts.

(k) All preparatory work to the adjoining structure for attachment of the Works.

(l) Sealants within work of this section and at boundaries with work of other sections.

(m) Thermal insulation at non-vision areas including all necessary support and retention materials.

(n) Mock-up erection and tests (see also Clause 16.73 and 16.74)

(o) Field tests for resistance to water leakage.

(p) Material tests.

(q) Final cleaning.

(r) Lightning protection.

(s) Field and/or Laboratory mock-ups.

Related work **16.4** Works related to, and requiring coordination with, but not necessarily forming part of the Works include:

(a) Reinforced concrete structure.

(b) Rendering and screed to concrete structure.

(c) External and internal finishes.

(d) External paving and asphalt work.

(e) Forming grooves and chases in the structure for the proper execution of the Works.

(f) Mechanical air-handling installation.

(g) Ceiling installation.

(h) Fixing of anchorages into structure.

(i) External curtain wall cleaning system.

(j) Granite cladding.

(k) Lightning protection installation.

(l) Closure panel for Venetian Blind/shutter.

(m) Waterproofing/water-tightness.

(n) Equipotential bonding.

Abbreviations **16.5** The following abbreviations are used in this Specification:

AAMA	American Architectural Manufacturers Association.
AISC	American Institute of Steel Construction
AMCA	Air Movement & Control Association
ANSI	American National Standards Institute
APP	Buildings Department Practice Note APP- for Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers, issued by the Buildings Department
ASTM	American Society for Testing and Materials
BS	British Standards
BS EN	European technical standards as adopted in the UK
CWCT	Centre for Window and Cladding Technology
EN	European Standard
GANA	Glass Association of North America
OSHA	Occupational Safety and Health Administration

Ordinances, Regulations, Codes and standards **16.6** Comply with the documents contained in this Specification regarding Ordinances, Regulations, Codes of Practice, Standards and PNAP relevant for Curtain Walls and Glazing under Section 16 and Section 20. All Standards and Codes of Practice are to be the latest issue. If there is any conflict between the standards and codes listed, the more onerous is to apply.

Contractor's design responsibility **16.7**

The design and performance of the system is the responsibility of the Contractor. The Drawings and Specification define design intent and performance requirements, they do not purport to show the details of the system as relating to the performance requirements. The details show the overall sizes and the preferred profiles. The connections and interfacing with other areas are the responsibility of the Contractor.

Responsibilities include, but shall not be limited to, the following:

(a) Unless otherwise specified, the appearance of exposed elements, including width and depth, shall be consistent throughout the project.

(b) Unless otherwise specified, the overall thickness of each glass type, and the component thicknesses of each multiple layer glass type, shall be consistent throughout the project.

(c) Provide anchor adjustment capability for the full range of specified tolerances. This must include provision for the angularity of the anchorage mounting surface.

(d) Provide movable joints to accommodate the full range of manufacturing tolerances, field tolerances, thermal movements, floor sag, beam sag, and column settlement. This includes provision for imposed load deflection of the slab and inter-storey drift.

(e) Provide corrosion protection between dissimilar materials. The material used must be impervious to moisture whether or not it is installed in a designated dry area.

(f) Provide water-tightness by the use of "pressure equalization and rain screen" curtain wall design principles. This may be enhanced by the use of drained gutter systems and/or the provision of weep holes to enable water to be controlled and diverted to the exterior.

(g) Provide a complete external envelope which is accessible internally or externally for maintenance.

INFORMATION TO BE PROVIDED

Tender submission **16.8**

Not used.

Programme for the Works **16.9**

Within 6 weeks of the date of acceptance of the tender or nomination by the SO, submit a detailed programme for the Works as specified, to show the following:

(a) Submission of structural calculations, shop drawings and samples of materials.

(b) Ordering of components including aluminium extrusions, glass and anchorage.

(c) Manufacture of components including aluminium extrusions, glass and anchorage.

(d) Preparation of all mock-up samples required.

(e) Testing in laboratory

(f) Delivery of components.

(g) Installation.

(h) Field Tests.

(i) Final cleaning.

'Installation' shall be further sub-divided into principal constituent operations.

Provision of drawings and calculations **16.10** Provide the following submittals for approval as specified. First submittals and resubmittals shall be complete and in the required form. Resubmittals shall include requested corrections and shall respond to previous comments.

Each sheet that is revised shall bear a revision date and number. Revisions shall be flagged with a conspicuous revision symbol and number. Failure of a submittal to be complete, in the proper form, responsive to comments, or identified with revisions shall, at the SO's discretion, be a cause for non-approval and return of documents without review.

Failure of reviewing comments to note a noncompliance with the Specification and Drawings shall not relieve the Contractor from his obligation to comply. The failure of the Contractor to note a noncompliance on a given submittal shall not preclude a directive by the SO for the Contractor to comply on future submittals. Allow sufficient time for preparation and processing of submittals and resubmittals.

(a) Provide drawings certified by a qualified structural engineer, showing materials in place. Drawings shall be fully co-ordinated to allow identification from elevation to section and from section to elevation. Drawings must include elevations, floor plans, sections and full size details. Details shall be fully drawn (not outlined). Drawings shall include the following information:

(i) Assembly and water-tightness and/or pressure equalization and rain screen system of curtain wall.

(ii) Glass and metal thicknesses.

(iii) Metal alloy, temper and finish.

(iv) Glass strength, tint, coating, opacifier, frit and safety backing.

(v) Fastener alloy, strength, plating, diameter, length and spacing.

(vi) Glazing materials identification.

(vii) Sealants identification by product name.

(viii) Relative layout of walls, beams, columns and slabs with dimensions noted.

(ix) Dimensioned position of glass edge relative to metal surface.

(x) Provisions for thermal movements and building movements.

(xi) Locations of, and details for, any embedded anchors.

(xii) Identification of, and details for, thermal insulation.

(xiii) Weld information and weld symbols conforming to **BS 499-2C,** BS **EN ISO 2553.**

(xiv) Glazing details applicable to replacement glass, with outline of procedure for glass replacement.

(xv) A drawing to show any changes to the typical anchorage system required to accommodate the maximum and minimum concrete condition is to be provided to confirm that provisions for adjustment of anchors, relative to tolerances of building structure, has been considered.

(xvi) Details of spandrels, copings, louvres and operable window.

(xvii) Details of ceiling and bottom/floor closure panels or strips if applicable.

(xviii) Details of fire barriers between perimeters of floors and curtain wall.

(xix) Details of lightning protection.

(xx) Location of equipotential bonding points.

(b) Provide shop drawings and fully coordinated structural calculations, certified by a qualified structural engineer, as specified. Calculations shall be legible and shall incorporate sufficient cross references to the shop drawings to make the calculations readily understandable and reviewable. Test reports shall not be an acceptable substitute for calculations. Calculations shall include the following information:

(i) Analysis and design for all applicable loads on glass elements, framing members and their connections.

(ii) Analysis and design for all applicable loads on anchors, including anchors embedded in concrete.

(iii) Section property computations for glass elements and framing members.

(iv) Analysis of stress in structural silicone applications at vision or spandrel glass lights, stiffeners to panels and all other areas where silicone is used to retain items subject to structural loading.

(v) Certification of a Registered Structural Engineer.

(c) Drawings and structural calculations shall be required for test mock-ups. The requirements for test mock ups shall generally be the same as for the actual Works, with particular reference to mock-up conditions.

(d) Additional submittal requirements:

(i) Prior to, or at the same time as, the first submittal of structural calculations for approval, provide dimensioned die drawings for all aluminium extrusions.

(ii) In the event that extrusion profiles are not finalized, provide die drawings for the profiles contemplated at that time. If profiles are revised, provide revised die drawings with the first calculation or shop drawing submittal which follows the revision.

(iii) Die drawings shall show all profile dimension, metal thickness, alloy and temper.

(iv) Prior to construction, provide die drawings of gaskets and weather-strips. Die drawings shall show all profile dimensions and shall identify materials.

(v) Prior to construction, provide glass manufacturer's wind pressure analysis and thermal stress analysis, as well as glass manufacturer's review of shop drawings stating that details shall be suitable for the proposed glass products.

(vi) Prior to construction, provide sealant manufacturer's compliance certificate comprising test reports confirming sealant adhesion, compatibility and absence of staining for all relevant substrates and sealant manufacturer's print review report stating that the sealant manufacturer has reviewed all the shop drawings and accepted the glazing details, conditions and glazing materials for the satisfactory performance of the sealant. This includes all materials that are designed to or may come into contact with sealants.

(vii) Prior to construction, provide certification that, as a minimum, insulating glass conforms to **BS EN 1279**. The quality documents as required in items (a) and (b) of Clause 20.2C shall also be provided.

(viii) Prior to submitting any documents for approval, submit laboratory test reports for structural silicone assembly, as required under TESTING.

(e) Samples of materials:

(i) Submit together with Clause 16.10 (a) above, samples of all materials together with fully glazed samples of principal junctions and assemblies.

(ii) Submission shall consist of three samples of each material and principal junction or assembly, two to be retained by the SO, and the other to be returned after approval. Approved samples shall be so marked by the SO. Samples of materials required shall be as follows:

Aluminium/Stainless steel sections	300 mm length of each.
Galvanized mild steel	300 mm length of each section.
Sheet, plate, mesh	500 x 1000 mm piece of each type.
Glass	600 x 600 mm piece per type and/or edge finish.
Fastening devices	Each type.
Sealants	150 mm cured sample each type.
Gaskets	300 mm length of each type.
Flashings	300 x 300 mm piece of each type.
Stone	300 x 300 mm piece of each type.
Access panel/sash window	500 x 500 mm part with all accessories.

Samples shall show the complete range of colour, texture and other characteristic changes through the manufacture, fabrication, assembly, installation and cleaning processes.

Submit finished samples of every extrusion or section to be used and of every other material of the thickness and weight as required by the SO. Aluminium samples shall include samples of high and low colour range of anodic and organic coating finish and shall be labelled accordingly. Stone samples should include the name of the quarry and country, and consist of full range of colour, texture and the grading of the stone.

Where the sample size is not sufficient to show all differences in appearance, such as stone panels, the Contractor must specify any additional discontinuities, changes to colour texture or other changes that will affect the appearance and/or performance.

(f) Erection and protection method statement

Submit together with Clause 16.10 (a) above, a detailed method statement for erection and protection of the Works. This should include details of storage and protection when materials are stored on site prior to installation.

(g) Mock-up samples

Refer to in Clause 16.73.

(h) Structural adequacy tests of anchorages

Refer to in Clause 16.75.

MATERIALS

Generally **16.11**

(a) Materials shall be structurally sound, able to withstand local pollutants and marine conditions, as well as relative humidity fluctuations as may be experienced in the vicinity of the project. In addition, the materials shall be free from defects and blemishes, and shall conform to the relevant specified standards.

(b) Proprietary items that are site fixed shall be delivered to site in the manufacturer's original packaging.

(c) Materials of common type shall be obtained from the same manufacturer.

(d) All materials or components shall be fully compatible with each other. Submit test certificates to prove compatibility of any materials or components as requested by the SO.

Steel **16.12**

(a) Stainless steel shall be to **BS EN 10048, BS EN 10095, BS EN ISO 9445-1, BS EN ISO 9445-2** grading not inferior to 304 S15 with minimum thickness of 1mm and with all exposed edges rolled round. Manufacturer's test certificates shall be provided with each consignment to the Site to show that the material has been tested and found to comply with the relevant requirements of **BS EN ISO 9445-1, BS EN ISO 9445-2.** Alternatively, stainless steel shall be to **BS EN 10088** of corresponding grading with properties not inferior to Grade 1.4301(304 S15).

(b) Structural steel shall be to Clauses 15.2 and 15.3, galvanized in accordance with Clause 15.63 and tested in accordance with Clause 15.17.

Aluminium **16.13**

(a) Aluminium and Aluminium alloy shall be to Clause 17.07.

(b) The following alloy and temper combinations are acceptable for extrusions subject to fabrication, finish and structural requirements: 6063-T5; 6063-

T6; 6061-T6. Other alloys of the 6xxx series and other tempers may be submitted for approval. Nominal wall thickness of 3.0 mm or greater is acceptable for structural extrusions; wall thickness less than 3.0 mm may be acceptable and is subject to approval. Minimum nominal wall thickness for non-structural trim shall be 1.5 mm.

(c) The following alloy and temper combinations are acceptable for sheet and plate subject to fabrication, finish and structural requirements: 3003-Hl4; 5005-H14. Other alloys of the 3xxx, 5xxx and 6xxx series and other tempers may be submitted for approval. Provide 3.0 mm minimum nominal thickness.

Glass **16.14** Refer to Clauses 20.2 and 20.18.

Stone **16.15**

(a) The nominal thickness of the stone shall be determined by the specified tests and design rules but shall not be less than as specified. These tests must include for flexural strength test in accordance with **ASTM C880/C880M** and anchorage test in accordance with **ASTM C1354/C1354M**. Determination method for thickness should follow accepted methods (e.g. **CWCT** Recommendations).

(b) Actual stone thickness shall be nominal thickness plus/minus 2.0 mm.

(c) Stone shall be free of damage to front face, back face and edges.

(d) Stone type shall be as specified.

(e) Stone finish shall be as specified and within acceptable colour range.

Anchors in stone **16.16**

(a) Stone shall be supported by continuous kerf clips in sawn grooves at two opposite edges of each piece of stone as a minimum. Kerf clips shall be set in a continuous bed of neutral cure silicone sealant, which has been shown by specified test requirements not to stain the stone. Where the stone has exposed edges and kerf clips are therefore not suitable for use, other methods of anchorage will be permitted.

(b) Kerf clips shall be formed stainless steel or aluminium extrusions. Mill finish aluminium extrusions are not permitted. Extrusions should be anodized (5 μm minimum) or have a chromate conversion / alodine finish.

(c) Anchors in stone other than kerf clips for use in limited areas shall be considered if submitted. Such anchors shall be stainless steel and may be supplemented by an epoxy adhesive which must not restrict the thermal movement or result in any stresses being imparted to the stone other than those due to wind load. However, anchors which rely solely on adhesive shall not be acceptable, positive engagement of the restraint in the stone must be achieved. Alternate anchors shall be subject to approval.

(d) The following types of anchors shall not be acceptable:

(i) Wires.

(ii) Anchors whose only means of attachment to stone or building is a bed of grout, mortar or adhesive.

(iii) Anchors secured in a hole with lead wool packing.

(iv) Anchors which transfer load from one piece of stone to another, rather than to the building structure.

(e) Anchors in stone shall allow for differential thermal movement of stone and the support system.

(f) Adjustment slots in brackets with serrated grooves and matching serrated locking washers will be permitted but tests are required to demonstrate the capacity of the anchorage method is acceptable.

(g) Open ended slots in any stone anchorage brackets are not permitted.

Glazing materials **16.17** Refer to Clause 20.2.

Anchors in concrete and masonry **16.18**

(a) Anchors, including cast-in-situ anchor channels or other embedded fixings in concrete and masonry that are not manufactured from stainless steel shall be hot dip galvanized rolled steel, or hot dip galvanized cold formed steel to **BS EN ISO 1461**. Galvanize steel parts of anchors. After field welding, remove weld slag and touch up affected area as specified in Clause 15.63.

(b) Strength of embedded anchors shall be developed by integral projections or by welded deformed bars or headed studs.

(c) At masonry, through bolts shall be acceptable provided that bearing plates are used at both masonry surfaces. Anchor bolts shall be acceptable only with prior approval from the SO.

(d) At concrete, all fixings including bolts should be cast-in-situ. Anchor bolts shall be acceptable only when prior approval has been obtained from the SO.

(e) Self drilling, self threading screws shall not be acceptable.

(f) Screw-in plugs and powder actuated fasteners shall not be acceptable.

(g) Where curtain wall anchors are installed in “wet area”/“area exposed to weather”, anchors are upgraded to Stainless Steel Anchors embedded in concrete.

(h) Anchor bolts, anchor channels or other proprietary fixings shall be installed in accordance with manufacturers’ specifications including bolt distance, edge distance and embedment depth.

Fastener **16.19**

(a) Fastener requirements listed below shall be applicable to screws, bolts, nuts, washers, rivets and pins.

(b) Stainless steel fasteners shall be to **BS EN ISO 3506-1** and **BS EN ISO 3506-2** on Mechanical properties for corrosion- resistant stainless steel fasteners. Fasteners outboard of or within a glazing pocket, gutter, flashed cavity or other potentially wet location (after completion of construction) shall be of grade preferably A4. Fasteners inboard of potentially wet locations shall be of grade not inferior to A2.

(c) Stainless steel washers shall comply with **BS 4320** and **BS 4464** as far as sizes and tolerances are concerned.

(d) Bolts, screws, nuts and washers shall be to Clauses 15.6, 15.7 and 15.39, as a minimum, galvanized to Clause 15.63 and tested to Clause 15.19.

(e) Provide lock washer or other locking device at all bolted connections.

(f) Powder actuated fasteners shall not be acceptable.

(g) Aluminium fasteners shall be to **BS 1473**.

(h) Actions subsequent to any failure of material or test specimens shall be in accordance with the requirements of Clause 15.21.

(i) The mechanical properties, dimensions, load capacities and specific proprietary model number/series of metal spider fixing and the fixing components shall be shown in relevant drawings and submitted for approval. The Contractor shall carry out proof load testing of spider fixing.

Shims **16.20**

(a) At connections subject to thermal movement or other movement, separate all pairs of moving surfaces with friction reducing pads. Pads shall be minimum 3 mm thick, sufficiently capable of reducing friction to permit movement and shall also reduce movement noise to a level acceptable to the SO, shall be resistant to wear and positively retained in position (open ended slots shall not be acceptable). Pads shall not be subjected to heat damage from welding or cutting or to excessive pressure from over-tightening of bolts.

(b) Shims which transfer shear forces (tending to slide one shim against another) shall be steel plates, set in a staggered pattern and fillet welded to each other and to the adjacent steel surfaces. The shims and welds shall be structurally designed to support the applied loads.

(c) Plastic shims shall be acceptable at static connections for which the shims transfer only compressive forces.

(d) Wood shims shall not be acceptable.

Weep hole filters **16.21**

Weep hole filters shall be 8 to 18 pores per centimeter reticulated PVC coated cell urethane foam, compressed by 30% to 50%.

Sealants **16.22**

(a) Capping sealant shall be a one part gun grade neutral curing silicone elastomeric sealant meeting the performance requirements stated below:

Capping Sealant Properties	**Testing Method**	**Performance Requirement**
Shore A Hardness	**ASTM C661**	15-30
Tensile Strength	**ASTM D412**	0.69 MPa min. (100 psi)
Ultimate Elongation	**ASTM D412**	350% min.
Movement Capacity	**ASTM C719**	± 50%
Elasticity Modulus	**ASTM D412**	0.3 MPa min. (45 psi)
Peel Strength	**ASTM C794**	3.5 kN/m min. (20 lb/in)
Accelerated Aging	**ASTM C793**	250 hrs min. UV exposure time without cracks
Ozone/Ultraviolet Resistance	Weatherometer	Excellent
Staining	**ASTM C510**	None

The colour of the sealant shall be as selected / approved by the SO.

(b) Caulking sealant shall be either:

(i) One part gun grade neutral curing silicone elastomeric sealant or

(ii) One part gun grade moisture curing modified polyurethane.

(c) The preferred caulking sealant shall be a one part gun grade neutral curing silicone elastomeric sealant meeting the performance requirements stated below:

Caulking Sealant Properties	**Testing Method**	**Performance Requirement**
Shore A Hardness	**ASTM C661**	15-30
Compression Set	**ASTM D395** Method A	
Tensile Strength	**ASTM D412**	0.69 MPa min. (100 psi)
Ultimate Elongation	**ASTM D412**	
Movement Capacity	**ASTM C719**	± 50%
Elasticity Modulus	**ASTM D412**	
Peel Strength	**ASTM C794**	
Accelerated Aging	**ASTM C793**	250 hrs min. UV exposure time without cracks
Ozone/ Ultraviolet Resistance	Weatherometer	Pass
Staining	**ASTM C510**	Pass

If modified polyurethane sealant is used, properties must be submitted for approval prior to the placement of the order.

(d) Structural sealant shall be either:

(i) One part gun grade neutral moisture curing silicone elastomeric sealant or

(ii) Two part structural silicone elastomeric sealant. Products requiring mixing of components shall be acceptable only for shop application with mixing and application equipment acceptable to the sealant manufacturer.

(e) The structural sealant shall meet the performance requirements stated below:

Structural Sealant Properties	Testing Method	Performance Requirement
Shore A Hardness	**ASTM C661**	25-50 as in **ASTM C1184-05**
Tensile Strength	**ASTM C1184**	0.83 MPa min. (120 psi)
Ultimate Elongation	**ASTM C1184**	100% min.
Movement Capacity	**ASTM C719**	± 25%
Elasticity Modulus	**ASTM C1184**	0.3 MPa min. (45 psi)
Peel Strength	**ASTM C794**	4 kN/m min. (20 lb/in)
Accelerated Aging	**ASTM C1184**	pass 5000 hrs weathering test
Ozone/Ultraviolet Resistance	Weatherometer	Excellent
Staining	**ASTM C510**	Pass

(f) Comply with printed instructions and recommendations of the sealant manufacturer regarding joint size limitations, mixing, priming, and application. Unless printed instructions advise to the contrary, do not apply sealants when substrates are wet or when the temperature is below 4ºC.

(g) Sealant back-up materials shall be polyethylene foam, urethane foam or extruded silicone as recommended by sealant manufacturer.

(h) All sealant shall be tooled as a separate operation after application.

(i) Coordinate with other sections to assure compatibility of intersecting sealants.

Thermal insulation and fire-safing insulation

16.23 The maximum Overall Thermal Transfer Values (OTTV) to be used in the design of the building envelope shall be as designated in the Particular Specification but is required to be more energy efficient than the requirements of **APP-67**. The ArchSD requirement for the OTTV should be referred to the Department Operational Instruction.

(a) Insulate spandrel glass and other non-vision areas with thermal insulation having a 50 mm minimum thickness and a 0.127 mm thick reinforced aluminium foil vapour barrier. Insulation is to be installed on the interior side of the backpan. Maintain a suitable air space between glass and the back pan. U value is to conform to the overall OTTV requirements of the building as specified in the Particular Specification. Care must be taken to ensure that a double vapour barrier is not caused by the use of any foil sealing tape.

(b) Insulation shall be mechanically retained by aluminium or galvanized steel clips or straps, or integral pockets within the window frames. Maximum spacing of clips and straps shall be 600 mm. Welded or glued impaling pins at 300 mm centres shall also be acceptable. Maintain a suitable air space between glass and the back pan.

(c) Support insulation where it contacts fire-safing, to prevent bow of insulation from pressure exerted by fire-safing.

(d) Completely fill void at floor and roof edges with fireproof material, thickness as required to provide a 2-hour fire rating. The fire barrier must also prevent the passage of smoke. If fire-safing material is used it must be foil backed and smoke seal used at all junctions on the upper face.

(e) Fire-safing is to be compressed 20% to 30%. Support fire-safing insulation on galvanized steel support clips spaced at a maximum of 450 mm centres if the installed fire-safing width is in excess of 150 mm. Alternatively a full width galvanized mild steel tray can also be used to support the fire-safing.

Operable windows **16.24**

Operable windows shall be required to conform to the requirements of this Specification. Except as otherwise specified herein, operating windows shall also conform (as a minimum) to **App-37**, **App-116**, **BS 4873, BS 6375-1+A1, BS 6375-2 and BS 6375-3+A1**:

(a) Weather-strips, glazing gaskets and glazing blocks shall be extruded silicone, EPDM or neoprene. Provide gaskets on both sides of the vent glass unless it is structurally glazed.

(b) The required test specimen size is the maximum size operable window for this project.

(c) Locks and strikes shall be white bronze or type 304 or 316 stainless steel, although suitably finished aluminium extruded keepers and strikes will be acceptable if part of a proven multi-point lock set. Provide a minimum of two locks and two strikes per vent.

(d) Fixed frames and vent frames shall be extruded aluminium with an acceptable factory applied finish. Vent frames shall consist of a tubular profile.

(e) Weather-strips shall have a continuous spline engaged in a continuous groove in the aluminium sash and/or fixed frame. Two continuous lines of weather-strip shall be required at vent perimeters, except for the designed apertures in the external gasket to allow pressure equalization of the interstitial cavity.

(f) If an integral pivot is not used, balance arms shall be provided and these shall be four-bar 300 series stainless steel type 304 or 316 with adjustable friction shoe. Provide two balance arms per vent.

(g) Provide two limit stops per operable window. Material shall be 300 series stainless steel type 304 or 316. Stops shall restrict clear opening to 100 mm. Effective ventilating area shall be based on the maximum clear opening, not on the gross window area.

(h) Operable windows are to have removable handles or special keys to enable the windows to be opened.

(i) Hinges and fastening mechanisms shall withstand positive and negative pressures due to specified wind conditions when the windows are in the open or closed positions.

Composite and honeycomb panels **16.25**

(a) Honeycomb Panels

(i) Honeycomb panels shall have a construction method with a minimum in-use history of 15 years and shall have a nominal overall thickness of 25.0 mm

(ii) Face and back sheets shall generally be aluminium with nominal thickness of 1.0 mm. Alloy shall be of the 3xxx, 5xxx or 6xxx series and shall satisfy structural and finish requirements. Provide formed edge returns and seal edges with silicone sealant. Bonding surfaces shall be chemically pretreated to assure effective and durable bond. Other facing materials may also be suitable and will only be permitted if approved prior to use.

(iii) Core shall be hexagonal cell aluminium foil with minimum nominal thickness of 0.0762 mm. Cell size shall not exceed 6.0 mm measured across flats. Foil shall have an organic corrosion resistant coating. Alloy shall be 3003, 5052, or 2024.

(iv) Adhesive shall be a thermal setting modified epoxy with a minimum set temperature of 121ºC. The adhesive shall form a fillet at the perimeter of each cell, and shall continuously bond each cell to the face and back sheets.

(v) The face sheet, back sheet, and core of each panel shall be cut from single pieces of material. No joinery shall be permitted unless the size of the panel exceeds the sizes that are commercially available.

(vi) For panels in place, deviation from flatness of exterior face shall not exceed 2 mm along any straight line which extends from a panel edge to any other edge. Where the edge is concealed, the nearest exposed point to the edge shall be used.

(vii) Panel exterior face shall be free of visual discontinuities such as ripples, creases, dents, bubbles and blisters, regardless of the measured deviation from flatness at such discontinuities.

(b) Composite Panels

(i) Composite panels shall have a construction method with a minimum in-use history of 15 years and shall have a minimum overall nominal thickness of 4.0 mm.

(ii) Face and back sheets shall generally be aluminium with equal thickness of 0.5 mm. Alloy shall be of the 3xxx, 5xxx or 6xxx series and shall satisfy structural and finish requirement.

(iii) Core shall be entirely of non-combustible materials which meet the requirements of **BS 476-4** or **BS EN 13501-1** Class A1.

(iv) Edges requiring Vee-cutting to enable folding to occur shall be cut in accordance with the manufacturer's requirements. Failure to do so may result in rejection of the material.

(v) Provide formed edge returns with a residual core thickness of 0.2 to 0.4 mm and seal edges with reinforcements and silicone sealant.

(vi) Structural support must be provided by means other than the return edge.

(vii) Bonding surfaces shall be chemically pre-treated to assure effective and durable bond.

(viii) Other facing materials may also be suitable and will only be permitted if approved prior to use.

Louvres **16.26**

(a) Louvres shall consist of extruded or roll formed aluminium perimeter frames and blades. Frame corners and blade ends shall be welded or fastened with 300 series stainless steel screws. Provide concealed extruded aluminium stiffeners for blades, such that vector sum of blade deflections parallel to blade principal axes does not exceed 1/175 times span at design pressure. Assume that pressure acts perpendicular to the plane formed by the corners of the perimeter frame, and that the tributary area for one blade equals its projected area on the same plane.

(b) Louvres in external walls are to comply with the water resistance requirements of **ANSI/AMCA Standard 500-L**. Coordinate free area of louvres with mechanical requirements.

(c) Inactive louvres shall be closed by aluminium sheet with minimum 3.0 mm nominal thickness, fastened and sealed to the indoor louvre surfaces. External face of sheet is to be finished with an approved factory applied architectural finish.

Copings **16.27**

Copings shall comply with the following:

(a) Copings shall comprise of aluminium, minimum 3.0 mm thick or stainless steel, minimum 2.0 mm thick. Unless specified to the contrary in the Particular Specification, the surface finish shall be the same type of finish and colour as the visible external framing.

(b) Copings shall be rigid, reinforced with a metal frame if required and shall be fixed rigidly to the structure. Copings shall be strong enough to resist forces due to typhoon and casual impact.

(c) Ends of coping panels and joints to curtain wall frame shall be tightly sealed up and an effective drainage system shall be provided to drain out any water that may penetrate through the joints.

Concealed and exposed flashing **16.28**

(a) Acceptable elastomeric materials are silicone, neoprene or EPDM sheet. If rigid sheets are used, stainless steel sheet and aluminium sheet with a chromate conversion/alodine or a minimum 5 μm anodized finish are acceptable. Minimum thicknesses are 1.6 mm for PVC and neoprene, 0.25 mm for stainless steel, and 1.0 mm for aluminium. Aluminium shall be required to have a bituminous or other type of separation coating against dissimilar metallic materials.

(b) Provide sealed lap joints, end dams and transitions to gutters, dressings to roofs/abutments, louvres and screens to A/C intakes and exhausts.

(c) PVC, EPDM, Silicone or neoprene sheet shall not be acceptable as primary gutters, which shall be metal with suitable corrosion protection.

(d) Exposed flashing shall be strong enough to resist forces due to typhoon and casual impact.

Maintenance replacement standby materials **16.29**

(a) Upon completion of construction, deliver to designated storage area replacement standby materials for maintenance and repair. Materials shall conform to the same requirements as materials used for construction.

(b) The replacement standby materials shall be stored in clearly labeled protective boxing and/or crates and positioned on support frames and/or storage racks which are placed in appropriate locations to ensure that the material shall not be damaged or deteriorate.

(c) The requirements for the maintenance/replacement standby materials are stated in the Particular Specification.

FINISHES

Generally **16.30** Exposed metal surfaces shall be finished to match the appearance, colour and texture of the samples as approved by the SO.

Finishes to metals shall be as specified in Section 17 and the Particular Specification, complying with the requirements stated below shall be the minimum:

(a) Clear or coloured anodic finish to aluminium shall comply with the relevant clauses of **BS 3987, BS ISO 10074** and **BS EN 12373**.

(b) No. 8 bright polished finish to exposed faces of stainless steel.

(c) No. 7 polished finish to stainless steel or chromium plated ironmongery.

(d) Alternative finishes shall be approved by the SO.

(e) Organic coatings shall meet the requirements of **AAMA 2604** for internal and **AAMA 2605** for external finishes.

(f) All as specified and indicated on the drawings.

Protective treatments **16.31** Protective treatment to concealed steel parts of the curtain wall system such as fixings, connectors, etc., shall be hot dip galvanizing to **BS EN ISO 1461**.

All welding and provision of holes shall be completed before galvanizing.

No in-situ welding is allowed unless prior approval has been obtained from the SO. Details of the protective treatment to damaged galvanizing caused by the welding must be submitted to the SO prior to any welding being carried out.

Anodic coating to aluminium and testing of same **16.32** The thickness of anodic coating shall be a minimum of 25 μm for external use and 15 μm for internal usage.

Concealed surfaces are to have a 10 μm minimum thickness. Coloured anodic coatings and testing of same shall be as approved by the SO.

Anodic coatings are required to be sealed using a hydrothermal process, or cold impregnation/cold sealed based on nickel fluoride immersion process to achieve a finish in accordance with **AAMA 611**.

Six sets of colour range samples for both sheets and extrusions (with at least 2 samples each) are to be provided which show the limits of both colour and patina of the anodic coating. These are to be submitted for approval prior to the commencement of production.

Samples of finished aluminium from production lots shall be tested in accordance with **AAMA 611** and **BS EN 12373** and the requirements of the European Qualanod Quality Organisation.

Complete sets of finish process records and certified inspection records for quality of finish shall be maintained and made available to the SO on request. The client or his representative will have the right to audit and inspect any manufacturer without prior notice.

Repair of damage to finished surfaces by mechanical means (other than those specified) or by painting is strictly forbidden unless authorized in writing by the SO.

Surfaces prior to finish shall be free from mechanical imperfections such as scratches, scrapes and dents. Finished surfaces shall be free from finished imperfections such as spots, stains and streaks.

Anodized aluminium shall comply with **AAMA 611** and remain free from visible chalking, crazing and surface corrosion (when viewed from a distance of 3 m) for the duration of the warranty period.

Materials may be finished more than once provided that all specified requirements are satisfied. However, any material which has been finished twice and is still not acceptable shall be rejected.

Organic coating finish to aluminium **16.33**

Organic coating finish shall comply with the following general requirements:

Also refer to Section 17 of this GS.

(a) All coatings, when cured, shall be visibly free of flow lines, streaks, sags, blisters or other surface imperfections. Extrusions shall be free from visible die lines that will show through the organic paint system. In the event that die lines occur, the coating supplier shall specify an appropriate treatment that will fully comply with the specification and warranty requirements.

(b) All finishes shall match in gloss, and fall within the colour range of the approved samples. Six sets of colour range samples for both sheets and extrusions (with at least 2 samples each) are to be provided which show the limits of both colour and gloss retention of the organic coating. These shall be submitted for approval prior to the commencement of production.

(c) Dry film thickness of coating on all the exposed surfaces, or on hidden surfaces if required, shall not be less than the minimum requirements of the paint manufacturer. Paint all visible and exposed surfaces of metal cladding. Surfaces that are not exposed to view must have a protective coating that, if not the same as the visible surfaces, must be approved by the SO.

Prepare and submit colour samples to the SO. After selection by the SO, prepare 6 sets each of two samples which shall define the colour and gloss range and submit to the SO for endorsement. Samples shall be identified and attached with a full laboratory report as required by **BS 4842, BS EN 12206-1** and the requirements of the relevant **AAMA** specification if applicable.

Painted aluminium PVDF finish shall be a factory applied oven cured minimum two-coat finish of a fluoropolymer resin supplied by a licensed formulator with a minimum of 70% Kynar 500 / Hylar 5000 solids. The licensed formulator shall confirm that the finish which is supplied meets the minimal requirements for formulation as set forth in the licensing agreement. Painted aluminium powder coat finish shall be a factory applied oven cured system of a single coat that complies with the performance requirements of **AAMA 2604** as a minimum.

Application of the finish shall be carried out in accordance with the specifications issued by the licensed formulator and by an applicator specifically approved by one (or more) of the formulators. Test panels must be painted during the production process and tested to ensure adhesion, coating thickness and all other significant properties are in accordance with the manufacturer's requirements. Evidence of these test samples may be required to be submitted prior to final acceptance of the finish. The applicator shall provide written notification of approval by a formulator prior to application of the finish. The formulation shall contain at least 70% Kynar 500 / Hylar 5000 fluoropolymer resin in the residual solids.

Pre-treat metal surfaces in accordance with the procedure recommended by the manufacturer to provide proper surfaces for coating. In the absence of any recommendations from the manufacturer. For all exterior powder coating and painting, etching is required to a depth equivalent to 2 g/m^2 of substrate removal. Interior coatings require etching to a depth of 1 g/m^2. Where possible "Chrome Free" chromate conversion should be carried out in accordance with a procedure that is acceptable to the organic coating supplier.

Aluminium finish at structural silicone **16.34**

(a) Mill finish shall not be acceptable at structural silicone bonding surfaces.

(b) Aluminium surface to which structural silicone will be adhered shall have a finish which demonstrates by test the ability to satisfy specified requirements. Subject to testing, acceptable finishes shall be as follows:

(i) Factory applied single coat powder polyester or a minimum two-coat oven cured fluoropolymer paint conforming to **AAMA 2605** for external usage.

(ii) 25 μm anodizing conforming to **AAMA 611**.

(iii) Alodine conversion coating.

WORKMANSHIP

Generally **16.35**

Material, components and systems shall be used in compliance with the standards and procedures of the appropriate manufacturers. All work shall be of the highest quality and be carried out by competent tradesmen holding relevant trade certification; such that the finished work satisfies the requirements of the specification. Practice shall conform to the relevant part and in the priority of:

(a) **BS EN 1999-1-1**, **BS EN 1999-1-3** & **BS EN 1999-1-4**

(b) Structural steel shall be to Section 15 of this GS**.**

(c) **BS 6262 -** Code of practice for Glazing for Buildings and **BS 6262-1 to BS 6262-4, BS 6262-6 & BS 6262-7:** Glazing for Buildings.

(d) **BS 8200** Design of non-loadbearing external vertical enclosures of buildings.

(e) The subclass P sealants refer to **BS EN ISO 8339, BS EN ISO 9046** and **BS EN ISO 10591**; the subclass E sealants conform to **BS EN ISO 8340, BS EN ISO 9047**, **BS EN ISO 10590** and **BS EN ISO 11431**; the subclass F&G sealants to **BS EN ISO 11600+A1**.

(f) Recommended glazing guidelines for monolithic, laminated and insulating glass by **GANA**.

(g) Aluminium Curtain Wall Design Guide Manual by **AAMA**.

(h) Metal Curtain Wall Manual by **AAMA**.

No temporary stress or force shall be applied at any time to the assembly, units, individual components or fixing devices which these have not been designed to withstand. Provide temporary supplementary frame stiffeners for curtain wall units for handling purposes when required.

Conform strictly to the material finishes, shapes, sizes, thickness, and joint locations required by the agreed shop drawings and the Specification.

Match all materials to produce continuity of line, colour and texture.

Protect from damaging curtain wall units and components stored on the Site.

Store glass on the site in a dry well-ventilated sheltered location.

Handling glass shall be kept to a minimum and all glass shall be carefully protected from soiling, condensation and damage. To avoid damage of glass, glass must not be slid directly onto a hard surface and the glazing rebates of the frames should be checked to ensure they are free from sand or any other debris prior to glass installation.

Carry out all final fitting and assembly work on the Site in a workshop established and equipped for that purpose.

All components exposed in the finished work shall be free from warping, oil-canning effects and the telegraphing of welds, studs and other fasteners.

Provide specified finishes on all exposed surfaces. Provide specified galvanizing on concealed steel.

Setting out **16.36**

Before commencing any work, verify all measurements of the "as constructed" building. If any discrepancies are found they shall be brought immediately to the attention of the SO. Design curtain wall anchorage to accommodate a minimum 25 mm construction tolerance in any direction of the building structure.

Accurately set out the Works and take all necessary Site dimensions.

Joints in curtain wall **16.37**

Visible joints in the curtain wall shall be as shown on the drawings. Other joints shall be hairline joints, tightly fitted and coordinated with mullion grids.

All fastening, jointing and splicing of members shall be concealed. Exposed fasteners shall only occur where expressly permitted by the SO. Where exposed in the finished work, screws shall be the countersunk head type, finished to match the adjacent surface.

Fasteners shall not penetrate gutters and drainage systems.

Corrosion Protection **16.38**

Aluminium in contact with dissimilar metal excluding non-magnetic stainless steel shall be treated with an approved treatment for the prevention of electrolytic action and corrosion.

Aluminium surfaces in contact with mortar, concrete, plaster, masonry and similar materials and wet-applied materials in fire-proofing and absorptive materials shall be coated with an approved anti-corrosive moisture-barrier material.

The Contractor shall clearly state what material is to be applied and provide a certificate from the curtain walling manufacturer certifying that the material is suited for its intended purpose.

Metal to metal contact **16.39**

Separate metal surfaces in such a manner that metal does not rub against metal. Materials used for this purpose shall be lubricating devices, sealants, slip pads or gaskets.

Welding **16.40**

Welding of steel shall be in accordance with **BS EN 1011-1**.

Welding of aluminium shall be to **BS EN 1011-4**.

Welding of Aluminium shall be tested to **BS EN ISO 4136** Destructive tests on welds in metallic materials - Transverse tensile test, **BS EN ISO 5173** Destructive tests on welds in metallic materials - Bend tests, **BS EN 1320** Destructive tests on

welds in metallic materials - Fracture tests and **BS EN 1321** Destructive test on welds in metallic materials - Macroscopic and microscopic examination of welds.

The type, size and spacing of welds shall be as shown on the agreed shop drawings. Welding materials and methods shall be such as not to cause distortion, discolouration, or result in any other adverse effect on the required profiles and finishes of the exposed curtain wall.

Weld spatter and welding oxides on exposed surfaces shall be removed, and prime painted with zinc rich coating.

Unless otherwise shown or specified, weld beads on exposed surfaces shall be ground and finished to match and blend with finish on adjacent metal. Grinding and polishing of nonferrous metal shall be done only with clean wheels and compounds free from iron and iron compounds. No soldering and/or brazing shall be allowed.

Application of sealant and gasket **16.41**

The subclass P sealants refer to **BS EN ISO 8339, BS EN ISO 9046** and **BS EN ISO 10591**; the subclass E sealants conform to **BS EN ISO 8340, BS EN ISO 9047**, **BS EN ISO 10590** and **BS EN ISO 11431**; the subclass F&G sealants to **BS EN ISO 11600+A1**.

The design of all sealed joints shall be in accordance with the recommendation of the sealant and/or gasket manufacturer.

Protect all adjoining surfaces to sealants and gaskets against staining.

Joints, joint surfaces and glazing rebates shall be clean, dry, and free of any material that may have an adverse effect on the bonding or sealing of the sealant and gasket materials or on the proper drainage of the glazing rebates.

Apply sealants and gaskets under the conditions and in the manner recommended by the manufacturer. No sealant that has started to set in its container or has exceeded its shelf life shall be used. Do not apply sealants externally during raining period.

The sealant manufacturer shall provide written notification if the relevant substrates in contact with sealants shall or shall not require priming. The recommendations shall be based on tests conducted by the sealant manufacturer using samples of the relevant substrates for the project. Unless printed instructions state to the contrary, sealant shall not be applied when substrates are wet or when the temperature is below 4.5ºC.

Fill all joints continuously and completely with sealant, forming a neat, uniform, concave or flat bead finish flush with adjoining surfaces unless otherwise shown on the drawings. All sealant surfaces shall be tooled smooth.

Exposed sealants shall be installed so that top surfaces of the horizontal sealant beads shall be sloped to drain water away.

Structural sealant for glazing shall be applied strictly according to the recommendations outlined in the sealant manufacturer's print review and adhesion test report. Deglazing test shall be carried out in accordance with the sealant manufacturer's recommended testing percentage to confirm the factory production quality of the structurally glazed glass panes before transportation to the Site for installation. Submit the deglazing test report to confirm the compliance.

Render stops **16.42**

Incorrect placement, levelling or lining-through of angles to in-situ finishings and the like fixed by others shall be immediately reported in writing to the SO.

Sequence of installation **16.43** Coordinate and carry out the installation of the curtain wall in sequence with related work operations to be executed by others as necessary to achieve a weather-tight and satisfactory visual relationship between the various components and the structure, finishes and weather seals.

Erection **16.44**

(a) Install materials and fixings in accordance with approved drawings and method statements. Provide labour, materials, equipment and supervision necessary for a complete installation. Align and anchor materials to building structure. Seal joints within work of this section and at joints with adjacent construction.

(b) Coordinate erection with requirements of materials hoist and personnel lift. Defer installation at areas obstructed during construction and install materials when obstructions are removed.

(c) Tolerances:

(i) Provide anchor adjustment capability for the full range of specified tolerances for the building structure and to accommodate construction tolerances and short term building movements (i.e. concrete column settlement).

(ii) Work of this section shall be within the following tolerances:

(1) Deviation from plumb, level or dimensioned angle shall not exceed 3.0 mm per 3600 mm of length of any member, 6.0 mm in any total run in any line.

(2) Deviation from theoretical position in plan or elevation, including deviation from plumb, level or dimensioned angle, shall not exceed 10.0 mm total at any location. Change in deviation shall not exceed 3.0 mm per 3600 mm run in any direction.

(3) Maximum offset from alignment between two consecutive members placed end to end shall not exceed 1.5 mm.

(4) Maximum offset between glass framing members at corners of glazing pocket shall not exceed 0.8 mm.

(iii) Following concrete placement, the position of cast-in anchors shall be surveyed within 3 days after removal of formwork and the survey report shall be submitted to the SO within one week after the survey check.

(d) Anchorage

(i) Anchor component parts securely in place by bolting. Welding may be used if prior approval is obtained from the SO. Install slip pads between moving parts.

(ii) Provide non-corrosive separators between dissimilar materials.

(iii) Remove weld slag and apply prime paint over welds. Touch up hot dip galvanizing that is damaged by welding or other causes as Clause 15.63.

(iv) Where slots or oversize holes are provided for adjustment only, secure the connection after final adjustment. Interlocking serrations in extruded aluminium brackets and washers shall be acceptable. Steel weld washers with 6.0 mm minimum thickness shall be acceptable with steel brackets. Special washers or nuts

which rely on friction and/or surface indentation of the fastened part shall not be acceptable.

(v) Bolts shall be double nutted, have an acceptable spring washer or be painted/coated with a lock-tight liquid to prevent bolts from loosening.

(vi) All fixings shall be concealed when the work is completed.

(e) Clean surfaces shall be sealed. Install backers, bond breakers, primers and sealants in accordance with drawings, test results and manufacturer recommendations. Tool sealants as a separate operation after application. Immediately remove any masking.

(f) Install thermal insulation, vapour barrier and fire-safing insulation with specified supports.

(g) Adjustment:

(i) Adjust operating windows and doors for proper fit within fixed frame.

(ii) Adjust weather-strips for continuous contact and seal in closed position.

(iii) Adjust hardware for proper operation from closed and locked position to fully open position.

Glazing **16.45** Refer to Section 20.

Stone fabrication **16.46** (a) Fabrication tolerances for exposed surface of individual pieces of stone shall be as follows:

(i) Length and height (or width): 1.0 mm.

(ii) Depth of a saw cut: 2.0 mm.

(iii) Depth of a drilled hole: 3.0 mm.

(iv) Deviation from flat plane in 1200 mm, any direction: 2.0 mm.

(v) Deviation from square: 2.0 mm difference in diagonals.

(vi) Deviation from nominal thickness: 2.0 mm.

(vii) Position of kerf cut relative to outdoor face: ± 1.0 mm.

(b) Fabrication tolerances for exposed surface of one stone system assembly with stone anchored to a support system shall be as follows:

(i) Sealant joint width between pieces of stone: ±25% of nominal. (Joints which absorb thermal and building movements shall require stricter tolerance.)

(ii) Overall length and height (or width), stone edge to stone edge: 3.0mm.

(iii) Offset (in/out) between adjacent stone edges: 1.5 mm maximum.

(iv) Deviation from flat plane for overall length: 5.0 mm.

(v) Deviation from flat plane for overall height (or width): 3.0 mm.

(vi) Difference in overall diagonals measured to outside corners of stone: 5.0 mm maximum.

(vii) Deviation from straight line along entire length of vertical edge: 2.5 mm maximum.

(viii) Deviation from straight line along entire length of horizontal edge: 2.5 mm maximum.

(ix) Offset (in plane) between adjacent granite corners: 3.0 mm maximum (distance between parallel horizontal or vertical lines through corners).

(x) Window opening dimension: 6.0 mm.

(xi) Where more than one tolerance applies, the stricter tolerance shall govern.

DESIGN AND PERFORMANCE REQUIREMENTS

Structural requirements **16.47**

(a) Pressures and loads used for design shall be as calculated in accordance with the requirements of **Code of Practice on Wind Effects in Hong Kong** and **APP-139** or as indicated by the results of a boundary layer wind tunnel test. A boundary layer wind tunnel test shall be carried out if it is specified.

(b) Wind pressures act perpendicular to flat surfaces, regardless of surface orientation. Wind pressures act perpendicular to tangents of curved surfaces. At corners and other changes in plane, both surfaces shall be assumed to experience their inward design pressures simultaneously, and their outward design pressures simultaneously. Design for simultaneous occurrence of inward design pressure on one surface, and outward design pressure on the adjoining surface, is not required.

(c) Unless agreed to the contrary, minimum design pressure loads shall be:
(i) outward (negative) wind pressure 2.82 kPa.
(ii) inward (positive) wind pressure 2.01 kPa.

(d) When protective barrier is not provided separately, the use of curtain wall glazing as protective barrier shall comply with all the structural requirements as specified in **APP-110**. Horizontal imposed loads specified in Table 3 of **Regulation 17(3)** of the **Building (Construction) Regulations** shall also be catered for in the design.

Criteria for framing members and anchors at glass and stone **16.48**

Performance criteria at design pressures and loads for glass, metal panels, stone and their support system shall be as follows:

(a) Deflection Limits and Performance Requirements at Pressures and Loads are to be as stated below unless otherwise required by **APP-37**:

(i) Framing member residual deflection after pressure or load is removed shall not exceed 1/1000 times distance between supports or 2/1000 times cantilever length.

(ii) At anchors, framing member deflection relative to building structure shall not exceed 3.0 mm during pressure application and 1.5 mm after pressure load is removed.

(iii) Upon reversal of pressure or load direction, relative movement between two components that are fastened or clamped together shall not exceed 3.0 mm.

(iv) Upon reversal of pressure or load direction, relative movement between the mullion and the anchor shall not exceed 3.0 mm.

(v) There shall be no disengagement, failure or gross permanent distortion of any component, including glass and gaskets.

(b) At 50% of design pressures, glass centre deflection relative to glass edges shall not exceed 25.0 mm. Glass deflection at 1.5 times design pressures shall be limited to prevent glass disengagement from frame.

(c) At 100% of design pressures and loads:

(i) Perpendicular to the plane of the wall, net deflection of framing members shall not exceed:

(1) 1/180 of the span or 20 mm, whichever is the less, for span not greater than 7.2 m.
(2) 1/360 of the span for span greater than 7.2 m.
(3) 1/90 of the span or 20 mm, whichever is the less, for cantilever type member.

(ii) Net deflection perpendicular to enclosure surface for framing members supporting stone shall not exceed: 1/360 times distance between supports, not to exceed 13.0 mm; 1/180 times cantilever length, not to exceed 6.0 mm; lesser values which may be required to limit stress in stone.

(iii) Net in-plane deflection of framing members shall not exceed 3.0 mm due to dead load only or 3.0 mm change in opening size at any point. In-plane deflection between supports is not to exceed 1/360 times the distance between supports or 10.0 mm whichever is the lesser.

(iv) Net deflection parallel and perpendicular to enclosure surface for framing members at perimeter sealant joints shall not exceed the least value of the smallest of: values specified above or 50% of joint width or a value corresponding to the movement capability of the sealant.

(v) Maximum deflection of metal panels and metal faced panels shall not exceed 0.01 times the shorter dimension (width or height) of the panel. This deflection limit also applies to any stiffeners (but not the perimeter framing members) which are attached to panels.

(d) Design Rules for Framing Members at Design Pressures and Loads:

(i) Stresses shall not exceed the allowable values established by the specifications listed under Clause 16.6. An increase in allowable stress is not permitted for: metal plates or legs up to (12.0 mm) thick bent about the weak axis; fasteners in drilled holes in concrete and concrete masonry units; fillet welds; partial penetration groove welds; stresses resulting from dead loads.

(ii) Glass, sealants and interior finishes shall not be assumed to contribute to framing member strength, stiffness or lateral stability.

(i) Compression flanges of flexural members may be assumed to receive effective lateral bracing only from

(1) anchors to the building structure and
(2) horizontal glazing rails or interior trim which are in actual contact with the compression flange.

Points of contra-flexure shall not be regarded as lateral braces or as the end points of an unbraced length; unbraced length shall be the actual distance between effective lateral braces as defined above.

(ii) Where a framing member reaction is resisted by a continuous element, the maximum assumed effective length of the resisting element shall be four times the bearing length, but not more than 300 mm.

(iii) Splice joints which permit thermal and/or other movements by slippage within the joint shall be assumed to have zero moment capacity.

(iv) Where a framing member runs continuously past a deflection support, combined deflection of member and support shall not exceed specified limits.

Criteria for fasteners **16.49** Performance criteria for fasteners at design pressures and loads shall be as follows:

(a) General requirements

(i) Actual tension shall be taken as the sum of direct tension plus tension due to prying.

(ii) The penetrations of a shim stack with total thickness "t" by a fastener with nominal diameter "d" shall require reductions in allowable tension force and allowable shear force. The minimum reduction shall be 0% for t=d, varying linearly to 100% for t=2d. Such reduction shall be in addition to any other reductions which may be applicable. An acceptable alternative method is to assume that the shims provide no resistance to fastener bending, compute fastener bending stress with cross sectional properties based on root diameter, add bending stress to tension stress, and evaluate tension/shear interaction.

(iii) Unless otherwise specified, combined tension and shear shall be evaluated according to an interaction formula in which each term equals the square of the actual force divided by the square of the allowable force. The sum of the terms shall not exceed 1.0.

(iv) Unless otherwise specified herein or required by code, allowable values for stresses produced by wind loading may be increased by one fourth, except for anchorages, but not in combination with any reduction of combined loads.

(b) Requirements for carbon steel machine bolts and sheet metal screws:

(i) For all fasteners less than 12 mm compute actual tensile stress and actual shear stress based on the tensile stress area. Tensile stress shall not exceed 0.44 times ultimate tensile stress. Shear stress shall not exceed 0.22 times ultimate tensile stress.

(ii) For nominal diameter equal to or greater than 12 mm, evaluate tension, shear and combined stress according to **AISC Steel Construction Manual**.

(c) Requirements for 300 series stainless machine bolts and sheet metal screws:

(i) For nominal diameter equal to or greater than 6 mm, the computed tensile stress based on the tensile stress area shall not exceed 0.541 times tensile yield stress. Shear stress based on gross area shall not exceed 20% of the ultimate tensile stress where threads are not included in the shear plane, and 14% of the ultimate tensile stress where threads are included in the shear plane.

(ii) For nominal diameter less than 6.0 mm tensile stress based on the tensile stress area shall not exceed 0.541 times tensile yield stress. Shear stress based on tensile stress area shall not exceed 20% of the ultimate tensile stress.

(iii) Unless manufacturer's written certification of greater strength is submitted with design calculations, provide fasteners with minimum yield stress of 207 MPa and minimum ultimate tensile stress of 518 MPa.

(d) Requirements for fasteners in drilled holes in concrete and concrete block:

(i) Tension shall not exceed 25% of ultimate tensile strength. Shear shall not exceed 25% of ultimate shear strength. Combined load shall be evaluated by an interaction formula, the terms of which shall be actual load divided by allowable load; the sum of the terms shall not exceed 1.0. Allowable loads shall not be increased by one fourth or any other factor. Comply with manufacturer design rules if more stringent than specified herein. Apply reductions for spacing and edge distance.

(ii) Self drilling, self threading fasteners shall not be acceptable. Screws in plugs and powder actuated fasteners shall not be acceptable.

(e) For self-drilling steel fasteners in aluminium and steel:

Screws that could suffer from hydrogen embrittlement are not permitted unless effective measures have been taken to eliminate the possibility of hydrogen embrittlement occurring. Tension and shear shall not exceed 50% of their respective ultimate strengths.

Criteria for cyclic test **16.50** Performance criteria for cyclic test shall be as specified in Clause 8.3.1 of the **Code of Practice for Structural use of Glass** issued by Buildings Department.

Criteria for structural silicone **16.51** Performance requirements for structural silicone and related structural components shall be as follows:

(a) Wind pressure shall be supported in tension or shear, but not tension and shear simultaneously.

(b) Allowable tension stress or shear stress (but not combined tension and shear stress) shall not exceed 138 kPa at design pressures and loads. The allowable stress is subject to specified material tests, which may result in a value of less than 138 kPa.

(c) The allowable stress shall not be increased by 1/4 or any other factor for wind load.

(d) Structural silicone shall not be used to support long-term loads such as the dead weight of glass, panels or any cladding materials.

(e) Structural silicone shall demonstrate by test an ultimate stress of at least three times the stress caused by design conditions. The force per unit length corresponding to ultimate silicone stress (three times design) shall be transmitted without failure by metal finish (including paint films), glass coatings, insulating glass edge, laminated glass edge and all other components in the line of stress.

(f) Where a test mock-up is subjected to 1.5 times design pressures and loads, the structural silicone and related structural components shall be required to withstand such loading without failure.

(g) On the building, structural silicone shall not experience adhesive or cohesive failure.

(h) Structural silicone shall not be applied to edges of insulating glass units, or to edges of laminated glass units.

Criteria for glass **16.52** Refer to Clause 20.2.

Criteria for stone **16.53**

(a) It should be noted that thermal and age durability testing is required for all stone other than granite. Flexural strength of stone shall be determined by test, and the smallest average value shall be computed, as required in the Clauses 16.74 to 16.79. In the absence of any other calculation methodology, the smallest average value shall be reduced by the design factor to obtain an allowable stress at design pressures. The allowable stress shall not be increased by 1/4 or any other factor. In the absence of specified test data, the assumed allowable stress for preliminary design shall not exceed 1.7 MPa for granite, 1.1 MPa for marble and travertine, 0.92 MPa for limestone. Final design shall be based on specified test results, not assumed values.

(b) Ultimate strength of stone at its anchors shall be determined by test, and the average value for each group shall be computed, as required in the Clauses 16.74 to 16.79. The average values shall be reduced by design factors to obtain allowable loads or stresses at design pressures. The allowable loads or stresses shall not be increased by 25% for stresses attributable to wind loading or any other factor.

(c) Unless an alternate acceptable calculation methodology, such as Method 1 for aged stone or Method 2 for non-aged stone as stated by the CWCT, is to be adopted, the minimum ratio of flexural strength to actual bending stress in stone is the design factor and is related to the spread of data within each subgroup of specimens used to determine flexural strength. Within each subgroup an average value is computed and the high and low values are expressed as a percentage of the average. The design factor shall be computed for the subgroups.

(i) If within all subgroups, the high and low values deviate 10% or less from the average, the design factor is 3.0 for granite, 4.0 for marble and travertine, and 5.0 for limestone.

(ii) If within one or more subgroups, the high and/or low value deviates more than 10% but not more than 20% from the average, the design factor is 4.0 for granite, 5.0 for marble and travertine, and 6.0 for limestone.

(iii) If within one or more subgroups the high and/or low value deviates more than 20% from the average, the design factor is 6.0 for granite, 7.0 for marble and travertine, and 8.0 for limestone.

(d) Unless an alternate acceptable calculation methodology, such as Method 1 for aged stone or Method 2 for non-aged stone as stated by the CWCT, is used the following calculation method is to be adopted. The minimum ratio of stone ultimate strength at its anchors to actual load or stress is the design factor and is related to the spread of data within each group of anchor test samples. Within each group, an average value is computed and the high and low values are expressed as a percentage of the average.

(i) If within a group, the high and low values deviate 10% or less from the average, the design factor is 4.5 for granite, 6.0 for marble and travertine, and 7.5 for limestone.

(ii) If within a group, the high and/or low value deviates more than 10% but not more than 20% from the average, the design factor is 6.0 for granite, 7.5 for marble and travertine and 9.0 for limestone.

(iii) If within a group, the high and/or low value deviates more than 20% from the average, the design factor is 8.0 for granite, 10.0 for marble and travertine, and 12.0 for limestone.

(e) Each piece of stone shall have its own dead weight anchors. Stacking of multiple pieces over a shared dead weight anchor shall not be permitted. Wind load anchors and dead load anchors which rely solely on adhesive bond shall not be permitted.

(f) Calculation of actual stone stress shall be based upon minimum stone thickness (nominal thickness minus thickness tolerance).

(g) Stone shall be supported by continuous stainless steel or anodized aluminium kerf clips engaging continuous sawn grooves at two opposite edges. The clip shall nominally overlap the stone on both sides of the groove by at least 13.0 mm. The theoretical overlap based on the worst combination of specified building and wall movements shall not be less than 10.0 mm. Actual overlap as measured in the field shall not be less than 10.0 mm or a greater dimension if required by design criteria. Clip and stone design shall be based on transfer of force at the midpoint of the overlap dimension.

(i) Stone shall not be designed to act as part of a composite flexural member.

Criteria for track and tie-back **16.54** Continuous scaffold track and discrete tiebacks for cable restraint shall be capable of withstanding an ultimate concentrated force of 9.6 kN acting in any direction, at any point on the track, without failure or gross permanent distortion of the track, tieback or any other component of the exterior wall.

The Contractor can propose alternative designs for the scaffold restraint system for the SO's approval. Allowable working stress for tracks, tiebacks and wall components shall not be exceeded for a force of 2.4 kN acting in any direction. Tiebacks shall conform to **OSHA Instruction STD 1-3.3** as amended November 12, 1985.

Criteria for weather seals **16.55** Sealants used as weather seals shall not experience adhesive or cohesive failure. Sealants shall withstand movements up to the limits prescribed by the manufacturer. Exposed sealant surface shall not crack or bubble. Sealants and primers shall not stain adjacent materials. Sealants shall be used only if the

manufacturers' adhesion, compatibility and stain tests yield favourable results. Sealants shall not be adhered to, or placed against, the edge of a laminated glass unit inter-layer.

Floor sag and other movements **16.56** Provide movable joints to accommodate the full range of manufacturing tolerance, field tolerance, thermal movement, lateral movement, floor sag, and beam sag and column settlement. Joints shall accommodate the worst possible combination of effects so as to prevent internal stress, failure, deterioration or failure of weather seals. In no case shall the computed and as-built glass bite relative to metal frame be less than 10.0 mm. In no case shall the computed and as-built glass edge clearance to nearest metal be less than 6.0 mm. The design differential movements shall be as specified. Expansion joints in ribbon window heads and sills shall not be located such that thermal movement exerts shear stress on structural silicone. Unless other specified, the minimum design differential movements shall be:

(a) Lateral movement is 1/500 per increment of height.

(b) Vertical shortening of column/wall under load is 2 mm per storey.

(c) Vertical deflection of supporting beam/slab is L/350 or 20 mm whichever is the lesser. (Where L is the span, or length in the case of a cantilever.)

(d) Thermal movements are movements arising from temperature variations stipulated in Clause 16.57.

The Contractor shall satisfy himself that the above design differential movements provide sufficient factor of safety in his design. Should he consider that these design differential movements do not provide an adequate factor of safety in his design, he shall submit alternative design differential movements with adequate justification for the approval of the SO.

Criteria for thermal movement **16.57** Thermal component of joint movement shall be based upon a minimum material temperature increase of 55ºC and decrease of 55ºC relative to nominal condition. Design for these assumed temperature changes regardless of surface areas exposed to exterior and interior. Assume the entire cross section has uniform temperature. For thermal design other than joint movement, the surface temperature should be 0ºC to 50ºC for clear glass and 0ºC to 90ºC for tinted glass. The internal ambient temperature shall range from 15ºC to 25ºC. All components including adhesives and sealants shall be capable of withstanding without failure the maximum and minimum surface temperatures with simultaneous specified loads.

Water leakage control **16.58** Provide internal gutters and weep system to collect and drain water leakage and condensation to the exterior. Stick built curtain walls and punched windows shall have an isolated gutter cavity at each glass perimeter, so that any leakage is confined to and wept from the opening of leakage origin. Unitized curtain walls shall have continuous spliced gutters at the horizontal stack joints, with sealed end caps at termination conditions. Sloped walls shall convey leakage to the lowest point and drain it to the exterior. Horizontal ribbon windows shall have a continuous gutter and weep holes at the glass sill, and a continuous gutter at the glass head which either drains directly to the exterior or directs any leakage from the spandrel above it to the glass sill via internal cavities. Coordinate with other sections to achieve interface and/or overlap of gutter and weep systems.

Condensation gutters **16.59** Sloped and horizontal walls shall have continuous condensation gutters of the same material (Aluminium/Stainless steel) at all framing members. Condensation shall be wept to the exterior.

The design and installation of the condensation gutters shall follow **BS 5250+A1** on **Code of Practice for Control of Condensation**.

Glass replacement **16.60** Glazing details shall permit glass replacement after initial construction, shall permit reuse of original gaskets, shall permit replacement of glass with the same nominal size as original glass, and shall not require cutting of framing members or removal of interior finishes. Vision glass in conventional frames shall be replaceable from the interior. Spandrel glass shall be replaceable from the exterior. Silicone supported vision glass shall be replaceable from the exterior and/or interior.

Gasket disengagement not permitted **16.61** Gaskets and weather-strips shall not disengage for pressures up to 1.5 times design pressures, for specified movements, or for specified thermal changes.

Criteria for interior trim **16.62** Interior window sill trim shall not deflect more than 3.2 mm when subjected to a concentrated force of 111 N at any point. Residual deflection after removal of force shall not exceed 1.6 mm.

Criteria for snap-on components **16.63** Snap engaged trim shall not disengage when subjected to a concentrated force of 50 N at any point or during uniform pressure structural tests at pressures less than or equal to 1.5 times design pressures. Exterior snap engaged trim shall provide secondary means of securement. Snap engaged trim shall be secured against migration. Snap engaged components shall not serve any primary structural function, such as retention of glass or panels. Snap engaged plastic components shall not be permitted, except as non-structural thermal improvement for interior trim. Joints in continuous snap covers and other continuous trim shall have splice sleeves of the same material and finish as the cover or trim. Mechanically fasten splice sleeves to trim.

Criteria for painted finishes **16.64** Performance requirements for painted finishes on aluminium shall be as follows:

(a) As a minimum, comply with the relevant parts of **BS 4842, BS EN 12206-1** and the **AAMA 2604** or **AAMA 2605** standard.

Paint film shall not crack or peel during the specified special warranty period.

Additional requirements in testing **16.65** Additional performance requirements are contained in Clauses 16.74 to 16.79.

Requirements applicable to mock-up, samples and building **16.66** In general, performance requirements specified for test mock-ups and specimens also apply to the actual building, and vice versa. Variations in criteria over the surface of the building, such as wind pressure, are taken into account in testing of mock-ups and samples. Where certain performance is required for specific test conditions of mock-ups and samples, that same performance is also required of the actual building, for natural conditions equivalent to or less severe than the test conditions.

Criteria for operable window **16.67** Criteria for operable windows shall be as follows:

(a) Operable windows shall conform to the GS. In addition, and as a minimum, operable windows shall also conform to **BS 4873, BS 6375-1+A1, BS 6375-2** and **BS 6375-3+A1**.

(b) Prior to any other mock-up tests, operable windows shall be unlocked, fully opened, closed and locked for a minimum of 50 cycles. If any repairs or adjustments are performed after cycling, the minimum 50 cycles shall be repeated. Mock-up specimens shall be tested for water leakage.

(c) As part of any mock-up tests, provide separate window vents in fixed frames to the laboratory for tests per **BS 6375-2**.

(d) Operable windows shall be complete with ironmongery and accessories and only operable by special keys.

(e) Hinges and fastening mechanisms shall withstand positive and negative pressures due to specified wind conditions when the windows are in both open and closed positions.

Closure panels and sills **16.68** Ceiling and bottom/floor closure panels, strips or sills shall comprise aluminium minimum 3.0 mm thick or stainless steel minimum 1.2 mm thick. The surface of the aluminium shall match the colour of the framing. Ceiling closure strips shall be capable of supporting Venetian blinds of any type and weight and if indicated on the Drawings shall be recessed for the same.

Criteria for honeycomb panels and composite panels **16.69** Performance requirements for aluminium honeycomb and composite panels shall be as follows:

(a) Panels are included in the overall performance requirements for the curtain wall.

(b) At design pressures, center deflection of panels shall not exceed 0.01 times the smaller panel dimension.

(c) Panel edges shall not compress or crush due to clamping pressures exerted by the frame and gaskets.

(d) Face sheets and back sheets shall not totally or partially delaminate from cores for specified temperature variation and building movement, in combination with wind pressures up to 1.5 times design pressures. Delamination is unacceptable regardless of the measured deviation from flatness which results.

(e) Panels in place shall not warp or bow such that deviation from flatness exceeds 3.0 mm along any straight line which extends from a panel edge to any other edge. Where the edge is concealed, the nearest exposed point to the edge shall be used.

(f) Structural calculation submittal shall include computations for deflection, face stress, core shear stress, face dimpling and face wrinkling. At design pressures, the ratios of face yield stress, core shear strength, critical dimpling stress and critical wrinkling stress to actual respective stresses shall be at least 2.0. Allowable stress shall not be increased by 1/4 or any other factor for wind loading.

(g) Structural calculation submittal shall include data for the honeycomb core with a certification from the core manufacturer, or a test report from an independent laboratory for tests conducted within 30 days of submittal date. Data shall include stabilized compressive strength, stabilized compressive elastic modulus, crush strength, shear strength and elastic modulus in “L” and “W” directions.

(h) Structural calculation submittal shall include a test report from an independent laboratory for tests conducted within 30 days of submittal for the adhesive used to bond face and back sheets to core. Tests shall be conducted on samples using the production facings, core and adhesive. Data shall include tensile and shear strength of bond line at -18, 4, 27, 49, 71ºC. Each strength value shall correspond to a constant load (not constant deformation) maintained for a minimum of 10 seconds. Actual stresses shall be computed at the adhesive plane. The ratio of strength (based on the lowest test value, not the average) to actual stress shall be a minimum of 2.0. Combined stress shall be evaluated by a linear interaction formula. The allowable stress shall not be increased by one fourth or any other value. The applied load shall not be reduced by any factor.

Criteria for skylights **16.70** Criteria for skylights shall be as follows:

(a) Provide continuous condensation gutters, with drainage to the exterior, at all glass perimeters. Condensation gutter intersections shall have sealed overlaps.

(b) Provide continuous bearing of exterior glass retainers on the rafters and cross bars.

(c) Provide continuous recessed pockets for any wet seals at glass perimeters.

(d) Any structural silicone shall adhere to the indoor glass surface, not to the glass edge.

(e) Sloping skylights shall be designed to prevent water from collecting on top of the exterior surfaces of the horizontal framing members.

Fire resistance **16.71** Curtain wall, which protects the building against the elements and which extends beyond one storey in height, should be constructed entirely of non-combustible materials (except for window sealants and gaskets) according to **Code of Practice for Fire Safety in Buildings**. The top and bottom gaps between the structural floor slabs and related beams and the panels of the curtain wall shall be completely sealed up with fire resistant material, having a Fire Resistance Rating (FRR) of not less than that of the floor slabs, against fire and smoke. Anchorages between the curtain wall and the structure shall be similarly protected with fire proof material to give a total resistant period of 2 hours. The fire resistant material in the gaps between the curtain wall and the structural floor and related beams shall be rigidly fixed to the structure continuously such that it shall remain in position when subjected to the prolonged action of heat and fire. Asbestos products shall not be used. Test, if specified, to the relevant clauses of **BS 476-4** for External Curtain Wall System to determine the resistant period for stability and integrity.

Lightning protection **16.72** The design shall provide an efficient continuous electrical conductivity both with negligible resistance vertically and horizontally along the entire surface of the metal framework of the curtain wall in compliance with the **IEC 62305**. Carry out continuity tests by a qualified electrical engineer and submit test records to the SO for approval. If deemed necessary by the SO incorporate additional conductors wiring connections etc. in the curtain wall.

The electrical earthing and lightning protection system for the entire building will be installed by others and will bond the highest point of the curtain wall framework to air terminations and the lowest point of the curtain wall framework to earth. Provide the necessary connection terminals to permit such bonding.

Mock-ups erection and tests **16.73** Fabricate and erect within 60 days of the agreement by the SO of shop drawings, the following mock-up samples for the SO's approval prior to fabrication of the bulk:

(a) Furnish labour and materials to build and test mock-ups as shown on drawings. Mock-ups shall accurately represent job conditions including joints, sealants, glass, glazing, stone panels, anchors and finishes. Install sufficient fire-safing insulation to demonstrate details of installation. Install sufficient thermal insulation to demonstrate details of installation. Delay installation of fire-safing and thermal insulation until completion of air, water and structural tests.

(b) Each mock-up shall be glazed with one consistent set of gaskets for each similar glazing condition. The use of multiple gasket profiles and/or thicknesses at the Contractor's discretion shall not be permitted.

(c) Prior to tests, and in the presence of authorised parties, remove and reglaze selected glass units, using the details and procedures intended for glass replacement on the actual building. Reglazed units shall satisfy test criteria.

(d) Provide at least one extra light of glass for each type and size on mock-ups. Glass which breaks during testing shall be replaced with new glass and the tests continued. Repeated glass breakage (twice at the same location) shall constitute failure.

(e) Construct mock-ups in strict accordance with approved mock-up shop drawings. Deviations from or additions to details shown on Drawings shall be subject to approval.

(f) Construct mock-up with the exterior side facing outward.

(g) The testing laboratory shall be responsible for conducting and reporting the tests, and shall state in the report whether or not the test specimen is as specified, and shall specifically note deviations therefrom.

(h) If failures occur, revise and retest mock-ups until satisfactory test results are achieved. Modifications shall be realistic in terms of job conditions, shall maintain standards of quality and durability, and shall be subject to approval.

(i) Mock-up testing shall be done at an Accredited Laboratory to be approved by the SO. If dynamic water infiltration test is specified, laboratory shall have capability to conduct dynamic testing as specified. Submit detailed information on laboratory facilities and test equipment for approval.

(j) Mock-ups shall be subject to observation by the SO throughout their construction and testing. Provide minimum two week notice before beginning construction of mock-ups. Provide materials and personnel for prompt continuous construction of mock-ups. The Contractor shall coordinate chamber availability, shipping schedules and mock-up construction schedules directly with the laboratory.

(k) The testing laboratory shall not do any of the following:

(i) Act as consultant to the Contractor for the Works.

(ii) Modify performance requirements.

(iii) Modify mock-up configuration.

(iv) Dismantle mock-ups until notified that no further testing is required.

(l) Undocumented tests shall not be permitted. All test results and all remedial work shall be documented in the laboratory report.

(m) Mock-up configuration is shown on Drawings. The mock-up design pressures and maximum test pressures shall be as specified.

TESTING

Laboratory tests on full scale mock-ups **16.74**

(a) Testing sequence shall be:

(i) Unlock, fully open, close and lock all operating windows for a minimum of 50 cycles. If any repairs are performed after cycling, the minimum 50 cycles shall be repeated after repairs.

(ii) Preload at 50% of inward design pressure for 10 seconds.

(iii) Air infiltration and exfiltration.

(iv) Water infiltration under static pressure.

(v) Water infiltration under dynamic pressure if so specified.

(vi) Structural test at 50% and 100% of inward and outward design pressures. Pressure shall be held for 10 seconds for each pressure load. Unless otherwise required, test 50% and 100% inward loads before 50% and 100% outward loads.

(vii) Repeat test for water infiltration under static pressure.

(viii) Racking test for live load and interstorey drift.

(ix) Water infiltration under static pressure.

(x) **Code of Practice for Structural Use of Glass**, structural mock-up cyclic test.

(xi) Structural test at 75% and 150% of inward design pressure. Pressure shall be held for 10 seconds.

(xii) Structural test at 75% and 150% of outward design pressure. Pressure shall be held for 10 seconds.

(xiii) Concentrated load test of track/tieback.

(xiv) Concentrated load tests of operating window as per **BS 6375-2**.

(b) Air leakage testing shall conform to **ASTM E283**, and mock-ups modified to include measurement of exfiltration in addition to infiltration. Differential static test pressure shall be 300 Pa. If overall figure is significantly below the allowable leakage for the specimen, the chamber leakage does not require to be determined. If the overall figure is within 10% of the allowable leakage for the specimen, the leakage of the chamber must be accurately determined, not estimated. The overall air infiltration and exfiltration of the specimen wall area shall not exceed 1.6 $m^3/hr/m^2$ of projected exterior surface, inclusive of any operating window areas. Air infiltration and exfiltration of operating windows shall not exceed 2.0 $m^3/hr/m$ of crack length but the figure is to be included in projected wall area for the overall leakage figure and not treated as an additional figure. Fixed panels of sliding windows shall be included in fixed wall area, and shall not be included in operator crack perimeter.

(c) The occurrence of condensation during water infiltration tests is acceptable. The accumulation of water in sliding window sill tracks is acceptable; overflow, percolation or leakage of water from sill tracks is not acceptable. Other water leakage is acceptable only if all of the following conditions are satisfied:

(i) The water is contained and drained to the exterior;

(ii) There is no wetting of a surface that would be visible to building occupants;

(iii) There would be no staining or other damage to any part of the completed building or its furnishings.

This definition of water leakage shall govern over other definitions which may appear in referenced documents.

(d) Static water infiltration test shall conform to **ASTM E331**. Differential test pressure shall be 20% of the maximum inward design wind load but not less than 0.77 kPa. There shall be no unacceptable water leakage as defined herein. The sources of all water leakage during testing shall be identified. The test shall be performed with water flow rate of 3.4 L/min/m^2, for 15 minutes. No presoaking of the wall is required. The differential pressure should be applied promptly after the water flow rate is deemed as being acceptable.

(e) Dynamic water infiltration test shall conform to **AAMA 501.1** except as otherwise specified herein. Differential test pressure shall be equivalent to 20% of the maximum inward design wind load but not less than 0.77 kPa. If necessary supplement the dynamic pressure with static pressure. There shall be no unacceptable water leakage as defined herein. The sources of all water leakage during testing shall be identified. The test shall be performed with a water flow rate of 3.4 L/min/m^2, for 15 minutes. If this test is performed immediately after a static water test, a period of 15 minutes must be allowed to elapse for the specimen to drain prior to commencement of the test. Drainage must occur due to gravity only; no forced pressurization of the specimen is permitted.

(f) Structural tests shall conform to **ASTM E330**. Deflection gauges or transducers shall be set to zero prior to each application of pressure at 50%, 75%, 100% and 150% of design pressures. Deflection readings shall be recorded after each application of pressure. Deflection measurements shall not be required for the initial pre-load but are required for reversal of loadings during the structural load testing to enable any movement at the anchors to be determined. Specified deflection and set limitations are intended to apply to one application of pressure. Limits do not apply to the cumulative effects of two or more loadings. The results of these test loads shall comply with Clauses 16.48, 16.61, and 20.2.

(g) Glass provided for a test mock-up shall be identical (including strength) to the glass provided for the corresponding zone on the actual building. Mock-up glass which breaks shall be replaced with the same type glass, and the tests continued. Repeated glass breakage, twice in the same location, shall constitute failure.

(h) Perform concentrated load test on track/tieback as follows:

(i) Apply 3.6 kN, (2.4 kN x 1.5 SF), side load in both directions for at least 10 seconds.

(ii) Apply 3.6 kN, (2.4 kN x 1.5 SF), outward for at least 10 seconds.

(iii) There shall be no failure or gross permanent distortion of the track or any part of the exterior wall including tie back fasteners.

(i) Racking test:

(i) The mock-up test chamber shall be constructed so that the simulated floor structure at approximate mid-height of the mock-up is moveable in a horizontal sense parallel to the glass plane(s).

(ii) The magnitude of movement, shall be 1/500 storey height or 10 mm per storey whichever is the greater, in each direction, plus and minus from nominal. The magnitude of racking for vertical movement shall

be equal to the anticipated live floor movement plus the anticipated long term creep and column shortening.

(iii) Displace moveable structure first in one direction, then in the other direction. Repeat for a total of at least 20 two-stroke cycles.

(iv) There shall be no failure or gross permanent distortion of anchors, frames, glass or panels; structural silicone shall not experience adhesive and/or cohesive failure; glazing gaskets may not disengage; weather seals may not fail. At the discretion of the test engineer, an additional water test may be applied between the horizontal racking and vertical racking to enable the cause of any potential failure to be accurately determined.

Field tests on actual buildings **16.75**

(a) Method for field check for water leakage, but not interpretation of results, shall conform to **AAMA 501.2**, except as modified herein. Operable windows shall be tested in the same manner as fixed wall areas. There shall be no unacceptable water leakage as defined herein. Provide powered scaffold, hose, water supply and manpower to perform at least two successful tests, plus any unsuccessful tests on each wall system. Water testing shall be conducted early in the construction schedule, prior to 30% of completion of the relevant wall type. Construction sequence shall include provisions for timely completion of test areas. Remedial measures shall maintain standards of quality and durability and shall be subject to approval.

(b) Periodically test sealants in place for adhesion, using methods recommended by sealant manufacturer. Promptly replace any sealant which does not adhere or fails to cure.

(c) For on-site application of structural silicone, perform a peel test using methods recommended by the sealant manufacturer, on at least 10% of the glass openings.

An acceptable alternative for shop applied structural silicone is to perform a uniform pressure test at outward design pressure for at least 10% of the glass openings. Maintain records describing type of test, date of test, person conducting test, results and identification marking of unit tested. Mark each unit so that structural silicone batch numbers and date of application can be traced. Submit records upon request.

(d) Verify during construction that water leakage and condensation are effectively collected and drained to the exterior. Test internal gutters by temporarily plugging weep holes and filling with water. After a minimum of fifteen minutes, inspect for water leakage. Correct deficiencies and re-test until successful tests are achieved. Remove weep hole plugs immediately after testing.

(e) Structural adequacy of anchorages shall be tested to 1.5 times the unfactored loading of Clause 16.47 without failure. The test shall be carried out in accordance with **BS 5080-1** and **BS 5080-2** unless otherwise approved by the SO. The number of tests shall be at least 1% of the anchorages or 5 numbers, whichever is more, of each type and size of the anchorages installed. Each sample anchorage shall be tested for tensile load by pull-out test and/or shear load by shear load test, as appropriate. The sample anchorage shall not show any signs of separation, plastic deformation or deleterious effect, and shall have at least 80% recovery of the total deformation upon removal of the test load.

If the loading test of any sample anchorage fails, the failure mode shall be recorded and the cause shall be determined and reported to the SO. Propose

remedial measures, including justification calculations for any design and method statement, for agreement with the SO prior to carrying out any remedial works. For remedial anchorage, carry out load test in accordance with the above requirements, except that the sampling rate shall be at least 5% of the remedial anchorages or 5 numbers, whichever is more, of each type and size of the anchorages. For remedial anchorage using drill anchors, the load shall be maintained for at least 60 minutes under maximum test load.

The sample anchorage shall not be used for permanent work unless agreed by the SO.

Employ an independent laboratory to carry out the testing of anchorages, and provide any necessary labour and attendance. The independent laboratory shall submit test reports directly to the SO in sealed envelopes within 3 days after the testing.

Laboratory tests of structural silicone assembly **16.76**

(a) Provide minimum two week advance notice to the SO before assembly of specimens and testing of specimens.

(b) Assemble specimens using: aluminium members with proposed production finish; proposed structural silicone (with proposed mix ratio if more than one component); proposed silicone joint size; proposed silicone backer; proposed glass (including insulating glass edge construction and reflective coating) or proposed panel. Fully cure specimens and then immerse in water for 7 days. Samples are to conform to the requirements of the silicone manufacturer.

(c) A minimum of 3 specimens each shall be tested by tensile loading. The force per unit length shall correspond to three times the design pressure which is transferred through all elements in the sandwich. Apply the load in one minute or less (but without impact) and maintain the load for at least one minute.

These and any other tests required to ensure the suitability of the sealant are to be carried out by the sealant manufacturer and all test results confirmed by the manufacturer and submitted to the SO in writing.

(d) All specimens tested shall withstand the specified loading with no failure of any element. Failure of any element(s) on one or more specimens requires a new set of revised specimens to be tested.

Manufacturer's tests of sealants **16.77**

(a) Provide to sealant manufacturers samples of all substrates which are in contact with sealant, regardless of whether adhesion must be achieved.

(b) For substrates which shall support adhesion, submit for record only sealant manufacturers' reports of adhesion tests. An acceptable test method is defined by **ASTMC794**. Other test methods may be submitted for approval prior to the test being performed.

(c) For substrates to which sealant may not adhere, but which are in contact with sealant, submit for record only sealant manufacturers, reports of compatibility tests. An acceptable test method is to place the substrate on uncoated glass, and apply sealant to the glass against the substrate. If, the intended sealant colour is dark, the dark colour and a light colour of the same product shall be used for the test. Subject specimen to continuous exposure of 2000 $\mu W/cm^2$ minimum ultraviolet radiation for a minimum of 21 days. Specimens showing discolouration of the sealant but no adhesion loss after 21 days shall be subjected to an additional 120 days minimum of the same exposure. Discoloured specimens shall be rated as compatible only if there is no adhesion loss after the initial and extended exposure.

Extensive discolouration of the intended sealant colour, even without adhesion loss, shall be rated as incompatibility. Other test methods may be submitted for approval prior to the tests being performed.

Laboratory tests of stone **16.78**

(a) Submit for record only reports by an independent testing laboratory for tests conducted within 30 days of submittal date. Submit written certifications that test specimens are representative of production material for this project. Provide a minimum 2 weeks advance notice to the SO before conducting stone tests. Provide access to testing laboratory during tests.

Unless an alternative acceptable method of determining the allowable design strength of the stone is used, such as Method 1 for aged stone or Method 2 for non-aged stone, as stated by the CWCT, the following methodology must be applied.
It must also be noted that thermal and age testing of all stone other than granite must be carried out. Stone used for this purpose must be cut from the same block as the original tested stone. If the number of thermal cycles used are less than that stated by the CWCT, then the worst case durability and deviation factors given by CWCT must be used.

(b) As used in this Specification, the term “rift” means the plane of easiest splitting. In stratified stones, rift is assumed to coincide with the bedding or stratification. Rift shall be identified by the quarryman on all test samples, and the identification shall be marked on all test specimens by the party preparing the specimens. As used in this specification, the term “specimen” means a single piece of stone or an anchor-in-stone assembly having specific shape, size and surface finishes.

(c) Perform tests for the following properties:

(i) Flexural strength per **ASTM C880/C880M**.

(ii) Stone strength at anchors as defined herein.

(iii) Water porosity as defined herein.

(iv) Density per **ASTM C97/C97M.**

(d) Specimens tested per **ASTM C880/C880M** shall have the following surface finishes:

(i) The outdoor surface shall have its production finish and shall be the tension side.

(ii) The indoor surface shall have its production finish and shall be the compression side.

(iii) Edges shall have a finely sawn finish.

(iv) Separate groups of specimens shall be required for each outdoor finish to be provided.

(e) Specimens tested per **ASTM C880/C880M** shall have the following nominal dimensions:

(i) Depth shall be equal to proposed thickness.

(ii) Width equals 100 mm when thickness is less than 70 mm, or shall be equal to 1.5 times the thickness when thickness is greater than 70 mm.

(iii) The span as tested shall be equal to 10 times thickness.

(iv) Overall length shall be not less than 50 mm and not more than 100 mm greater than the span as tested.

(f) Results shall be reported for all specimens tested. No result shall be disregarded in computing average values.

(g) At least 20 specimens each, representing at least 5 different quarry blocks shall be tested per **ASTM C880/C880M**. Separate sets of 20 or more specimens shall be required for each outdoor finish for **ASTM C880/C880M** tests. Each group of 20 or more specimens shall consist of 4 subgroups of 5 or more specimens, representing all possible combinations of quarry block, wet or dry conditioning, and loading parallel or perpendicular to rift. Each specimen shall be identified by quarry block, wet or dry conditioning and loading direction.

(h) Bending strength used to compute allowable stress shall be the smallest of the average values computed for each subgroup of 5 or more specimens tested per **ASTM C880/C880M**.

(i) For each type of proposed stone anchor, carry out tests in accordance with **ASTM C1354/C1354M**. Test at least ten specimens, two from each of five different quarry blocks. Test at least five specimens, each from a different block, with inward load, and at least five specimens with outward load. Crosshead movement shall not exceed 0.63 mm/min. Wet or dry condition of stone shall correspond to the weaker condition as determined by flexural strength. Orientation of rift plane shall correspond to orientation on the building. Stone thicknesses shall be minimum (nominal thickness minus tolerance) for anchor test specimens. Continuous kerf type anchors which exceed 300 mm in length may be tested as 300 mm long specimens and the results interpreted as stress in the stone at the bottom of the kerf cut. Results shall be reported for all specimens tested. No result shall be disregarded. Strength of stone at an anchor used to compute allowable values shall be the average value for each group of 5 or more specimens.

(j) For each proposed stone type and finish, perform a water porosity test. A minimum of three specimens shall be required, each having the correct outdoor finish, indoor finish and thickness. Each specimen shall be taken from a different quarry block. Minimum specimen size is 300 mm by 300 mm. Place specimens in a horizontal position, outdoor surface facing upward, such that the indoor surface is clearly visible and is not in contact with any other surface, other than small supports. Air temperature shall be in the range 18 to 29ºC. Seal to the outdoor stone surface a circular or square sleeve having an internal cross sectional area of at least 180 cm^2. The sleeve shall be at least 50 mm from stone edges. Fill sleeve with cold tap water to a depth of 250 ± 6 mm. Maintain test conditions for 7 days. Record the times at which dampness (if any) is first visible on the indoor stone surface; water droplets (if any) are first visible on the indoor stone surface; dripping of water (if any) from the indoor stone surface begins. If dripping occurs, once during each 24 hour period collect the water for one hour and record the volume collected. The formation of water droplets on the indoor stone surface (with or without dripping) constitutes failure. All specimens tested shall pass.

(k) Based on the above test requirements, minimum quantities of test specimens shall be as follows. To assure adequate quantities for testing, at least twice the minimum number of specimens shall be prepared.

(i) **ASTM C880/C880M**; total of (20) specimens, (4) specimens taken from each of (5) quarry blocks.

(ii) Separate sets of (20) or more specimens shall be required for each outdoor finish for **ASTM C880/C880M** tests.

(iii) Each anchor type in stone; (10) specimens, (2) from each of (5) quarry blocks.

(iv) Water porosity test; (3) specimens for each outdoor finish; each specimen from a different quarry block.

(v) **ASTM C97/C97M** (density); total of (6) specimens, (3) specimens taken from each of (2) quarry blocks.

(l) In addition to the testing programme described above, quality control testing shall be required. For each type of stone, flexural specimens shall be wire sawn from a minimum of 5% of the total number of quarry blocks. Size of specimens shall be as specified herein. For each of the sampled blocks, flexural strength shall be determined per **ASTM C880/C880M** for two specimens. If at least one of the two specimens for each sampled block has flexural strength equal to or greater than 80% of the design bending strength as specified herein, no further testing or reduction in working stress is required. If for one or more sampled blocks, both specimens have flexural strength less than 80% of the design bending strength, additional testing or a reduction in working stress shall be required. The additional testing option consists of applying the two-specimen test and 80% rule to each quarry block. For any block which fails, the two-specimen test and 80% rule may be used for each slab cut from the block. Any slab which fails shall be rejected; any block which fails shall be rejected unless its slabs are checked individually. The reduction in working stress option consists of reducing the allowable bending stress in stone, and the allowable load exerted on stone by an anchor, both of which are derived from the results of other tests specified herein. The reduction factor shall be the average of specimens from blocks which failed the 80% rule (both specimens included in average) divided by the original bending strength. Quality control test results shall not be used to increase allowable bending stress or allowable load exerted on stone by an anchor.

Test reports **16.79** Submit a certified laboratory test report in accordance with **BS 5368-4**. Include the following for the tests carried out under Clause 16.74:

(a) Test results together with comparison with permitted parameters.

(b) Remarks and conclusions by the testing professionals.

Submit photographic records of the test arrangement, set-up and of the performance of the mock-ups, and constituent components of the same, during fabrication, assembly and under test.

Provide two copies of the agreed shop drawings for recording any modifications found necessary during and after the laboratory tests. The testing laboratory shall accurately and neatly record all changes, revisions, and modifications etc., made to the shop drawings. At completion of the testing, the marked-up drawings shall be passed to the SO.

Subsequently and before any installation work commences on the site provide the SO with six copies of the shop drawings incorporating the modifications made.

PROTECTION AND CLEANING

Protection **16.80** Provide protective sheeting or tape to aluminium or stainless steel members and ancillaries. Package and store materials in a manner that shall prevent surface damage or contamination, distortion breakage or structural weakening.

Remove sheeting or tape as soon as practical so as not to stain and/or leave an adhesive residue on the relevant substrates.

Protect glass against damage, discolouration or staining. Replace damaged or broken glass, regardless of the cause.

Labels **16.81** No labels shall be adhered to glass other than those of the glass manufacturer which shall be adhered with a non-alkaline adhesive. Remove labels from glass after glazing.

Cleaning **16.82** Thoroughly wash and clean the work immediately prior to hand-over. No alkali washes or other patent cleaning solutions shall be used which may stain, mark or otherwise harm the installation.

Periodically remove from the site debris, excess materials and unused tools and equipment resulting from this work. At the conclusion of construction, leave the premises in a clean condition.

Ironmongery **16.83** All hinges, locks, opening devices etc., shall be properly adjusted and in perfect working order. Hand over two sets of keys for each lock to the SO on completion.

Maintenance manual **16.84** The Contractor shall provide a maintenance manual for the completed works which shall include, but not be limited to the following information:

(a) The name, address and telephone number of each firm and/or sub-contractor involved in the supply of components for the curtain wall.

(b) The manual shall include a clear, concise description of the construction methods used to form the various areas of the curtain wall for the particular project.

(c) The manual shall include copies of material and component certification, as well as, test reports as required herein.

(d) The manual shall include a method statement covering the procedures for the replacement of damaged or otherwise defective components such as glass lights, stone panels, aluminum panels and/or components or anchors.

(e) The manual shall include specific recommendations for routine maintenance, cleaning procedures, suitable cleaning agents as well as the frequency of inspections and adjustments that may be necessary.

(f) The manual shall include a full/complete set of Drawings, modified to incorporate any omissions and/or additions to the Works.

(g) The manual shall indicate the terms and periods of any guarantees and/or warranties.

Maintenance access **16.85** The Contractor shall submit proposals whereby the curtain wall can be cleaned and maintained, meeting the requirements under **Code of Practice on Access for External Maintenance**.

Environmental Green Requirements

16.86 Green requirements of adhesives and sealants:

(a) The product of adhesive and sealant shall comply with the VOC content limits on regulated adhesives stipulated in the Air Pollution Control (VOC) Regulation of Hong Kong.

(b) The product shall not contain the following substances regulated in the Montreal Protocol on Substances that Deplete the Ozone Layer (particularly CFCs, HCFCs, 1,1,1-trichloroethane and carbon tetrachloride).

(c) The product shall contain no more than 0.01% by wet weight of formaldehyde.

(d) The product shall contain no more than 0.5% by wet weight of the sum total of aromatic compounds, which include benzene, toluene, xylenes, and ethylbenzene.

SECTION 17

METALWORK

MATERIALS

Steel **17.1**

Steelwork shall comply with requirements stated in this Section unless specified otherwise in the Drawings or steelwork requiring the design to be certified by a Registered Structural Engineer shall comply with Section 15.

Hot-rolled or hot-finished steel shall comply with **BS EN 10025** or **BS EN 10210** respectively.

Cold-formed open section and profiled steel sheets shall comply with **BS 5950-7** or equivalent. Cold-formed hollow sections shall comply with **BS EN 10219-1** and **BS EN 10219-2**.

Bolts and nuts shall comply with **BS 4190**, and washers shall comply with **BS 4320**. Holding down bolts shall comply with **BS 7419**.

Valid manufacturer's certificates which include mill certificates shall be provided for all steelwork materials delivered to the Site.

Galvanized steel sheet and coil **17.2**

Hot dipped galvanized plain steel sheet and coil shall be to **BS EN 10143**.

Steel mesh **17.3**

Welded wire mesh shall be steel wire of the specified diameter welded to form a square or oblong mesh as specified and shall be hot dip galvanized after manufacture as specified.

Expanded steel mesh shall be to **BS 405.**

For expanded metal lathing in plastering and rendering, see Section 18.

For expanded metal mesh or lathing in brickwork or blockwork, see Section 9.

Steel tubing **17.4**

Steel tubing shall be to **BS EN 10255** "medium" grade and galvanized.

Slotted steel angle **17.5**

Slotted steel angle shall be self-finished angle. Fittings to be stainless steel.

Cast iron **17.6**

Cast iron shall be grey cast iron to **BS EN 1561** Grade 150.

Aluminium alloy **17.7**

Aluminium alloy plate; sheet and strip shall be to **BS EN 485-1+A1, BS EN 485-2, BS EN 485-3, BS EN 485-4, BS EN 515, BS EN 573-1, BS EN 573-2, BS EN 573-3, BS EN 573-5** of required alloy designation.

Aluminium alloy bars, extruded tube sections and hollow sections shall be to **BS EN 515**, **BS EN 573-1, BS EN 573-2, BS EN 573-3, BS EN 573-5, BS EN 755, BS EN 12020,** alloy designation 6063.

Aluminium alloy sections for structural purposes shall be to **BS 1161**.

Aluminium alloy drawn tubes shall be to **BS EN 515, BS EN 573-2, BS EN 573-3, BS EN 573-5** and **BS EN 754** alloy designation 6063.

Brass rods and sections **17.8**

Brass rods and sections shall be to **BS EN 12163, BS EN 12164, BS EN 12167** designation CW 106C condition M.

Stainless steel **17.9**

Stainless steel plate, sheet and strip shall be of grade 316 or 304 to **BS EN 10088-2** for flat product, **BS EN 10088-3** for long product; **BS EN 10095; BS EN 10048;**

BS EN ISO 9445-1; BS EN ISO 9445-2, of Finish No. DP1 for dull polish or "satin" finish, No. 2R for smooth, bright and reflective finish, No. 2B for mill finish, No. 1G or 2G for polish and low-reflective finish with fine grit and No. 1P or 2P for bright reflective mirror polished finish with a high degree of image clarity, or otherwise as required. Where the surface finish is specified as micron (RA), a certificate shall be submitted for the SO's verification.

Where welding is required, the steel shall be grade 316S13 or 304S11.

Stainless steel tubes for structural and general engineering purposes shall be to **BS EN 10296-2**, composition and finish shall be as above.

Stainless steel fasteners to follow steel grade of members shall be connected and to **BS EN 10263-1, BS EN 10263-5**.

Stainless steel anchors and inserts shall be of grade 316S31, A4 to **BS EN ISO 3506**.

Each consignment of the stainless steel material delivered to the Site shall be accompanied with test certificates or reports regarding the compliance of grading, issued by an accredited laboratory.

Fixings generally **17.10**

Fixings generally shall be of the same material and finish as the material to be fixed.

Unless specified otherwise, all drill anchor bolts for external environment shall be in Grade A4 stainless steel to **BS EN ISO 3506-1** to **BS EN ISO 3506-4**, and electroplated anchors and hot-dip galvanized anchors shall not be allowed.

Unless specified otherwise, grout under base plate and end plates shall be either (i) fluid cement mortar not leaner than 1:1 cement to fine aggregate by volume and be mixed as thickly as possible consistent with fluidity; or (ii) approved proprietary non-shrink polymer modified cementitious or resin based grout. Grout shall have at least the same grade strength as the surrounding concrete.

Metal insert channels for concrete **17.11**

Concrete insert channel shall be an approved galvanised steel channel, with expanded polystyrene temporary filler. Provide matching sliding fixing devices.

Adhesive for metal **17.12**

The application of adhesive for bonding metal to metal shall be according to the manufacture's recommendations, and the specimen tests shall be conducted to ASTM standards. Tensile test can refer to **ASTM D897**. Peel or stripping strength to **ASTM D903**. Impact strength of adhesive bonds to **ASTM D950**. The material shall be accompanied with test certificates or reports, issued by an accredited laboratory.

The following requirements shall be complied with:

(a) VOC content limits on regulated adhesives stipulated in the Air Pollution Control (VOC) Regulation of Hong Kong.

(b) Shall not contain the following substances regulated in the Montreal Protocol on Substances that Deplete the Ozone Layer (particularly CFCs, HCFCs, 1,1,1- trichloroethane and carbon tetrachloride).

(c) Shall contain no more than 0.01% by wet weight of formaldehyde.

(d) Shall contain no more than 0.5% by wet weight of the sum total of aromatic compounds, which include benzene, toluene, xylenes, and ethylbenzene.

WORKMANSHIP

Samples **17.13**

Submit samples for approval, as required.

Prototypes **17.14** Obtain approval of prototypes before starting fabrication of repetitive components.

Fabricating generally **17.15** Prior to fabrication, submit to the SO for approval fabrication shop drawings to show all necessary details and dimensions. Fabrication shop drawing shall not be reproductions of contract drawings without providing information required. Acceptance by the SO of the fabrication shop drawings shall not relieve the Contractor of his responsibility for accuracy of his detail dimensions on the drawings, nor the general fit-up of parts to be assembled on site.

During fabrication, protect all surfaces that shall be visible in the finished work.

Mitre junctions of identical sections.

Assemble moving parts to move freely and without binding.

Remove all burrs and sharp arrises which shall be visible after fixing or a hazard to the user.

Welding generally **17.16** Remove grease, dirt, moisture, oxide and scale from the edges to be welded.

Ensure accuracy, using clamps or jigs where practicable. Use tack welds for temporary attachment where jigs are not practicable.

Joints shall be fully fused throughout with no holes, pores or cracks.

Prevent weld splutter falling on self-finished surfaces visible in the completed work.

Butt welds, visible in completed work, shall be ground smooth and flush and fillet welds to be ground smooth, if required. For continuous butt welds and fillet welds of exposed architectural steelworks, mock-up samples of the welded joints with ground smooth surface shall be submitted to the SO for approval.

Ensure complete removal of flux residue and slag.

Welding of steelwork shall be by metal arc process in accordance with **BS EN 1011-1** or other method subject to the SO's approval. Welder shall be tested to meet the requirements of **BS EN 287-1** or approved equivalent standards.

Welding consumables for steelwork shall be to **BS EN ISO 2560**, **BS EN ISO 14341**, **BS EN ISO 14171** or **BS EN ISO 17632** as appropriate and strictly in accordance with the manufacturer's recommendation. Choose welding consumables to ensure that the mechanical properties of the weld metal are not less than those required for the parent metal.

Welding of aluminium alloy **17.17** Welding of aluminium alloy shall be by inert-gas arc welding to **BS EN 1011-4** or other method subject to approval.

Welding of stainless steel **17.18** Welding of stainless steel shall be by inert-gas arc welding to **BS EN 1011-3** or other method subject to approval.

Brazing **17.19** Guidance on the application of brazed joints to **BS EN 14324**. Non-destructive examination shall refer to **BS EN 12799**. Destructive tests of joints to **BS EN 12797**. For brazer approval, to **BS EN ISO 13585**, and the Procedure approval to **BS EN 13134**.

Design of articles to be coated **17.20** Metal articles which are to be coated shall be designed in accordance with the recommendations of **BS 4479-1** to **5** & **7** to **9**. Hot dip galvanizing and sherardizing to **BS EN ISO 14713**.

Finishing to steel **17.21** Finishes to steel shall be as follows:

(a) Bare to receive painted finish.

(b) Electroplated coating of zinc shall be to **BS EN ISO 2081**, Class A, 0.025 mm thick.

(c) Zinc sprayed coating shall be to **BS EN ISO 2063** - nominal thickness 0.2 mm unless otherwise specified.

(d) Galvanising shall be hot-dip galvanising to **BS EN ISO 1461**. Components shall be galvanised after fabrication, if required. The name and location of the galvanizing factory shall be submitted to the SO for approval. Provide the valid galvanizing factory's certificate showing that the galvanized coatings comply with the requirements including the test results carried out for thickness of coating.

No zinc sprayed coated or hot-dip galvanised items shall be welded or drilled and any subsequent cutting is defined as damage which shall be subsequently made good after coating or galvanising.

Make good damage to zinc coatings and galvanising, treat cut ends of galvanised sections with two coats of metallic zinc-rich priming paint to **BS 4652**.

Finishes to aluminium **17.22** Finishes to aluminium alloy shall be as follows:

(a) Mill.

(b) Polished.

(c) Polished and treated with a protective lacquer.

(d) Clear anodised shall be to **AAMA 611** and of the thickness grade and surface texture as follows:

(i) Interior work Class 15 (minimum average thickness of 15 μm).

(ii) Exterior work Class 25 (minimum average thickness of 25 μm).

(iii) Internal concealed surface Class 10 (minimum average thickness of 10 μm).

(e) Colour anodised shall be to **AAMA 611** average 25 μm thick.

(f) Approved proprietary hardcoat anodic finish with better wearing qualities than standard anodising of the required thickness.

Chromium plating **17.23** Chromium plating shall be to **BS EN ISO 1456,** for "service condition No. 3", with "bright", "dull" or "satin" finish.

Chromium plating to window components shall not be formulated with the following substances or their compounds:

(a) Arsenic
(b) Cadmium
(c) Hexavalent chromium
(d) Lead
(e) Mercury
(f) Organic tin
(g) Phthalates

Protection **17.24** Protect all decorative finishes to metalwork against damp, scratching and other damage. Apply a strippable coating or masking tape to all stainless steel, anodised

aluminium or similar surfaces and only remove as and when necessary for construction or just prior to inspection for handover. Remove surplus adhesive with non-damaging solvent and wash down.

Contact of aluminium and concrete etc. **17.25** Avoid contact in the completed work between aluminium and concrete, mortar, plaster, or similar materials. Where unavoidable, paint one coat of bituminous paint on aluminium surfaces, or use approved tape.

Contact of dissimilar metals **17.26** Avoid contact in the completed work between the following metals:

(a) Aluminium alloys with copper alloys, nickel, lead or stainless steel.

(b) Iron and steel with copper alloys.

(c) Zinc (including galvanizing) with copper alloys or nickel.

Where unavoidable, coat contact surfaces with bituminous paint, protective tape or other approved means.

Galvanized steel tubing **17.27** Carefully notch, fit and weld galvanized steel tubing to produce accurate joints which shall be ground smooth and treated with two coats of zinc rich priming paint to **BS 4652**.

Castings **17.28** Castings shall be sound free from bubbles, cracks or other defects and to include the construction of patterns and moulds as required.

Slotted steel angle **17.29** Cut slotted steel angle square and securely bolt together using nuts bolts and washers and angle braces as necessary.

Fixing steel mesh **17.30** Fix steel mesh at 75 mm centres as follows:

(a) To steel framing by,

(i) Tack welding.

(ii) Tying with 2 mm galvanised tying wire.

(b) To wood framing with 1.8 x 25 mm galvanised staples.

On completion **17.31** Lubricate and adjust moving components, and leave in perfect working order on completion.

METAL WINDOWS AND DOORS

Steel windows and doors **17.32** Steel windows and doors shall be obtained from an approved manufacturer and constructed to **BS 6510** and in accordance with the following:

(a) When fixed in position, windows and doors shall be designed to withstand a wind load calculated in accordance with the **Code of Practice on Wind Effects in Hong Kong** with a minimum pressure of 3 kPa and a permissible maximum deflection of 1/180 of the length of the member under consideration. Calculations shall be required to be submitted for approval.

(b) Frames shall be square and flat with mitred, welded corners and with glazing bars machine tenoned and/or welded to frames.

(c) Water bars shall be welded to the frames for the complete width of the windows or doors.

(d) When weather bars are specified, weld same to the frames for the complete width of the windows or doors.

(e) Provide all slotted adjustable lugs and screws necessary for building in the windows and doors and ensure that lugs project 60 mm (minimum) beyond the metal frames.

(f) Provide loose mullions and transoms of total length to suit window or door openings together with additional 75 mm at each end for building in.

(g) Provide sufficient mastic and bolts for assembly of all composite units and assemble same at the Site, including bedding mullions and transoms in mastic with all interstices completely filled.

(h) Windows and doors shall be suitable for external glazing unless otherwise specified. Provide rolled steel heavy channel section glazing beads size as specified for windows and doors, mitred at corners and fixed with galvanized mild steel flat headed countersunk screws at 225 mm centres (maximum) and tap frames to receive screws.

(i) All members shall be hot-dip galvanized or zinc sprayed as specified in Clause 17.21.

(j) When specified, provide an approved chloroprene rubber or polyvinyl chloride weatherstrip securely fixed into the dovetail groove in the section to provide a continuous contact between the opening casement and the fixed frame.

(k) Window and door fittings and furniture shall be approved and as follows:

(i) Steel hinges with brass pins and welded or riveted to frames. Projecting hinges to side-hung casements where windows shall be cleaned from the inside.

(ii) All fittings including friction grip pivots, casement fasteners, spring catches, brackets, slide arms, shoes, slip bolts, cabin hooks and eyes and handles, all of manganese brass with bronze finish. All to retain the opening parts rigidly in both the open and closed positions.

(iii) Handle plates, round headed stay brackets welded to the fixed frames with interchangeable handles and stays.

(l) Windows and doors shall be hung to open as indicated and fitted with the following fittings and furniture:

(i) Side-hung casement and vertically centre-hung ventilator - a two-point nose fastener or a two throw casement fastener with mild steel adjustable connecting rod and a 250 mm peg stay or bronze sliding stay, as specified.

(ii) Projecting casement - bronze sliding shoes, pivots and friction side arms and one spring catch with ring for hand or pole operation and two square-shank barrel bolts.

(iii) Top-hung ventilator - 200 mm peg stay with round-headed stay bracket welded to the fixed frame and with a second peg to secure the stay firmly and horizontally against the first peg when the ventilator is closed.

(iv) Bottom-hung ventilator - a spring catch and fanlight roller stay to limit opening and to permit the ventilator to swing free for cleaning.

(v) Horizontally centre-hung ventilator with a spring catch, with ring and eye for cord or pole operation.

(vi) Doors - sliding bolts of suitable length, striking plates at top and bottom, cabin hooks and eyes of suitable length, three-lever mortice lock with two keys, lever handles and escutcheon plates, as specified.

(m) When specified, provide extruded aluminium flyscreens having plastic covered fibre-glass mosquito gauze with 7 x 7 mesh per 10 mm^2.

Where flyscreens are provided, side hung casements shall have a locking handle and an opening and closing mechanism consisting of a bronze cam handle and bronze roto operator, and top hung casements to have bronze "through-the-frame" type stays.

(n) When specified, high openable windows in inaccessible locations shall be fitted with either electrical or manual remote control gear.

(o) Provide temporary steel clamps at the top and bottom of all opening lights of casements prior to transportation from factory till fixed in position.

(p) Paint surfaces: as specified in Section 21. Metal windows and doors shall be delivered to site unprimed.

Aluminium windows and doors **17.33** Aluminium windows and doors shall be obtained from an approved manufacturer and constructed in accordance with the following:

(a) When fixed in position, windows and doors shall be designed to withstand a wind load calculated in accordance with the **Code of Practice on Wind Effects in Hong Kong** with a minimum pressure of 3 kPa and a permissible maximum deflection of 1/180 of the length of the member under consideration. Where necessary use galvanized steel cores, anchors, brackets, etc. as stiffeners. Calculations shall be required to be submitted for approval. Cores, anchors and brackets etc. shall be finished to Clause 17.33(p).

(b) Sections shall be extruded aluminium alloy to **BS EN 485-1+A1, BS EN 485-2, BS EN 485-3, BS EN 485-4, BS EN 515, BS EN 573-1, BS EN 573-2, BS EN 573-3, BS EN 573-5** and **BS EN 755, BS EN 12020,** British alloy designation 6063 with a minimum wall thickness of 2.0 mm and dovetail grooved for weatherstrip.

(c) Aluminium coating shall be as follows:

(i) Refer to Clause 16.32 for anodic coating.

(ii) Refer to Clause 16.33 for organic coating.

(d) Frames shall be mechanically jointed of mortice and tenon construction to provide rigid and secure connections. Mechanically joint and mitre sash members to develop the full strength of members using solid block angle pieces and provide a neat weather-tight joint. Provide adequate drainage in bottom members.

(e) Provide galvanized steel fixing lug spaces at 300 mm centres (maximum) for outer frames of each unit. Where specified, fix lugs with rag-bolts or approved proprietary stud anchors fixing bolts.

(f) Provide water bars of galvanized steel or other approved material for the complete width of the windows or doors where the design of the window requires.

(g) Assemble all composite units at the Site, including provision of all necessary bolts, screws etc. and sealing all joints with an approved sealant.

(h) Unless otherwise specified, provide an approved chloroprene rubber, polyvinyl chloride or nylon pile weatherstrip securely fixed into the dovetailed groove in the window or door sections to provide a continuous contact between each opening part and its fixed frame.

(i) Windows and doors shall be suitable for internal glazing unless otherwise specified. Provide an approved glazing system and aluminium beads. Securely clip beads to the frame or use beads which shall be an integral part of the frame.

(j) Use aluminium alloy, stainless steel or nylon for all exposed fixings including screws, nuts, bolts, washers and rivets and match up with finish where possible. Use stainless steel or galvanized steel for all concealed fastening devices.

(k) Window and Door fittings and furniture shall be approved and as follows:

(i) Friction pivots and sliding stays - stainless steel. To provide a maximum opening of 100° and a minimum clearance of 100 mm between frame and window for cleaning purposes.

(ii) Casement fasteners, locking handles, spring catches, casement stays, brackets, slip bolts and the like:

(1) Diecast zinc alloy to **BS EN 1774** suitably coloured to match the anodised window or door metal.

(2) Moulded stainless steel with satin finish.

(iii) Locks stainless steel or brass shoots etc.

(iv) Pull handles anodized aluminium.

(v) Rollers, guides etc. stainless steel or brass rollers to suit weight of door or window. To be adjustable after installation.

(l) Remote control gear shall be hand operated shaft and lever or conduit and cable remote control system with bronze or diecast zinc alloy bevel gear boxes, adjustable arms and keyed shafts.

(m) Windows and doors shall be hung to open as indicated and fitted with the following fittings and furniture:

(i) Side and top hung windows - Friction pivots and sliding stays and casement fastener (dual if necessary) or pull handle and locking handle (dual if necessary).

Top hung windows in inaccessible locations shall be fitted with remote control gear.

(ii) Sliding windows - Rollers, guides etc., pull handle and stops, sliding bolts or locking mechanism. The window should be designed so that it cannot be lifted off its rollers without the removal of a safety device.

(iii) Side hung doors - Floor springs and adjustable top pivots, single or double action to stand open or not as specified, mortice dead lock, top and bottom flush lever bolts and push plates and pull handles as required.

(iv) Sliding doors - Heavy duty rollers, guides etc., pull handle and stops, hook bolt locking latch and four bolts.

(n) When flyscreens are specified, they shall be located on the inside. The frames shall be extruded aluminium with plastic covered mosquito gauze of 7 x 7 mesh per 10 mm^2. Screens shall be fixed to window frames by turn buckles. The windows shall be fitted with locking handles and an opening and closing mechanism comprising cam handles and roto operator.

(o) Prime with zinc chromate primer and paint two coats of bituminous paint on all steel framework, cores, anchors and brackets.

(p) Paint one coat of bituminous paint on concealed aluminium or stainless steel surfaces which may come into contact with wet mortar, cement, plaster or similar materials.

(q) Apply a strippable coating or masking tape to all exposed aluminium or stainless steel surfaces. (NOTE: The anodised surface may be permanently damaged by contact with wet cement and plaster) Wrap all window and door units and other associated materials in stout waterproof paper or polythene to protect against damp and scratching and do not make premature delivery to the Site.

(r) Return to site on completion of building work, carefully remove protective coating and leave clean.

Drawings **17.34** Provide drawings showing details of members and position of fixing lugs and obtain approval prior to commencement of manufacture.

Samples **17.35** Provide samples of windows, doors and all fittings and obtain approval before starting manufacture.

If specified, one sample unit shall be test loaded to ensure compliance with the stipulated wind load requirements. The testing shall be carried out under the supervision and in the manner approved by the SO.

Fixing metal windows and doors **17.36** When fixing metal windows and doors:

(a) Avoid distortion during handling and storage.

(b) Ensure tightness and clearance between sash and frame of all opening lights which shall be fixed until glazed.

(c) Avoid having construction access through window openings and/or placing scaffolding, boards etc. directly onto the window frames. If window openings must be used, then window frames at that opening location shall not be fixed until completion of the related internal works and the through-route is no longer required.

(d) Assemble composite units including the provision of all necessary bolts screws etc. and seal joints with an approved one pack gun type polysulphide sealant to BS **EN ISO 11600+A1**.

(e) Position, plumb, level and square.

(f) Form pockets in heads, jambs, cills etc. to receive fixing lugs, build in lugs and made good and screw to frames or plug and screw frames using packing pieces where necessary. Do not distort frames when tightening fixings.

(g) Bed steel frames with water-proof mortar, leaving no gaps. Mortar shall be an approved ready-mix mortar or consist of 1 part of cement to 3 parts of sand together with the minimum amount of water necessary to achieve a consistency suitable for completely filling the gap between the frame and the opening. The mixture shall contain an approved proprietary water-proofing and non-shrink admixture.

(h) Bed aluminium frames with water-proof mortar, leaving no gaps. Mortar shall be an approved ready-mix mortar or consist of 1 part of cement to 3 parts of sand together with the minimum amount of water necessary to achieve a consistency suitable for completely filling the gap between the frame and the opening. The mixture shall contain an approved proprietary water-proofing and non-shrink admixture.

(i) Rake out the joints around external edge of steel window and door frames to the approval of the SO and point with an approved oil based mastic sealant to form a smooth, flat joint. Remove excess sealant from adjoining surfaces and leave clean. Mask adjoining surfaces which would be impossible to clean if smeared with sealant.

(j) Rake out the joints around external edge of aluminium window and door frames to the approval of the SO and point with an approved one-pack gun type polysulphide sealant to **BS EN ISO 11600+A1**, sealant to form smooth, flat joint. Remove excess sealant from adjoining surfaces and leave clean. Mask adjoining surfaces which would be impossible to clean if smeared with sealant.

(k) Avoid contact with concrete, mortar, plaster, or similar materials.

ADJUSTABLE STEEL LOUVRE FRAMES

Adjustable and fixed steel louvres and frames **17.37**

Fixed louvres and frames shall be all hot-dip galvanized unless permitted otherwise by the SO.

Adjustable metal louvre frames and weatherstrips shall be obtained from an approved supplier and constructed in accordance with the following:

(a) Frames and clips shall be of 1.2 and 0.9 mm (minimum) steel sheet respectively. Clips shall be suitable for receiving 100, 150 or 230 mm wide and 6 mm thick glass blades, as required. Aluminium frames and aluminium or plastic clips may be supplied subject to approval.

(b) Frames shall be designed for hand or pole operation, as required, with single control and to automatically lock when closed.

(c) Weatherstrips shall be shaped metal strips of an approved design and thickness.

(d) Steel frames, clips and weatherstrips shall be hot-dip galvanized or electro-zinc plated on all surfaces prior to assembly.

(e) Where specified, provide 45 x 10 mm galvanized steel sub-frames for single side louvre frames, with necessary slotted adjustable lugs and screws for building in.

(f) Provide matching rustless screws, bolts and spacers etc. for coupling adjacent frames to form mullions, where required.

Samples and drawings **17.38** Provide samples and drawings, and obtain approval.

Origin **17.39** State Manufacturer's name and country of origin

Fixing adjustable steel louvre frames **17.40** Fix adjustable steel louvre frames as follows:

(a) Avoid distortion during handling and storage.

(b) Position plumb, level and square.

(c) Where required, form pockets to receive fixing lugs, build in lugs and screw to sub-frames or plug and screw sub-frames using packing pieces where necessary.

(d) Bed sub-frames in mortar as used for adjacent work, leaving no gaps.

(e) Where required, screw single side louvre frames to sub-frames at 225 mm centres. Do not distort frames when tightening fixings.

(f) Where required, plug and screw louvre frames and weather strips.

ROLLER SHUTTERS AND DOORS

Roller shutters and doors **17.41** Roller shutters and doors shall be supplied and fixed in accordance with the following:

(a) Steel roller shutters shall consist of horizontal hot dipped galvanised slats, which interlock through their entire length to form a continuous hinge. The shutters shall be designed to withstand a wind load calculated in accordance with the **Code of Practice on Wind Effects in Hong Kong** with a minimum pressure of 3 kPa on the entire surface area of the shutter or otherwise specified.

(b) Roller shutters shall be either:

(i) Self - closing.

(ii) Manually operated by an endless chain.

(iii) Electrically operated.

Self-closing shutters shall be operated manually through an internal self coiling mechanism by lifting handles or a pole and hook. The mechanism shall be adjustable to control the effort required to raise or lower the door.

(c) Shutters operated by means of an endless chain shall be fitted with a spur or worm reduction gear such that the shutter shall not fall or rise without manual operation of the chain.

(d) Electrically operated shutters shall comply with the **Code of Practice for Installation of Electrically Operated Sliding Gates, Sliding Glass Doors and Rolling Shutters** issued by the Electrical and Mechanical Services Department. The shutters shall be installed complete with electric motors, the associated overload protection, drive mechanism, limit switches, emergency stop, control buttons and other control devices required by the shutter manufacturer. The electrical installation of the shutter shall comply with the **General Specification for Building Services Installation in Government Buildings of the Hong Kong Special Administrative Region**, issued by the Architectural Services Department, and **Code of Practice for the Electricity (Wiring) Regulations,** issued by the Electrical and Mechanical Services Department.

(e) Shutters shall have a locking device, and in addition approved malleable iron shoot bolts shall be provided and fitted to the bottom bar at each end of all shutters to assist holding the shutter under high wind conditions.

(f) The horizontal steel barrel carrying the shutter curtain shall be of suitable diameter and strength to resist deflection, be rust proofed and have adequate counter balance springs to ensure the correct balance of the shutter in all positions.

(g) The shutter and its barrel shall be supported on brackets with adequate bearings. The brackets shall be provided with suitable fixings for attaching to the soffit, face or side of opening.

(h) The vertical channel guides shall be of galvanised steel of adequate size and depth to hold the shutter curtain under high wind conditions and they shall be provided with adequate fixings for attaching to the soffit, face, jamb or side of openings or at base and apex in the case of movable mullions.

(i) Hoods and casings shall be of galvanized steel of adequate gauge, or folded 3 mm thick aluminium panel fully supported and braced to prevent any sagging or distortion. Access doors or plates shall be provided at the appropriate places to enable routine inspection and servicing to be carried out.

(j) Screws, bolts and fixing lugs shall be supplied as necessary for the assembling and fixing of the steel roller shutters.

(k) All ungalvanized steel and cast iron shall be painted with one coat of rust inhibiting primer before despatch to Site.

(l) Full details of motors, gearing, drive mechanism and control mechanism shall be provided and obtain approval. The motors, the associated control and protective devices shall be suitable for operating on local electricity supply. Totally enclosed three-phase induction motors are preferred. The motors, driving gears, limit switches, and control mechanism shall be accessible for inspection and servicing. An isolating switch shall be provided to isolate the electricity supply during inspection and servicing. Adequate electrical power supply shall be provided to the isolating switch.

(m) Auxiliary manually operated gear shall be provided. The changeover should be easily effected without climbing up to the gearing drive mechanism to engage the gears for manual operation or disengage the manual operating gear for electrical operation.

(n) An interlock switch shall be provided to prevent the locked roller shutters from operating electrically and shall be fitted on a stationary part (such as the guide rails) but not on the moving part of the roller shutters.

Fire resisting shutters **17.42** The construction and installation of the fire resisting shutter shall comply with the requirements of the **Code of Practice for Fire Safety in Buildings**, the Buildings Department. The activation devices shall be constructed according to the requirements of Fire Services Department. The operation of the fire shutter and the activation devices shall be tested according to the requirements of the **Codes of Practice for Minimum Fire Services Installations and Equipment and Inspection, Testing and Maintenance of Installations and Equipment**, the Fire Services Department and the **Testing and Commissioning Procedure for Fire Service Installation in Government Buildings of the Hong Kong Special Administrative Region**, the Architectural Services Department.

The fire rated period of the fire resisting shutters shall satisfy the criterion of integrity relating to the method of exposure on each side separately when tested in accordance with **BS EN 1634-1** to **3** or **BS 476-20** to **24**.

The fire shutter shall be accompanied with test certificates or reports issued by an Accredited Laboratory or Building Authority regarding the specified fire resisting period.

The fire resisting shutters shall be provided with smoke detector(s) and manual control devise(s) on both side of the wall openings for automatic and manual operation respectively. The detectors installed shall comply with the requirements of the **General Specification for Building Services Installation in Government**

Buildings of the Hong Kong Special Administrative Region, the Architectural Services Department.

Design and manufacture of roller shutters **17.43** The design of the roller shutters, including boxes, hoods, guides and all other parts shall be the responsibility of the Contractor.

The Contractor shall be responsible for making good any defect which may appear after the rolling shutters shall have been taken over, and which arises either from defective materials, workmanship or design.

Detail drawings **17.44** The Contractor shall provide detail drawings for approval on confirmation of the order, and prior to commencement of manufacture.

Provide two instruction manuals giving detailed operating and maintenance instructions which shall include the wiring and schematic drawings, schedule of component parts and a priced list of recommended spares.

Sealant for metal **17.45** The following requirements shall be complied with:

(a) VOC content limits on regulated adhesives stipulated in the Air Pollution Control (VOC) Regulation of Hong Kong.

(b) Shall not contain the following substances regulated in the Montreal Protocol on Substances that Deplete the Ozone Layer (particularly CFCs, HCFCs, 1,1,1-trichloroethane and carbon tetrachloride).

(c) Shall contain no more than 0.01% by wet weight of formaldehyde.

(d) Shall contain no more than 0.5% by wet weight of the sum total of aromatic compounds, which include benzene, toluene, xylenes, and ethylbenzene.

METAL GATES

Metal gates **17.46** Metal gates shall be obtained from an approved manufacturer and constructed to **BS 4092-1** and in accordance with the following:

(a) When fixed in position, gates shall be designed to withstand a wind load calculated in accordance with the **Code of Practice on Wind Effects in Hong Kong** with a minimum pressure of 3 kPa and a permissible maximum deflection of 1/180 of the length of the member under consideration. Calculations shall be required to be submitted for approval.

(b) Design for the elements of the gate framework, post support and the connection to fix the gate framework to the surrounding structure shall be provided to demonstrate the stability of the metal gate during operation.

(c) For swing-type metal gates, all hinge fittings shall be welded all round to the gate framework and shall be able to withstand the dead weight of the metal gate and wind loads during operation. A minimum of 3 hinges shall be provided for the connection between the metal gate and each supporting post. One of the hinge fittings with the hinge pin pointing in a reverse direction shall be incorporated for providing restraint against vertical movement.

(d) For sliding metal gates, provide guide and end stoppers to maintain lateral stability of the metal gate and to resist the imposed loads and impact force. Similar provisions shall be provided for multi-passing metal gates.

(e) For folding metal gates with two or more hinged leaves, guided and/or supported at the top or at the bottom, clauses 17.46 (c) and (d) shall be complied with.

(f) Electrically operated metal gates shall comply with the **Code of Practice for Installation of Electrically Operated Sliding Gates, Sliding Glass Doors and Rolling Shutters** issued by the Electrical and Mechanical Services Department. The electrical installation of the shutter shall comply with the **General Specification for Building Services Installation in Government Buildings of the Hong Kong Special Administrative Region**, issued by the Architectural Services Department, and **Code of Practice for the Electricity (Wiring) Regulations**, issued by the Electrical and Mechanical Services Department.

(g) All members shall be hot-dip galvanized or zinc sprayed as specified in Clause 17.21.

(h) Paint surfaces: as specified in Section 21. Metal gates shall be delivered to site unprimed.

Submission of drawings and calculations

17.47 Submit drawings and fully coordinated structural calculations for SO's approval. Drawings shall include the following information:

(a) Fixing details of entrance gate to walls or posts and floors;

(b) Location of, and details for, any anchor bolts;

(c) Details of hinge and roller, completed with lubricated bearings, threaded hangers, connection bars etc. including materials specification and dimension;

(d) Welding details of components and parts;

(e) Details and sections to show sizes, profiles and fixings of assembling and concealed parts;

(f) Location of equipotential bonding points; and

(g) Relative layout of walls, columns and footings with dimensions noted.

Structural calculations shall be certified by a qualified structural engineer as specified.

SECTION 18

FINISHES

RENDERING

Generally

Cement **18.1** Ordinary Portland Cement shall be to **BS EN 197-1 (**Type CEM I**)**.

Water **18.2** Water shall be as Clause 6.35.

Sand **18.3** Sand for mixes not incorporating lime shall be clean hard durable crushed rock or clean sand free from salt to conform to the grading limits set out in Table 18.1.

TABLE 18.1
Grading

B.S. Sieve	Percentage by weight passing B.S. Sieve
5.00 mm	100
2.36 mm	90 - 100
1.18 mm	70 - 100
0.60 mm	40 - 80
0.30 mm	5 - 40
0.15 mm	0 - 10

Sand for mixes incorporating lime shall be clean sand free from salt to conform to the grading limits set out in the Table 18.2

TABLE 18.2
Grading

B.S. Sieve	Percentage by weight passing B.S. Sieve
2.36 mm	100
1.18 mm	90 - 100
0.60 mm	55 - 100
0.30 mm	5 - 50
0.15 mm	0 - 10

Lime **18.4** Lime shall be as Clause 9.15.

Lime putty **18.5** Lime putty shall be as Clause 9.16.

Admixtures and additives **18.6** Admixtures and additives shall be as Clause 6.36.

Bonding Agent **18.7** Bonding agent shall be compatible with background and finish, designated to be suitable for internal or external use and shall be an approved proprietary brand.

The approved proprietary bonding agent shall be used in strict accordance with the manufacturer's technical specifications and recommendations, including and not limited to the valid shelf life of the product. The expiry date shall be clearly indicated with label and stamp for necessary inspection by the SO.

Workmanship

Mixing rendering **18.8** Mix rendering shall be as Clauses 9.21 to 9.23.

Samples **18.9** Provide sample panels of approximately 2 m^2 for textured or coloured finishes and tile or slab finishes including pointing and obtain approval before starting work. Apply these finishes to sample areas of the work as directed.

Protection of existing work **18.10** Protect existing work with boards, dust sheets, and the like. Droppings on finished work shall be cleaned off immediately.

Cleanliness **18.11** Keep plant and tools clean and free of traces from previous mixes.

Mechanical application **18.12** Do not use mechanical coating methods of application without approval.

Preparation of background **18.13** Hack off extraneous concrete projections and fins.

Remove efflorescence, laitance, oil, grease, all traces of release agents, dirt, and loose material by dry brushing or scraping.

Protect surfaces from weather and ensure that they are completely compatible with the finish to be applied before starting work.

Dissimilar backgrounds **18.14** At junctions between dissimilar solid backgrounds in the same plane which are to receive the same applied finish, fix a strip of steel galvanized lathing as Clause 18.24 extending 150 mm (minimum) in width each side of the junction, nailed with 40 mm nails or stapled to plugs at 100 mm centres on both edges.

Spatterdash **18.15** Clean all laitance, dust, oil or any other such foreign substances from the concrete surface.

Spatterdash shall consist of (1:2) cement: coarse sand with an approved bonding agent.

Apply spatterdash to concrete vertical surfaces and soffits within 48 hours after striking formwork. Method statement shall be submitted for approval if the otherwise.

The mixture shall be applied by dashing it on the wall by a hand scoop or a trowel to give a complete coverage with a rough texture not exceeding 5 mm thickness. The surface shall be maintained moist for 24 hours.

Allow to cure and harden for at least two days before applying rendering / bedding screed.

Preparation of hardened or existing concrete **18.16** Where finish or screed shall be bonded to the hardened or existing concrete wall or base:

(a) Shortly before applying finish or screed, thoroughly hack concrete to remove laitance and expose coarse aggregate.

(b) Thoroughly clean and wet surface before applying finish or screed and remove surplus water.

(c) Brush neat cement slurry into damp surface immediately before applying finish or screed, or

Apply approved proprietary bonding agent in accordance with the manufacturer's recommendations.

Preparation of base for monolithic finish **18.17** Where finish or screed shall be laid monolithically on concrete base:

(a) Spray surface with water and brush with a stiff broom whilst concrete is green to remove laitance and loose aggregate.

(b) Lay finish or screed within 3 hours of laying base.

Surface finishes **18.18** Surface finishes shall be either:

(a) Smooth finish: finish with a steel trowel or power float to a smooth surface, free from blemishes.

(b) Wood float finish: finish with a dry wood float to give an even overall surface.

(c) Textured finish: finish by stippling, scraping or other means to produce an approved textured surface.

(d) Rough cast finish: throw onto the undercoat a wet mix of aggregate and cementitious material.

(e) Machine applied textured finish: apply in accordance with the manufacturer's recommendations.

Accuracy for wall and ceiling finishes **18.19** Finish wall and ceiling finishes to a true plane and to correct line and level. Maximum deviation permitted in surfaces shall be 3 mm from a 1800 mm straight edge. Angles and corners shall be right angles unless otherwise required, with walls and reveals plumb and square.

Drying out of wall and ceiling finishes **18.20** Prevent excessively rapid or localized drying out of wall and ceiling finishes by an approved means.

Curing of floor finishes, etc. **18.21** Immediately after laying, protect surface of floor screeds or in-situ finishes from wind and sunlight.

Cover surface, as soon as it is sufficiently hardened, with canvas, waterproof sheeting, mats, or a 50 mm layer of damp sand. Unless otherwise agreed by the SO, keep covered for 4 days.

Movement joints **18.22** Movement joints shall be equally spaced at a maximum spacing of 4m centres in each direction, in accordance with Clauses 6.61 and 6.62, or as directed by the SO to accord with dimensioned requirements, or as shown on the drawings.

Protection **18.23** Protect screeds from wear and other damage until the floor finish is laid. Protect all finishes from discolouration or damage until completion.

PLASTERING AND RENDERING

Materials

Steel lathing **18.24** Steel lathing shall be to **BS EN 13658-1** & **BS EN 13658-2** from an approved manufacturer:

(a) Plain expanded type of 6 mm short way mesh coated with tight coat galvanizing and weighing not less than 1.6 kg/m^2.

(b) Ribbed expanded type similarly coated and weighed not less than 2.25 kg/m^2.

Metal beads
Plastic beads **18.25** Galvanized steel corner beads, plaster stops and movement joint beads shall have expanded metal wings and be from an approved manufacturer.

Plastic corner beads shall be used if approved by the SO.

Wire netting **18.26** Wire netting shall be to **BS EN 10223-2**, of 0.9 mm galvanized wire and 50 mm mesh.

Staples **18.27** Staples shall be galvanized steel wire staples.

Tying wire **18.28** Tying wire shall be 1.25 mm annealed steel wire, galvanized to **BS EN 10244-2**.

Gypsum plasters **18.29** Gypsum plaster shall be Retarded hemihydrate gypsum plaster to **BS EN 13279-2** & **BS EN 13279-1**, Class B of the following types:

Undercoat Plaster

Type a - 1 Browning plaster
2 Metal lathing plaster

Final Coat Plaster

Type b - 1 Finish plaster
2 Board finish plaster

Delivery and storage of gypsum plaster **18.30** Gypsum plaster shall be delivered in sealed containers. Store in weather tight structures with a raised floor. Store different types of consignments separately, and use in the order of their delivery.

Plasterboard **18.31** Plasterboard shall be to **BS EN 520+A1**, "gypsum lath" or "gypsum baseboard" with square edges.

Nails for plasterboard **18.32** Nails for "lath" or "baseboard" shall be 30 x 2.6 mm plasterboard galvanized steel nails, jagged shank type to **BS 1202-1**.

(a) 30 x 2.65 mm for plasterboard not exceeding 12.7 mm thick.

(b) 40 x 2.65 mm for plasterboard 19 mm thick.

Joint reinforcement **18.33** Reinforcement for joints in plasterboard shall be jute scrim cloth not less than 90 mm wide.

Handling and storage of plasterboard **18.34** Carry plasterboard on edge. Stack plasterboard flat on level surface, properly supported to prevent sagging or bending of boards off the ground and inside a building. Keep plasterboard dry, prevent mould growth, and programme deliveries to ensure that storage periods on Site are kept to a minimum during periods of high humidity.

Acoustic plaster **18.35** Acoustic plaster shall be an approved proprietary brand free from asbestos, mixed and applied in accordance with manufacturer's recommendations.

Stone chippings **18.36** Stone chippings for exposed aggregate rendering or Shanghai plaster shall be granite, white stone or marble chippings, graded from 3 to 5 mm, and free from dust or other foreign substances.

Fire cement **18.37** Fire cement shall be as specified for firebrick mortar in Clause 9.22(c).

High quality finishes **18.38** Resin, epoxy, urethane and acrylic based decorative finishes shall be approved proprietary products applied by approved specialist contractors.

Workmanship

Generally **18.39** Plastering and rendering generally shall be in accordance with **PD CEN/TR 15123**, **BS EN 13914-2** & **BS 8481** and **BS EN 13914-1** respectively**.**

Dubbing out **18.40** Dub out if necessary to correct any inaccuracies, in layers 10 mm (maximum) thick in same mix as the first coat. Allow to dry out before the next coat is applied. Total thickness of dubbing out or levelling shall not exceed 25 mm. Cross scratch each coat to provide key.

Fixing steel lathing **18.41** Fix steel lathing as follows:

(a) Fix taut with the largest dimension of mesh running perpendicular to direction of supports.

(b) Apply one coat of bituminous paint to cut ends.

(c) Fix at 100 mm centres to wood with staples, to brickwork or concrete as Clause 18.14 and to steelwork with tying wire at 75 mm centres.

(d) Lap 25 mm (minimum) generally, and 50 mm where end laps occur between supports. Secure laps with tying wire at 75 mm centres.

Fixing plasterboard **18.42** Plasterboard fixing generally shall be to **BS 8000-8**.

Fix plasterboard to wood bearers as follows:

(a) Nail boards at each support, at 150 mm centres working out from the centres of the board, and 15 mm (minimum) from edges.

(b) Provide gap of 3 to 5 mm between edges.

Joints in plasterboard **18.43** Treat joints, etc. in plasterboard as follows:

(a) Fill all joints, nail holes and other imperfections with board finish plaster.

(b) Press strips of joint reinforcement into the plaster, trowel flat and allow the plaster to set, but not dry out before general plastering commences.

Undercoats generally **18.44** Allow 3 days for undercoats to dry out thoroughly before applying next coat. Cross scratch undercoats to provide key for next coat.

Cement render **18.45** Apply cement rendering consisting of cement and sand 1:3 with surface finish required as follows:

(a) Rendering not exceeding 10 mm thick in one coat.

(b) Rendering exceeding 10 mm thick in two coats, with finishing coat 5 mm thick.

External render **18.46** Apply external rendering to spatterdashed surfaces consisting of cement and sand in two coats as follows:

(a) Undercoat 10 mm (minimum) thick --- mix 1:3

(b) Finishing coat 10 mm (maximum) thick --- mix 1:3, with textured finish. Total thickness of spatterdash & external rendering shall not exceed 20 mm.

Undercoat shall be thoroughly dry before applying the finishing coat.

Pulverised Fly Ash (PFA) shall not be used for external rendering.

Internal lime plaster on solid backgrounds **18.47** Apply internal lime plaster in two coats on solid backgrounds as follows:

(a) Undercoat shall be 1:3 cement: sand mix

(b) Finishing coats use lime plaster gauged (cement:lime:sand 1:2:6) with not more than 25% by volume of lime putty. Addition of paper-pulp is not allowed.

(c) Thickness of undercoat shall not exceed 10 mm to walls and 5 mm to soffits.

(d) Thickness of finishing coat to walls and soffits shall be at least 3 mm.

(e) The drying out time for undercoats before applying finishing coats shall be as specified in the Clause 18.44.

(f) Metal plaster corner beads and stops shall be provided where specified shall be followed as Clause 18.53.

(g) Total thickness of plaster shall not exceed 15 mm to walls and 10 mm to soffits.

Pulverised Fly Ash (PFA) shall not be used for internal plastering.

Internal lime plaster on lathing **18.48**

Apply internal lime plaster in three coats on steel lathing as follows:

(a) First and second coats, consisting of cement, lime and sand 1:2:6.

(b) Finishing coat shall be as Clause 18.47 (a) and (b).

Total thickness of plaster shall not exceed 13 mm measured from the outer face of the lathing.

Gypsum plaster generally **18.49**

Apply gypsum plaster generally in two coats as follows:

(a) First coat consisting of Browning plaster and sand 1:2 or cement and sand 1:3.

(b) Finishing coat of neat finish plaster, or finish plaster with up to 25% of lime putty added, with smooth finish 5 mm max.

Total thickness of plaster shall not exceed 15 mm.

If approved by the SO, proprietary gypsum plaster can be used in strict accordance with the manufacturer's technical specifications and recommendations.

Where specified, bonding agents for use with gypsum plaster shall be as **BS 5270-1**.

Gypsum plaster on steel lathing **18.50**

Apply gypsum plaster in three coats on steel lathing as follows:

(a) First coat consisting of metal lathing plaster and sand 1:1.5.

(b) Second and finishing coats - as for first coat and finishing coat as Clause 18.49 (a) and (b).

Total thickness of plaster shall not exceed 13 mm measured from the outer face of the lathing.

Gypsum plaster on plasterboard **18.51**

Apply gypsum plaster as one finishing coat 5 mm (maximum) thick on plasterboard trowelled to a smooth surface using as little water as possible.

Arrises **18.52**

Arrises shall be square or pencil rounded, as required.

Metal beads **18.53**

Metal beads for internal plastering and dry lining, shall be to **BS EN 13658-1**. Metal beads for external rendering shall be to **BS EN 13658-2**.

Provide and fix metal corner beads, plaster stops and movement joints when specified including nailing, stapling or fixing with plaster dabs and trowel the finishing coat flush with the bead.

Cornices **18.54**

Coved or moulded cornices shall be either:

(a) Formed with a backing of cement and sand 1:3 with finishing coat of same plaster used for adjacent surfaces, finished with a steel template to a smooth finish.

(b) Preformed cornices from an approved manufacturer fixed in accordance with manufacturer's recommendations.

Exposed aggregate rendering or "Shanghai" plaster **18.55**

Apply exposed aggregate rendering or "Shanghai" plaster in two coats as follows:

(a) First coat 10 mm thick, consisting of cement and sand 1:3.

(b) Finishing coat 10 mm thick, consisting of cement and stone chippings 1:1, with the chippings mixed in one of the proportions shown in Table 18.3. Before the finishing coat has set, scrub off the surface to expose the aggregate.

TABLE 18.3
Proportions of Chippings

Colour	Cement	Stone Chippings Dark Grey/Light Grey/White			Marble Chippings Black/White	
Dark	Ordinary	70%	-	20%	10%	-
Medium	White	60%	20%	20%	-	20%
White	White	-	-	-	-	100%

Acoustic spray plaster **18.56** Mix and apply acoustic plaster by special spray equipment in accordance with the manufacturer's recommendations to the thickness and number of coats specified.

PREMIXED PLASTER

Materials

Generally **18.57** Premixed plaster shall be factory-produced by weighted combination of plaster raw materials and chemicals and supplied to sites in bags. Mixing with clean water shall be required before application.

Type of premixed plaster **18.58** There are two types of premixed plaster, cement based and gypsum based. Gypsum based is for internal use only.

Cement based premixed plaster **18.59** Cement based plaster contains mineral filler material as aggregate and Portland cement as main binder, with additives for improved compressive strength and reduced shrinkage.

Gypsum based premixed plaster **18.60** Gypsum based plaster contains pre-mixed minerals, gypsum base rendering materials and additives which could be applied in one single thick application without cracking and separation from the substrate.

Standards and ISO Certification **18.61** The premixed plaster shall comply with **BS 8481, BS EN 13279-1, BS EN 13279-2, BS EN 13914-1**, **BS EN 13914-2** and **PD/CEN/TR 15123**. The premixed plaster manufacturing company shall have acquired ISO certification in their manufacturing process of the premixed plaster product.

Workmanship

Mixing **18.62** Premixed plaster and clean water shall be mixed on Site with portable electrical mixer or other equipment according to manufacturer’s recommendations. Accurate amount of water shall be used to ensure effective mixing and consistent quality.

Handling & storage **18.63** Bagged premix mortar shall be separated by types and stored off the ground in dry, well-ventilated and covered space. Use in order of delivery and within manufacturer recommended time limit.

Tolerance of substrate **18.64** Tolerance of evenness of substrate shall be ± 5 mm for internal concrete wall, block wall and beams, and ± 3 mm for internal ceiling soffits.

Substrate preparation **18.65** Substrate shall be clean; free from dust, contamination, paint, oil and loose scale. Dampen dry substrate before plastering.

Spatterdash **18.66** Premixed plaster may require the substrate to be treated with spatterdash or to be keyed before application depending on manufacturer’s recommendations.

Re-tempering **18.67** Do not use mixes after initial set has taken place and do not re-temper or reconstitute mixes unless permitted by the manufacturer’s instructions.

Supervision **18.68** Premixed plaster shall be carried out by experienced applicators. All the workers and supervisory staff employed for the work shall be fully instructed and trained on

the method of preparation and application in accordance with the manufacturer's recommendations.

Cement based premixed plaster application **18.69** Cement based premixed plaster shall be applied with trowel or spraying machine in several coats. Application method, thickness, number of coats and drying time between coats shall be strictly in accordance with manufacturer's recommendations.

Gypsum based premixed plaster application **18.70**

(a) Gypsum based premixed plaster shall be applied with trowel or spraying machine in single coat of thickness in accordance with manufacturer's recommendations.

(b) Half-set plaster shall be levelled with featheredge, scraped off surplus material and worked from bottom to top of wall.

(c) Allow drying time of 30 – 60 minutes in accordance with manufacturer's recommendations; sprinkle surface with clean water and smooth with a hard sponge float to remove trowel and featheredge marks in circular motion.

SCREEDS

Materials

Aggregate for light-weight screeds **18.71** Aggregate for lightweight screeds shall be as follows:

(a) 5 mm exfoliated vermiculite to **BS EN 13055**.

(b) Approved proprietary lightweight beads or granules.

Air entraining agent for light-weight screeds **18.72** Air entraining agent for lightweight screed shall be an approved admixture which will produce screeds with a dry density not more than 1,200 kg/m^2.

Self-levelling screeds **18.72A** The self-levelling screeds system shall be an approved proprietary system installed by an approved applicator. The floor screeds generally shall be to **BS EN 13813** and as Clause 18.89.

The system shall be smooth to receive flexible tile or sheet finishes, paint or other finishes as required by the SO.

Vapour barrier **18.73** Vapour barrier shall be 0.08 mm polythene sheet.

Workmanship

Screeds generally **18.74** Floor screeds generally shall be in accordance with to **BS 8204–4+A1, BS 8000-0** and **BS 8000-11** and wall screeds to **BS 5385-1** & **BS 8000-0** and **BS 8000-11** respectively.

Mixes for screeds **18.75** Screeds generally shall consist of cement and sand 1:3. Use the minimum water consistent with workability.

For floor screeds over 40 mm thick, mix shall be 1 part cement, 1.5 parts sand or granite fines and 3 parts coarse aggregate graded 10 mm down with at least 75% being retained on a 5 mm B.S. sieve.

Use granite fines instead of sand, when required to avoid efflorescence on the surface of the finish.

Thickness of wall render **18.76** Thickness of wall render shall be 10 mm (minimum) with surface scratched to form key.

Thickness of floor screeds **18.77** Thickness of floor screeds shall be as follows:

(a) Laid monolithically with the base: 15 mm (minimum) thick. (For preparation of base, see Clause 18.17).

(b) Bonded to a hardened concrete base: 20 mm (minimum) thick. (For preparation of base, see Clause 18.16).

(c) Not bonded to the base: 50 mm (minimum) thick including tile finish.

(d) Floating: 65 mm (minimum) thick including tile finish.

Laying floor and roof screeds **18.78** Lay monolithic and bonded screeds in one coat.

Lay and compact screeds level or to falls, as required.

Bay sizes for floor and roof screeds **18.79** Lay screeds in bays of 15 m^2 (maximum) with length not more than 1.5 times the width in chequerboard pattern. Allow 24 hours (minimum) interval between laying adjoining bays.

Lightweight screeds **18.80** Lightweight aggregate screeds shall consist of cement and lightweight aggregate 1:8 for roofs and 1:6 for floors unless contrary to the manufacturers' recommendations.

Air entrained screeds shall have a dry density of not more than 1,200 kg/m^3.

Lightweight screeds shall be 50 mm (minimum) thick, excluding topping.

Finish lightweight screeds with cement and sand or granite fines 1:4 topping 15 mm (minimum) thick laid monolithically with the screed.

When specified lay vapour barrier under lightweight roof screeds. Lap 150 mm at joints.

Self-levelling screeds **18.80A** Surface shall be sufficiently dry, free from dust and contaminants to receive self-levelling screeds system. The build-up layers shall consist of primer, base coat, body coat, top coat and protection layer, unless contrary to the manufacturers' recommendations.

Construction tolerance of the levelling shall be 3 mm measured with a 1.2 m straight edge. Mock-up samples of the system shall be submitted to the SO for approval.

Surface finishes for screeds **18.81** The surface of screeds shall be finished with one of the following surface finishes, level, to falls as specified:

(a) Steel trowel or power float to give a smooth untextured surface.

(b) Wood float to give an even textured surface.

(c) Stiff brush to give a slightly roughened texture.

The finish shall be in accordance with manufacturer’s recommendations for the finish to be applied or laid.

Pipes through roofs **18.82** Where pipes of less than 50 mm diameter pass through flat roofs:

(a) Form cement and sand or granite fines 1:3 surround 150 x 150 mm around pipe sleeve, to project 150 mm above finished roof level.

(b) Finish top to slope.

(c) For groups of pipes, form combined surrounds.

IN-SITU FLOOR AND WALL FINISHES

Materials

Stone aggregate **18.83** Stone aggregate shall be crushed grey granite or white stone to **BS EN 12620+A1**, graded from 10 to 3 mm and free from dust.

Marble aggregate **18.84** Marble aggregate shall be angular crushed marble, free from dust, and of the colour required.

Surface hardener **18.85** Surface hardener shall be an approved proprietary liquid hardener and dust proofer.

Hardening admixture **18.86** Hardening admixture shall be an approved proprietary make.

Dividing strip **18.87** Dividing strip shall be aluminium, brass, Grade 316 stainless steel or plastic strip 3 mm thick and to the full depth of the screed. Plastic strip shall be of the colour required.

Form key as one of the following:

(a) Generally sides of section shall be grooved.

(b) Metal strip: one edge shall be cut and bent at 150 mm centres, to form lugs.

(c) Plastic strip: to have 5 to 10 mm holes at 150 mm centres with plastic pins inserted to form dowels.

Non-slip strip **18.88** Non-slip strip insert shall be 25 x 15 mm slightly curved on top and consisting of:

(a) A compound of cement and carborundum dust 1:1, or

(b) A proprietary insert strip.

Workmanship

Generally **18.89** In-situ floor finishes generally shall be to **BS 8204-1+A1**, **BS 8204-2+A2**, **BS 8204-4+A1** and **BS 8204-5+A1**.

Thickness **18.90** Unless otherwise specified, minimum thickness of in-situ floor and wall finishes shall be as Table 18.4.

TABLE 18.4
Thickness of Finish

Location	Granolithic			Terrazzo	
	Plain	Coloured Finish			
		First Coat	Finishing Coat	First Coat	Finishing Coat
Floors laid Monolithically	15 mm	-	15 mm	-	-
Floors	20 mm	10 mm	10 mm	10 mm	15 mm
Walls & Dadoes	20 mm	10 mm	10 mm	10 mm	10 mm
Treads	20 mm	-	20 mm	-	25 mm
Risers	15 mm	-	15 mm	-	15 mm

Laying flooring **18.91** Lay floor finishes as Clauses 18.78 and 18.79.

Cement and sand finish **18.92** Finish shall be composed of cement and sand 1:3.

Granolithic finish **18.93** Granolithic finish shall be mixed in the following proportions as Table 18.5.

TABLE 18.5
Granolithic Finishes

Type	Cement	Sand	Granite aggregate	White stone	Surface finish
A	2	1	4		Trowelled
B	2	1		4	or rubbed
C	1		2		Washed
D	1			2	

Surface finishes on flooring

18.94 Finish surface as Clause 18.81 as soon as compaction is completed. Do not bring excessive laitance to the surface and remove any which appears. Do not wet the surface. Repeat trowelling process or power floating at least three times at intervals within 10 hours of laying.

Surface finishes on granolithic

18.95 Form the following alternative finishes as on granolithic, as required:

(a) Trowelled: smooth or wood float finish as Clause 18.18 (a) and (b) respectively.

(b) Rubbed: after trowelled finish has set, rub down with fine carborundum stone to form a smooth finish and to expose the aggregate.

(c) Washed: before trowelled finish has set, brush off the surface to expose the aggregate.

Coloured finish

18.96 Coloured cement and sand and coloured granolithic finish are to be laid in two coats as follows:

(a) First coat with ordinary cement and sand 1:3 and

(b) Finishing coat as Clauses 18.92 or 18.93 and 5 mm thick (minimum) for cement and sand finish and 10 mm thick (minimum) for granolithic finish using coloured cement. Apply the finishing coat before the first coat has set.

Terrazzo

18.97 Where terrazzo is to be laid in two coats, the coats shall be as follows:

(a) First coat of cement and sand 1:3.

(b) Finishing coat mixed in one of the proportions shown in Table 18.6. Apply the finishing coat before the first coat has set.

TABLE 18.6
Terrazzo

Type	Coloured cement	Marble aggregate	Grade of aggregate(mm)
A	1	2	5 to 3
B	1	2.5	10 to 5
C	1	3	10

Minimum thickness of first and finishing coat shall be as Table 18.4.

Divide terrazzo work into panels of 1 m^2 (maximum).

Grind surface to expose the aggregate and produce a smooth finish.

Fill any voids with matching cement.

Apply one coat of wax polish to wall finishes. Floor finishes shall not be highly polished, or wax polished.

Dividing strip **18.98** Bed dividing strip through the total thickness of the base and finishing coat. Strips shall be firmly fixed in position prior to laying the base.

Non-slip strip **18.99** Fill non-slip compound or bed non-slip into groove, and finish to project 3 mm above finished surface.

Finishes to edge of stairs **18.100** Form granolithic or terrazzo aprons, strings and skirtings to edge of stairs as drawings.

RIGID TILE OR SLAB FINISHES

Materials

Samples **18.101** Submit samples of tiles, and obtain approval.

Concrete floor tiles **18.102** Plain concrete or granolithic concrete floor tiles shall be of the required colour and surface finish.

Ceramic floor tiles and floor quarries **18.103** Ceramic floor tiles including corresponding accessories, shall be to **BS EN 14411**.

Ceramic floor tiles shall be Group A I or B I: water absorption not exceeding 3%.

Floor quarries shall be to Group A IIb of **BS EN 14411**: water absorption of 6% < E =< 10%.

Where ceramic floor tiles or clay floor quarries are described as “including specials” the full range of BS fittings shall be required. Elsewhere mitred angles of coved skirtings and the like shall be permitted.

All tiles and fittings shall be from the same manufacturer and shall match in colour and texture.

Where tiles are described as anti-slip, they shall be suitably embossed or treated with carborundum or similar grit to comply with relevant standards, e.g. Germany DIN standard or other recognized international standards to provide an anti-slip surface.

Terrazzo floor tiles **18.104** Terrazzo floor tiles shall be to **BS EN 13748-1+A1** & **BS EN 13748-2** and of the required colour and surface finish.

“Canton” tiles **18.105** "Canton" tiles shall be hard, sound, square, well burnt, free from twist, cracks or other defects, 30 to 35 mm thick and from 300 to 400 mm^2.

Concrete roofing tiles **18.106** Concrete roofing tiles and fitting shall be to **BS EN 490+A1** and **BS EN 491**.

The tiles shall be flat tiles 30 mm thick and 300 mm^2 or 35 mm thick and 400 mm^2.

Insulating roofing tiles **18.107** Insulating roofing tiles shall be 40 mm thick and 300 mm^2 or 400 mm^2 with a density of 1,250 kg/m^3 ± 10%. The upper surface shall be hard and suitable for pedestrian traffic. Five legged tiles shall not be permitted.

External glazed ceramic wall tiles **18.108** External glazed ceramic wall tiles shall be to **BS EN 14411** and in Group A IIa or B IIa with a water absorption not exceeding 6%.

Tiles shall be glazed, white or coloured as required and with cushion edge and with inclusive spacer lugs as required by the SO.
Where antimony, cadmium or lead (or any of their compounds) are used in the glazes, their content shall not exceed the following specific limits:

(a) Antimony: 0.25% in weight of the glazes
(b) Cadmium: 0.1% in weight of the glazes
(c) Lead: 0.5% in weight of the glazes

External facing tiles **18.109** External facing tiles shall be of the specified type from an approved manufacturer.

Mosaic tiles **18.110** Unless otherwise specified mosaic tiles shall be from an approved manufacturer and as follows:

(a) Glass mosaic tiles shall be fully vitrified glass tile size 20 x 20 mm and 4 mm thick, regular in shape, free from cracks or sharp edges and uniform in colour and texture.

(b) Glazed ceramic mosaic tiles shall be similar to glazed wall tiles but size 18 x 18 mm or 25 x 25 mm and 5 mm thick and with square edges.

(c) Unglazed vitreous mosaic tiles shall be size 18 x 18 mm or 18 x 38 mm or 38 x 38 mm and 4 or 5 mm thick with matching coved tiles and from the colour range specified.

Stone slabs **18.111** Stone slabs for paving or wall facings or fittings shall be of the quality and colours specified on drawings or as selected by the SO and free from flaws and defects throughout. Unless otherwise specified, slabs for wall facings shall not be less than 20 mm thick and slabs for paving surfaces shall not be less than 32 mm thick.

Stones shall be jointed so as to be dressed to match stone by stone.

No stone shall be offered by quarries where variety is expected to develop or which deviates from the selected stone.

Marble shall be true metamorphic limestone.

Engineered Stone **18.111A** Prefabrication of engineered stone for paving or wall facings or fittings, including the processes used to install, modify or repair the engineered stone such as cutting, grinding, trimming, drilling, sanding, or polishing which generate silica dust shall be off-site in a controlled environment with adequate ventilation. Appropriate personal protective equipment shall be provided to prevent workers from inhaling dust particles.

Measures to prevent inhalation of silica dust shall be submitted for the SO's approval and implemented for on-site installation, modification and repairing of the engineered stone.

Precast concrete paving blocks **18.112** Precast concrete paving blocks shall be to **BS 7533-3+A1** & **BS EN 1338** and of the size, colour and surface textured specified.

Adhesive **18.113** Adhesive for tiles or mosaics shall be compatible with background and finish and shall be an approved proprietary brand. Adhesives for tiles shall be to **BS EN 12004-1**. Method statement specifying the types of equipment to be used, method of mixing, setting time and application time schedule shall be submitted for the SO's approval.

The approved proprietary adhesive shall be used in strict accordance with the manufacturer's technical specifications and recommendations, including and not limited to the valid shelf life and the setting time of the product, and the method statement approved by the SO.

The expiry date and the setting time shall be clearly indicated with label and stamp for necessary inspection by the SO.

The following requirements shall be complied with:

(a) VOC content limits on regulated adhesives stipulated in the Air Pollution Control (VOC) Regulation of Hong Kong.

(b) Shall not contain the following substances regulated in the Montreal Protocol on Substances that Deplete the Ozone Layer (particularly CFCs, HCFCs, 1,1,1-trichloroethane and carbon tetrachloride).
(c) Shall contain no more than 0.01% by wet weight of formaldehyde.
(d) Shall contain no more than 0.5% by wet weight of the sum total of aromatic compounds, which include benzene, toluene, xylenes, and ethylbenzene.

Slurry **18.114** Slurry shall be plain or coloured cement and water mixed to creamy consistency.

Grout **18.115** Grouts mixed with plain or coloured cement shall be:

(a) For floor tiling generally: cement and sand 1:3, mixed to a paste with the minimum of water.

(b) For mosaic tiling or glazed wall tiling: cement and powdered limestone 1:3.

(c) For external facing tiles: cement and sand 1:3.

If agreed by the SO, approved proprietary brands of grout may be used in strict accordance with the manufacturer's technical specifications and recommendations.

Epoxy grout **18.115A** Epoxy grouts shall be compatible with background and finish, designated to be suitable for internal or external use and shall be an approved proprietary brand. The grout shall be mixed in small quantities with all components in pre-measured ratios within its working time in accordance with manufacturer's technical specifications and recommendations.

Grouts shall be anti-fungal and resistant to solvents and oils.

Stone wall cladding **18.116** Material for stone wall cladding as in Clause 16.15 and sealant as in Clause 16.22.

Workmanship

Floor and wall tiling generally **18.117** Floor and wall tiling generally shall be:

(a) Floor tiling shall be to **BS 5385-3** & **BS 5385-5**.

(b) Internal wall tiling shall be to **BS 5385-1,** external wall tiling shall be to **BS 5385-2**.

(c) Buttering to Clause 3.2.1.8 in **BS 8000-0 & BS 8000-11**.

Laying floor tiles **18.118** Fix floor tiles as follows:

(a) Semi dry method direct to concrete base (for preparation of base, see Clause 18.16):

(i) Soak tiles in clean water and allow to drain.

(ii) Lay semi-dry mix cement and sand 1:4 bed thoroughly compacted to the required thickness (20 mm minimum) finished to the required levels, falls and currents.

(iii) Pour cement and sand slurry over bedding and spread and trowel to 3 mm (minimum) thick.

(iv) Lay tiles, mixed from six boxes, and tamp firmly into bed with straight and even joints and 3 mm (minimum) wide.

(v) Allow bedding to set.

(vi) Grout up joints and clean surplus grout face of tiles as work proceeds.

(b) Thick bed method to screed:

(i) Soak tiles in clean water and allow to drain.

(ii) Damp the screed with clean water to reduce suction if required.

(iii) Lay cement and sand 1:3 bed generally 15 mm thick but never thicker than the tiles.

(iv) Coat back of tiles with slurry immediately before fixing.

(v) Lay tiles mixed from six boxes and tamp firmly into bed with straight and even joints and 3 mm (minimum) wide.

(vi) Allow bedding to set.

(vii) Grout up joints and clean surplus grout from face of tiles as work proceeds.

(c) Thin bed method: If approved, fix floor tiles using a bed of proprietary tile adhesive to **BS EN 12004-1** in accordance with manufacturer's recommendations.

Laying roof tiles **18.119** Lay on roof "Canton", concrete or lightweight tiles as follows:

(a) Bed and joint tiles in cement mortar (1:4).

(b) Lay tiles loose and fill with cold bitumen between joints and point.

Expansion joints **18.120** Allow for expansion with a 75 mm space around perimeter and 25 mm joints per 9 m^2 cut through joints and fill with cold bitumen or approved sealant.

Traffic on floor tiling, etc. **18.121** Do not allow traffic on floors or roofs until 4 days after completion of tiling and subsequently permit only light traffic for a further 10 days.

Fixing internal wall tiles **18.122** Where tiles with face area greater than the maximum area set out in Table 18.7 are required to be fixed, fixing of wall tiles on wall rendering shall be wet fixed and secured by mechanical fixings:

(a) The mechanical fixings shall be made of stainless steel or aluminium.

(b) Method statement and shop drawings shall be submitted for the SO's approval.

(c) The fixing details with mechanical means shall be proposed and agreed by the tile supplier.

(d) Shop Drawings shall show all necessary details and dimensions.

(e) Acceptance by the SO of the Shop Drawings shall not relieve the Contractor of his responsibility for accuracy of his detail dimensions on the drawings.

TABLE 18.7
Maximum Face Area of Wall Tiles Without Secured by Mechanical Fixing

Height of Installation of Wet-fixed Wall Tiles Above Floor Level	Maximum Face Area of Tile
< = 3 m	< = 0.18 m^2 (e.g. 600 mm x 300 mm)
> 3 m & < = 18 m	< = 0.015 m^2 & nominal face dimension (shorter side) < = 70 mm (e.g. 250 mm x 60 mm, 200 mm x 70 mm)
> 18 m	< = 0.006 m^2 (e.g. 120 mm x 50 mm, 100 mm x 60 mm)

Where tiles with face area not greater than the maximum area set out in Table 18.7 are required to be fixed, fixing of wall tiles on wall rendering shall be as follows:

(a) Thick bed method:

(i) Sort and remove tiles with uneven colour or dimensions. Soak tiles in clean water for 30 minutes (minimum). Stack to drain and fix as soon as the surface water has drained off.

(ii) Damp the wall render with clean water sufficiently to prevent it from absorbing water from the bedding mortar.

(iii) Butter the back of each tile with cement slurry and tap firmly into position so that the bed is solid throughout. Thickness of finished bed shall be 5 to 15 mm.

(iv) Joints shall be 2 mm (minimum) wide, and maximum 3.5 mm wide unless specified otherwise.

(v) Make any adjustment to tiles within 10 minutes of fixing.

(vi) Clean tiles and joints before bedding hardens.

(vii) Grout up joints 24 hours (minimum) after fixing tiles. Clean off surplus grout as work proceeds.

(viii) Clean tiles at completion.

Thick bed method shall not be used for fixing wall tiles with water absorption value lower than 0.5%.

(b) Thin bed method:

(i) Apply wall render of cement: sand (1:3) to the concrete or substrate surface. Build up the render to the required thickness of 15 mm in layers. Thickness of each layer shall not exceed 10 mm. Allow the wall render to dry off thoroughly.

(ii) Fix wall tiles, mixed from six boxes, to the wall render using an approved proprietary adhesive to **BS EN 12004-1** in accordance with the manufacturer's recommendations.

(iii) Grout up joints using an approved grout or a proprietary grout to **BS EN 13888**.

Fixing external wall tiles **18.123**

(a) Where tiles with face area greater than the maximum area set out in Table 18.7 are required to be fixed, fixing of wall tiles on rendering shall be wet fixed and secured by mechanical fixings:

(i) The mechanical fixings shall be made of stainless steel or aluminium.

(ii) Method statement and shop drawings shall be submitted for the SO's approval.

(iii) The fixing details with mechanical means shall be proposed and agreed by the tile supplier.

(iv) Shop Drawings shall show all necessary details and dimensions.

(v) Acceptance by the SO of the Shop Drawings shall not relieve the Contractor of his responsibility for accuracy of his detail dimensions on the drawings.

(b) Where tiles with face area not greater than the maximum area set out in Table 18.7 are required to be fixed, fixing of wall tiles shall be thin bed method as follows:

(i) Apply wall render of cement: sand (1:3) to the substrate surface. Build up the render to the required thickness of 15 mm in layers. Thickness of each layer shall not exceed 10 mm. Allow the wall render to dry off thoroughly.

(ii) Fix wall tiles, mixed from six boxes, to the wall render using an approved proprietary adhesive to **BS EN 12004-1** in accordance with the manufacturer's recommendations. Width of joints shall be as specified.

(iii) Grout up joints using an approved grout or a proprietary grout to **BS EN 13888**. Upon completion of the tiling works, appropriate test methods, such as in-situ pull-out tests by specialist contractor and hammer tapping, shall be carried out to ensure that the external facing tiles have been applied properly to achieve the required adhesion to the building structure or substrate surface according to the approved proprietary tile adhesive.

(c) Carry out infra-red thermographic scanning by an approved specialist and submit report within 4 months upon completion of external tiling. Should the report indicate that any part of the wall tiling has not been affixed properly, the Contractor shall carry out approved remedial measures at his own expense and carry out further infra-red thermographic scanning to the satisfaction of the SO.

(d) Where tiles are required to be purely dry fixed, fixing of wall tiles shall be as follows:

(i) Dry fix method:

(1) The requirement for the anchor of tiles shall be same as stone cladding in accordance with Clause 16.16.

(2) Method statement and shop drawings shall be submitted for the SO's approval.

(3) Shop Drawings shall show all necessary details and dimensions.

(4) Acceptance by the SO of the Shop Drawings shall not relieve the Contractor of his responsibility for accuracy of his detail dimensions on the drawings.

Movement joints **18.123A** Movement joints with width of 15 - 20 mm shall be provided where tiling works abuts restraining surfaces, over construction joints, control joints or movement joints in the substrate structure.

Movement joints shall be positioned in the following locations:

(a) For internal wall tiles

(i) At the top and the bottom of interior walls.

(ii) Over existing and/or structural movement joints.

(iii) Where tiling abuts other materials.

(iv) Where tiling is continuous across junctions of different background materials.

(v) In large tiled areas, equally spaced at 6 m centres horizontally

(vi) At internal vertical corners.

(vii) Where stresses are likely to be concentrated, for example at changes of alignment.

(b) For external wall tiles

(i) Over existing and/or structural movement joints.

(ii) Where tiling abuts other materials.

(iii) Where tiling is continuous across junctions of different background materials.

(iv) In large tiled areas, equally spaced at maximum spacing of 2-storey heights or 6 m vertically.

(v) At vertical corners.

Movement joint sealant shall be applied in accordance with the guidance given in **BS 6213+A1** and to the manufacturer's recommendation.

Shop drawings showing the setting out of movement joints and details shall be submitted for the SO's approval.

Fixing mosaic tiles **18.124** Fix mosaic tiles as follows:

(a) Thick bed method direct to concrete slab as follows:

(i) Lay semi-dry mix cement and sand 1:4 bed thoroughly compacted to the required thickness (20 mm minimum) finished to the required levels and falls.

(ii) Pour cement and sand slurry over the bedding and spread and trowel 3 mm thick.

(iii) Coat back of sheets of mosaic tiles with cement slurry immediately before fixing. Slurry shall be of the same colour as the final grout.

(iv) Fix sheets of mosaic tiles and tamp firmly into bed, maintaining straight and regular joints, and ensuring that joints between sheets are equal to tile joints.

(v) Remove backing paper, complete final straightening and rub surface with grout, coloured as required, to fill joints, cleaning surplus grout from face of tiles as work proceeds.

(b) Thick bed method to wall render as follows:

(i) Damp the wall render with clean water sufficiently to prevent it from absorbing water from the bedding mortar.

(ii) Apply bedding coat of mortar 10 mm (maximum) thick consisting of cement and sand (1:3).

(iii) Coat surface of wall render and back of sheets of mosaic tiles with slurry immediately before fixing. Slurry shall be of the same colour as the final grout.

(iv) Fix sheets of mosaic tiles and tamp firmly into position, maintaining straight and regular joint, ensuring that joints between sheets are equal to joints between tiles.

(v) Remove backing paper, complete final straightening and rub surface with grout from face of tiles as work proceeds.

(c) Thin bed method:

(i) If approved, fix mosaic tiles using a bed of proprietary adhesive in accordance with the manufacturer's recommendations.

(ii) Grout up joints using a proprietary grout as specified, which may be coloured in accordance with the SO's requirements.

Fixing stone paving slabs **18.125** Bed stone paving slabs with one coat of approved sealer to all faces of stone slab. Bedding shall be not less than 12 mm thick comprising cement, and finely screened sand 1:3. Finish with a perfectly level and even surface and with joints between slabs 2.5 mm thick, or laid to fall as directed by the SO.

Fixing stone wall slabs **18.126** Generally fix stone wall slabs in accordance with Clauses 10.22, 16.15 and 16.16 for heights greater than 1.2 m above any structural floor level. Fix stone wall slabs not less than 12 mm from the structural surfaces on Keenes cement or Plaster of Paris dabs. Space slabs so that each slab is evenly supported by not less than five dabs. Dowel for and fit each slab with copper cramps and "S" hooks, formed from 3 mm diameter brass wire. Fix slabs at approximately 350 mm centres or as directed and solidly bed cramps to the structure and "S" hooks to backs of slabs. Provide semi dry cement and sand (1:4) filling 1500 mm high above floor level at public area with one coat of sealer at back of stone wall slab before fixing where specified.

Shop drawings shall be submitted for dry fixing system.

Precast concrete paving **18.127** Lay slabs minimum 50 mm thick on 25 mm minimum bed of lime and sand or cement and sand mortar 1:3. Lay slabs to an even surface, well pressed into bed, with no level differences between adjacent slabs.

Joints shall be even and about 5 mm wide. Stagger joints to form bond as specified. Grout up with cement lime and sand or granite fines 1:3:6. Work well into joints. Clean off surplus grout from surface of slabs.

FLEXIBLE TILE OR SHEET FINISHES

Generally

Approved brands and specialist contractors **18.128** Flexible tile and sheet finishes shall be of the best quality of approved type and colour, and in accordance with the following specification. Sizes and thicknesses shall be as specified hereafter unless specifically ordered otherwise. The work shall be executed by an approved specialist contractor.

Materials

Samples **18.129** Submit samples and obtain approval.

Emission **18.129A** Emission of formaldehyde from the approved proprietary products shall not exceed 0.13 mg/m^3 air.

Semi-flexible PVC tiles **18.130** Semi-flexible PVC tiles shall be to **BS EN ISO 10595**, size 225 x 225 or 300 x 300 and 2.5 mm thick.

Vinyl tiles **18.131** Unbacked flexible PVC (vinyl) tiles shall be to **BS EN ISO 10581**, size 225 x 225 or 300 x 300 and 2 mm thick.

Unbacked flexible PVC vinyl sheet **18.132** Unbacked flexible PVC (vinyl) sheet shall be to **BS EN ISO 10581**, 2.0 mm thick to floors and 1.2 mm thick to walls.

Foam backed vinyl sheet **18.133** Foam backed PVC (vinyl) sheet shall be to **BS EN 651** and 3 mm thick overall. The wearing layer shall be PVC (vinyl) sheet to **BS EN ISO 10581** and 1.5 mm thick.

Linoleum **18.134** Linoleum tiles and sheet shall be to **BS EN 12104** and shall be 3.2 mm or 4.5 mm thick.

Rubber tiles and sheet **18.135** Solid rubber tiles and sheet shall be to 4 mm thick.

The approved proprietary products shall have no flame retardant of polybrominated biphenyls (PBBs), polybrominated diphenyl ethers (PBDEs) or short-chain chlorinated paraffins added as formulated components.

The product shall not contain any heavy metals or their compounds as listed below:

(a) Arsenic
(b) Cadmium
(c) Chromium
(d) Copper
(e) Lead
(f) Mercury

Adhesive **18.136** Adhesive shall be that recommended by the tile or sheeting manufacturer. The following environment requirements shall be complied with:

(a) VOC content limits on regulated adhesives stipulated in the Air Pollution Control (VOC) Regulation of Hong Kong.
(b) Shall not contain the following substances regulated in the Montreal Protocol on Substances that Deplete the Ozone Layer (particularly CFCs, HCFCs, 1,1,1-trichloroethane and carbon tetrachloride).
(c) Shall contain no more than 0.01% by wet weight of formaldehyde.
(d) Shall contain no more than 0.5% by wet weight of the sum total of aromatic compounds, which include benzene, toluene, xylenes, and ethylbenzene.

Polish **18.137** Polish shall be emulsion polish of approved type recommended by the tile or sheeting manufacturer.

Store rolls after delivery, but before laying, in accordance with the manufacturer's instructions. Rolls which have deformed because of improper storage shall be rejected.

Workmanship

Damaged tiles **18.138** Do not use tiles or sheet which have deteriorated in stock or have a tendency to curl at the edges and corners.

Laying **18.139** Thoroughly clean the screed or backing from grease, oil, wax, paint, dirt or dust and fill all cracks, minor holes and services with a suitable filler recommended by the tile or sheeting manufacturer.

Lay all tiles, floor and wall sheeting strictly in accordance with the manufacturer's instructions. If these instructions call for heating the tiles prior to laying, then apply such preheating to a temperature just sufficient to cause pliability. Preheat tiles in batches. Preheating single tiles shall not be permitted.

Apply adhesive in a thin film and spread evenly with a notched or plain trowel, then even out with a roller as recommended by the manufacturer. If a notched trowel is used the notches shall be of the size recommended and shall be renewed periodically to ensure the correct spread of adhesive. Tiles or sheets shall be laid immediately after the adhesive is applied.

Closely butt joints and cut accurately at right angles to the tiles or sheet surface to an agreed design and with only the minimum necessary jointing.

Weld joints of PVC sheet to form a continuous surface with approved PVC welding rods coloured to match the sheeting.

Relay any areas insufficiently bonded or showing an uneven surface.

Polish **18.140** After laying, thoroughly clean the tiling or sheeting with water and a detergent recommended by the manufacturer. Apply two coats of approved non-slip, matt emulsion polish. Protect the floors with approved covering.

CARPET OR TEXTILE FLOOR COVERINGS

Generally

Approved brands and specialist contractors **18.141** All carpet shall be of approved type and colour and in accordance with the following specification, of an approved brand, laid on screed treated with an approved sealant to reduce dust and pollution.

Quality **18.142** Carpet shall be either of the following qualities as specified:

(a) "General contract quality carpet" for use in single occupant offices, committee and conference rooms, small libraries, staff quarters, light wear corridors and other areas as required.

(b) "Heavy contract quality carpet" for use in public rooms, general offices, reception areas, busy corridors and other areas as required.

Classification **18.143** Carpet shall be manufactured by one of the following methods:

(a) Single or face-to-face traditional loom.

(b) Needle insertion loom.

(c) Needle punch, fibre bonded, flocked or knitted.

(d) Other weaving machinery producing the quality of carpet to meet the performance requirements detailed in this specification.

Materials

Samples **18.144** Submit samples of carpet and underlays together with relevant manufacturer's literature and submit test certificates for carpet to demonstrate that it complies with the requirements of Clauses 18.149 and 18.150 and obtain approval.

The materials shall be accompanied with test certificates or reports, issued by an accredited laboratory.

Emission **18.144A** Emission of formaldehyde from the approved proprietary products shall not exceed 0.13 mg/m^3 air.

Emissions of Total Volatile Organic Compounds (TVOCs) shall not exceed 0.5 $mg/m^2/hr$.

Pile yarn **18.145** The composition of the pile yarn shall be fibres of one of the followings:

(a) Wool or wool blended with up to 20% nylon.

(b) Nylon with antistatic properties for general use.

(c) Polypropylene

(d) Blend of fibres with antistatic properties for general use.

(e) Blend of fibres formulated shall provide full antistatic properties to meet the requirements specified by International Business Machine (I.B.M.) or International Computer Company (I.C.L.) for computer floor coverings, or other equivalent approved by the SO.

Backing materials **18.146** The warp and weft shall be PVC free, and the materials shall be cotton, jute, resin or polypropylene.

Back coating **18.147** The back coating where required shall be evenly spread with no build-up at the selvedges of the carpet and which gives fray-resistant finish to cut edges.

(a) The quality and application of the back coating shall be such that:

(i) Its penetration shall assist tuft anchorage without wicking into the surface pile.

(ii) The finish carpet may be seamed without gumming the needle and sewing thread, due to softening of the compound.

(iii) Folding the carpet shall not cause permanent creasing.

(b) The backing coating shall:

(i) Not deteriorate substantially with age or low temperature.

(ii) Not become sticky with temperatures and humidities experienced when laid in Hong Kong, or in transit thereto.

(iii) Be capable of spot cleaning using dry cleaning solvents without serious deterioration.

(c) The backing compound may be loaded with 100 parts of filler to 100 parts of dry rubber.

Dyeing **18.148** Carpets shall be dyed by a process that produces full and even penetration of the fibres with minimum degradation of the yarn and it shall be applied strictly in accordance with the dyestuffs manufacturer's instructions.

Colour fastness **18.149** Colour fastness of carpet shall meet the requirements of Table 18.8.

TABLE 18.8

Colour Fastness Related to	Minimum Acceptable Grade	Method of Test
Light	5	**BS EN ISO 105-B01, E01, B02, D02, G02, B03, B04, E05, C06, E06, X08, X13.**
Wet and dry rubbing	4	Pile yarn assembled and tested in accordance with **BS EN ISO 105-X12**
Shampooing	4	Test on finished carpet in accordance with the recommendations of the Society of Dyers and Colourists
Organic Solvents	4	**BS EN ISO 105-X05**

Physical properties **18.150** Physical properties of the finished carpet shall be in accordance with Table 18.9.

TABLE 18.9

Properties	Requirements	Method of Test
Number of tufts per 100 cm^2	Minimum 1,000	
Thickness loss under dynamic loading	Thickness loss after 1,000 impacts not more than 25%	**BS ISO 2094** Using dynamic loading machine on original pile thickness
Thickness; compression and recovery	Percentage compression recovery not less than 60%	**BS 4098** on original pile thickness
Dimensional stability; extension due to mechanical action	Mean non-recoverable not exceed Warp 1%, Weft 1%	to be decided by the SO

Dimensional change when immersed in cold water; to determine behaviour of the carpet when subjected to total saturation in cleaning or shampooing when excessive water is applied	Dimensional change not to exceed Warp 2%, Weft 2%	to be decided by the SO
Flammability	Shall not propagate flame after removal of nut and the charred area shall not exceed 35 mm radius	**BS 4790**
Moth proofing	The carpet shall be permanently moth proofed	to be decided by the SO

Resistance to wear **18.151** Although there is no standard laboratory test for resistance to wear, tenderers must satisfy the Employer that their products will sustain the wear anticipated. For example, they may quote tests or reports illustrating the suitability of their products, or list locations, preferably in Hong Kong where their products have been laid for a period of at least 2 years, or produce satisfactory evidence from overseas to endorse their suitability.

Foam backed carpet **18.152** Foam backed carpets shall not be permitted unless the foam is expanded PVC.

Carpet tiles **18.153** Carpet tiles shall be of the same size so that they could be easily interchanged, relocated, replaced or removed.

Special tiles, with proper edging around, cut out to receive floor socket or outlet are required.

All carpet surfaces shall be "Scotch-guarded", or other approved protective treatment to be provided. No unravelling of yarn at edge of module is permitted.

All carpet tiles shall be dimensionally stable (resist shrinkage) in any circumstance.

Environmentally friendly carpets **18.154** Environmentally friendly carpets shall satisfy the following criteria:

(a) Carpet manufacturing company shall have acquired "ISO 14001– Environmental Management Systems" or "Eco-Management and Audit Scheme (EMAS) of Denmark" or similarly approved by the SO.

(b) Carpets shall be completely free of Polyvinyl Chloride (PVC).

(c) Carpet backings shall be PVC free; materials to be cotton, jute, resin or polyurethane.

(d) Adhesives shall be free of synthetic latex, giving no volatile organic compound emission. Water-based adhesives or adhesive-free installation shall be used.

(e) Metal complex dyes and acid dyes shall not be used for dyeing.

(f) Carpets shall be long lasting, having a lifecycle not less than 10 years.

(g) Carpets shall not contain harmful substances and odour. They shall pass the testing and labelling program run by "Carpet and Rug Institute's Indoor Air Quality Carpet Testing Programme" (U.S.A.) or "Danish Indoor Climate Labelling" (Denmark) or "GUT" (European association for environmentally friendly carpets) or similarly approved by the SO.

(h) Carpets shall be capable of being reused, recycled into new carpet or other products, acceptable by landfill for disposal, or being refurbished. When reused, the above requirements shall be followed. In case of recycle or landfill, the carpets shall not cause contamination to the surrounding environment.

(i) The approved proprietary products shall include a post-consumer or post-industrial recycled content of at least 5% in the carpet face fibre, primary backing or secondary backing.

(j) The approved proprietary products shall not be manufactured with topically applied biological inhibitors.

Underlay **18.155** Provide underlay, where required, one of the following types to **BS EN 14499**.

(a) Felt
(b) Cellular
(c) Rubber crumb
(d) Composite underlay

Carpet grippers **18.156** Carpet grippers shall have two rows of small angled pins at not less than 50 mm centres projecting 4 mm from a preformed strip. Submit samples of carpet grippers and obtain approval.

Adhesives **18.157** Adhesive for fixing carpet shall be as recommended by the carpet manufacturers and be compatible with the sub-base. Storage and use should be in accordance with the appropriate recommendations, e.g. the British Adhesive Manufacturers Association booklet "Safe Handling of Adhesives in Industry".

The following environment requirements shall be complied with:

(a) VOC content limits on regulated adhesives stipulated in the Air Pollution Control (VOC) Regulation of Hong Kong.
(b) Shall not contain the following substances regulated in the Montreal Protocol on Substances that Deplete the Ozone Layer (particularly CFCs, HCFCs, 1,1,1-trichloroethane and carbon tetrachloride).
(c) Shall contain no more than 0.01% by wet weight of formaldehyde.
(d) Shall contain no more than 0.5% by wet weight of the sum total of aromatic compounds, which include benzene, toluene, xylenes, and ethylbenzene.

Release bond agent **18.158** Release bond agent shall be a proprietary release coating or other approved system and be used strictly in accordance with the manufacturer's instructions.

Workmanship

Installation generally **18.159** Install carpets and underlays in accordance with **BS 5325**.

Install carpets so that they are flat and of even tension. Carpet shall not be displaced by movement of people or objects on the surface to the point where permanent slackness, rucking or rippling is caused.

Closely fit edges to skirting, cover fillets or other perimeters. Joint carpet at doorway within the thickness of the closed door.

Secure doorway terminations of carpet by sealing, whipping or binding before seaming or covering with cover strips where they abut dissimilar materials.

No carpet jointing shall be permitted at right angles to a door location within 2 m of any door centre line unless accepted by the SO.

No fitting-out of areas with small pieces or offcuts shall be permitted.

Carpet tiles on raised floor panels shall either be stuck down with double-sided tape or alternatively with some form of bonding agent integral with the backing of the tile with the approval of the SO.

Laying underlays **18.160** Provide underlays in all cases except as follows:

(a) Where foam or felt backing is an integral part of the carpet proposed.

(b) Where the carpet shall be fully adhered in accordance with the manufacturer's recommendations.

(c) Where the manufacturer recommends that no underlay is required.

Ensure the base is smooth, clean, and dry and compatible with the underlay and carpeting. Similarly ensure any adhesive to be used is compatible with the base, underlay and carpet.

Lightly smooth the underlay by hand to ensure that it lies flat with no bubbles or wrinkles visible on the surface. Secure the underlay sufficiently to prevent movement when the carpet is laid over it.

Seaming and jointing carpet **18.161**

Plan the layout of the carpet to keep seams to the minimum practicable. Seams shall be unobstructed and positioned such that, where possible:

(a) They run the length of the area.

(b) Traffic runs along the length rather than across the seams.

(c) Seams shall not be placed in areas subjected to heavier or twisting wear or in doorways or narrow accesses.

Seam or joint carpet by one of the following methods:

(d) Machine or hand sewing; sew seams to the full length and properly lock off. Stitch to an even tension and ensure the seam lies flat after laying. Protect the raw edge of the pile where necessary, to prevent loss of pile along the seam.

(e) Reinforced tape and adhesive (cold applied); ensure that the adhesive is dry before stretching.

(f) Heat bonded tapes; ensure that adequate penetration of adhesive is achieved by applying sufficient heat and pressure simultaneously.

(g) Seaming cement; Joint foam backed or unitary-backed carpets with a continuous bead of seaming cement to the full length of the primary backing and joint under compression.

Installations of carpet **18.162**

Secure carpets by using one of the following methods:

(a) Carpet gripper method (suitable for woven, tufted, and secondary backed bonded carpet):

Plug and screw or nail carpet gripper strip around the perimeter 6-8 mm from the skirting. Use recommended adhesives between screws and nail centres. Stretch carpet over the gripper using knee kickers, trim the edge of the carpet and ensure that it is securely trapped in the gap between the gripper and the skirting. Use power stretchers for installations over 7 m long or wide and use a double row of carpet grippers.

(b) Fully adhering method (suitable for all types of carpet):

Ensure that the floor is properly dry, free from dust, and contaminants which will affect the adhesion. Ensure that the adhesive is spread evenly and that only a sufficient area that can be properly bonded is laid at one time. Ensure that maximum adhesive contact is obtained by brushing or rolling in accordance with the manufacturer’s instructions.

Cut edges shall be seamed straight and square before adhesion in accordance with the manufacturer's instructions. Trim the carpet to the perimeter before the adhesive dries.

Do not permit traffic or installation of furniture on adhered areas for at least 24 hours.

(c) Release bonded method (suitable for all types of carpet):

Apply the release agent before adhering generally in accordance with the Clause 18.162 (b) above.

Protection and cleaning **18.163** Clear all carpet areas of tools and waste. Remove all pieces of partly loose warp or face yarn with napping scissors. Rectify any lumps, surface irregularities and areas of inadequate or uneven tension that are apparent.

Clean in an approved manner the installed carpet throughout the building once after completion prior to acceptance by the SO.

RAISED ACCESSED FLOORING

Materials

Generally **18.164** The raised floor deck shall be fitted with fully removable load bearing panels, interchangeable, and supported on adjustable pedestals.
The floor system shall not contain materials which by direct contact could be detrimental to the safety and comfort of the users or which may emit abnormally toxic combustion materials and gases when burned.

The floor system shall be sturdy, rigid and firm. The design of the system shall prevent vibration, rattles, rocking squeaks and other noises. Floor panels that are cut shall be supported by additional pedestals and shall have framing modified accordingly.

Accessories **18.165** All necessary accessories such as ramps, stairs, railings, air grilles, skirting trims, vertical edging panels, shall be of a similar standard or quality to the main floor system.

Dimensional requirements **18.166** All panels shall be of the following dimensional requirements:

(a) They shall be removable and fully transferable in position and direction.

(b) A close fit to all perimeters is required and the maximum gap shall be 15 mm and the edge panels shall be located to prevent movement.

(c) Before application of load, the platform floor surface shall be level to ± 1.5 mm over any 5 m^2 or ± 6 mm over the entire floor.

(d) Height difference between adjacent panels without finish, shall not exceed 0.75 mm, before load application. Height difference between loaded and not loaded shall not exceed 3.25 mm.

(e) Under no load condition, the concavity or convexity of the panel shall not exceed 0.75 mm when measured horizontally parallel to any edge or along the diagonal, and the deviation due to twist shall not exceed 1 mm.

(f) Panel deviation from square or work size shall not exceed ± 0.5 mm.

(g) Panel edge strips if utilised, shall be firmly fixed and shall not peel or become detached or break. The edging shall resist a pull off strength of 5 N for 5 minutes. Edge stripping shall be dimensionally stable during the stated service life.

Edges of panels shall be chamfered at an angle of 5 degrees for easy removal of panels. Site-cut edges of panels shall be treated to resist fire, moisture, and attack by vermin etc.

(h) The dead load of the raised access floor system shall not exceed 1 kN/m^2.

Structural requirements **18.167** The structural requirements of the floor system shall be in accordance with the followings:

(a) Uniformly distributed load - 12.0 kN/$m^{2.}$
Concentrated load - 4 kN over 25 $mm^{2.}$
Deflection shall not be more than 1/250 of the shortest span or 2.5 mm whichever is less, up or down from the unloaded plane when subjected to the loadings quoted above, for a period of 24 hours.
Horizontal load - 1.2 kN/m^2.

(b) The system shall sustain for 5 minutes, 3 times the specified static loadings without collapse, at any position in the panel.

(c) Base area of the pedestal shall not be less than 10,000 mm^2 and shall be fixed to the floors by mechanical means in addition to adhesives.

(d) Pedestals shall not be permanently deformed by more than 1 mm per 100 mm in height when subjected to a steady horizontal moment of 90 Nm up to a maximum applied load of 0.5 kN, applied to the uppermost part, for 5 minutes.

They shall sustain a vertical load of 4 x 18 kN over an area of 50 x 50 mm for a period of 5 minutes without collapse and 3 x 13.5 kN applied through a panel over one quadrant of the head.

Free movement in an unloaded pedestal at the maximum and minimum adjustment position shall not exceed 1 mm per 100 mm height. The free movement shall be induced by the application of a horizontal force of 5 N.

The adjustable device on the pedestal shall be positively locked and shall be designed so as not to become loose due to vibration during the life of the system. It shall be possible to release the locking by means of a tool should re-adjustment become necessary.

The length of threading for the upper part of the pedestal shall not be less than 60 mm.

(e) Where a supplementary support structure is required to accommodate variations greater than construction tolerances, i.e. to bridge service ducts etc., such bridging shall comply with all the relevant requirements of the specifications.

Alternatively, the raised floor system can be tested for concentrated load, ultimate load, rolling loads, stringer load, pedestal axial load, pedestal overturning moment, uniform load and drop impact load according to Ceilings and Interior Systems Construction Association (CISCA) Recommended Testing Procedure, subject to approval by the SO.

Hydrothermal requirements **18.168** The platform floor system, including the pedestals, panels, floor covering and fixings shall withstand the following conditions, without any delamination or other forms of deterioration:

(a) Temperature 5°C, relative humidity 90% on both sides of the floor panels.

(b) Temperature 5°C and 95% RH in the floor void side of the panels. Temperature 25°C and 25% RH on the room side of the panels.

(c) Temperature 8°C and 99% RH in the floor void side of the panels. Temperature 23°C and 55% RH on the room side of the panels.

(d) Temperature 30°C and 30% RH in the floor void side of the panels, 19°C and 60% RH on the room side of the panels.

(e) Temperature variation from 0°C to 60°C with humidity level of 95%.

The material shall, under the above-mentioned conditions and after the above-mentioned conditions comply with the Clauses 18.166 and 18.167. The material content of the floor panels shall not be capable of absorbing moisture.

Fire and safety requirements **18.169** The system shall comply with the following fire and safety requirements:

(a) It shall be non-inflammable and shall not sustain any combustion.

(b) It shall meet the fire requirements of **BS 9999** and **Part E of the Code of Practice for Fire Safety in Buildings 2011.**

(c) It shall achieve, within the cavity, Class 1 classifications when tested in accordance with **BS 476-7** and an index of Performance (1) not exceeding 12 and a sub index (i) not exceeding 6 when tested in accordance with **BS 476-6+A1**. The test certificates shall be issued by an accredited laboratory not more than 3 years ago.

(d) Panels that are constructed of combustible material shall be completely and securely clad on the underside in non-combustible material with a melting point of not less than 600ºC. This cladding shall be securely fixed to ensure that flame or radiant heat does not come into contact with the combustible material.

(e) All supporting structure shall be incombustible and shall have a melting point of not less than 600ºC.

(f) It shall have a thermal property such that mean temperature of the upper panel surface shall not increase by more than 140ºC, when subject to the 1 kg crib fire test.

Electrical requirements **18.170** The system shall have the electrostatic properties such that the resistance between the surface of the floor covering and the main building earth continuity conductor shall be between 5 x 100000 and 2 x 10 to the power of 10 ohms at RH 50%.

All substantial metallic components of the floor system shall be capable of being electrically bonded.

Fungi, mould and insects **18.171** All materials shall be resistant to the growth of fungi and micro-organisms, and to the attack by insects.

The materials shall meet **BS 1982-0, BS 1982-1, BS 1982-2 and BS 1982-3** method of test for fungal resistance and manufactured building materials made of or containing materials of organic origin. The materials shall be accompanied with test certificates or reports, issued by an accredited laboratory.

Toxicity **18.172** The system shall not contain any toxic materials which by physical contact or by inhalation of gases from such materials, could prove harmful to the occupants of the building.

Odour **18.173** The materials used in the system shall not give off any odours which could be unpleasant to the occupants of the building.

Vermin **18.174** Materials used in the system shall not be vulnerable to attack by vermin. The design of the system should resist infestation by vermin.

Creation of contaminations **18.175** The system and the floor panels shall not create dust or contaminations which are likely to be harmful to personnel or equipment.

Durability **18.176** The system supporting components and the floor panels shall have a minimum life of 25 years.

Protective finishes **18.177** All parts of the system shall be installed free of rust, corrosion, rot or any form of deterioration.

All parts of the system shall be suitably finished to prevent deterioration under normal use in the environments as defined by Clause 18.168. All finishes shall be clearly stated at the time of tender.

Insulation of under cavity floor where required **18.178**

Materials shall be non-combustible and shall be approved by the Fire Services Department. They shall be compatible with all other materials used in the raised floor system.

For insulation, the conductivity shall not be more than 0.036 w/mºC at 24ºC.

The following environment requirements shall be complied with:

(a) Discharge of Volatile Organic Compounds (VOCs) shall not exceed 500 $\mu g/m^2/hr$.

(b) The levels of the following hazardous substances as impurities shall not exceed the following:
- (i) Arsenic: 50 ppm
- (ii) Cadmium: 10 ppm
- (iii) Hexavalent chromium: 10 ppm
- (iv) Lead: 300 ppm
- (v) Mercury: 10 ppm
- (vi) Selenium: 20 ppm
- (vii) PBDEs (polybrominated diphenyl ethers): 100 ppm
- (viii) PBBs (polybrominated byphenyls): 100 ppm

Workmanship

Co-ordination with building services installation **18.179**

The Contractor shall co-ordinate with Specialist subcontractors for building services installation of floor boxes, trunkings and cables to be installed below the raised floor systems. Locations of the openings on the raised floor panels for the installation of the floor boxes shall be submitted for the SO's approval.

Preparation of Work **18.180**

All areas shall be examined before the beginning of the work to determine that the structure is in a condition to receive the system. The area shall be broom-cleaned, and uninterrupted for free movement of work flow.

Air and leakage test **18.181**

Subject to the SO's instruction, air and leakage test shall be performed according to CISCA Recommended Testing Procedure.

Cleaning **18.182**

The surface of the floor and the void below shall be left clean and dust free.

Protection of completed works **18.183**

The raised floor system shall be adequately protected from damage and dirt before handover to others for the installation of floor coverings and/or other works.

QUALITY CONTROL TESTING

Non-slip homogenous floor tiles **18.184** The quality tests for non-slip homogenous floor tiles shall be as follows:

(a) Dimensions and surface quality:

Test Items		Test Method	Acceptance Standards		
Nominal Size (mm)			200 x 200	300 x 300	400 x 400
BS EN 14411 Classification			BIb	BIb	BIb
1. Length and Width	Deviation from Work Size (%)	**BS EN ISO 10545-2**	± 0.75	± 0.6	± 0.6
	Deviation from Average Size (%)		± 0.5	± 0.5	± 0.5
2. Thickness (%)			± 5	± 5	± 5
3. Straightness of sides (%)			± 0.5	± 0.5	± 0.5
4. Rectangularity (%)			± 0.6	± 0.6	± 0.6
5. Surface flatness	Centre curvature (%)		± 0.5	± 0.5	± 0.5
	Edge curvature (%)		± 0.5	± 0.5	± 0.5
	Warpage (%)		± 0.5	± 0.5	± 0.5
6. Surface quality (%) free from visible defects that would impair the appearance of a major area of tiles			= > 95	> = 95	> = 95

(b) Physical properties:

Test Items		Test Method	Acceptance Standards		
Nominal Size (mm)			200 x 200	300 x 300	400 x 400
BS EN 14411 Classification			BIb	BIb	BIb
1. *Water absorption (%)	Average	**BS EN ISO 10545-3**	< = 3	< = 3	< = 3
	Individual		< = 3.3	< = 3.3	< = 3.3
2. *Modulus of rupture (N/mm^2)	Average	**BS EN ISO 10545-4**	> = 30	> = 30	> = 30
	Individual		>=27	>=27	>=27
3. *Scratch hardness of surface (Moh's Scale)		to be decided by the SO	> = 6	> = 6	> = 6
4. *Abrasion resistance	Deep abrasion (mm^3)	**BS EN ISO 10545-6**	< = 175	< = 175	< = 175
5. *Coefficient of linear thermal expansion ($x10^6$ °C)		**BS EN ISO 10545-8**	< = 9.0	< = 9.0	< = 9.0

Note: For the tests marked with '*', test certificates or reports shall be issued by an accredited laboratory not more than 3 years ago.

(c) Chemical properties:

Test Items		Test Method	Acceptance Standards		
Nominal Size (mm)			200 x 200	300 x 300	400 x 400
BS EN 14411 Classification			BIb	BIb	BIb
1. *Resistance to acids and alkali	Sulphuric acid	**BS EN ISO 10545-13**	Required	Required	Required
	Lactic acid		Required	Required	Required
	Potassium hydroxide		Required	Required	Required
2. *Resistance to household chemicals	Ammonium chloride		Required	Required	Required
	Standard cleaning agent		Required	Required	Required
3. *Resistance to swimming pool salts	Sodium hypochlorite		Required	Required	Required
	Copper sulphate		Required	Required	Required

Note: For the tests marked with '*', test certificates or reports shall be issued by an accredited laboratory not more than 3 years ago.

(d) Slip resistance:

Test Items		Test Method	Acceptance Standards		
Nominal Size (mm)			200 x 200	300 x 300	400 x 400
BS EN 14411 Classification			BIb	BIb	BIb
1.*Anti-slip property	External Areas				
	Ramps steeper than 1 in 14	**DIN 51130**	R12		
	Other external areas		R11		
	Internal Areas				
	Ramps steeper than 1 in 14	**DIN 51130**	R11		
	Ramps under 1 in 14		R10		
	Wet/ semi-covered area		R10		
	Other internal areas (excluding barefoot situations)		R9		

Note: For the tests marked with '*', test certificates or reports shall be issued by an accredited laboratory not more than 3 years ago.

Internal glazed ceramic wall tiles

18.185 The quality tests for internal glazed ceramic wall tiles shall be as follows:

(a) Dimensions and surface quality:

Test Items		Test Method	Acceptance Standards		
Nominal Size (mm)			108 x 108	152 x 152	200 x 200
BS EN 14411 Classification			BIII	BIII	BIII
1. Length & Width	Deviation from Work Size (%)	**BS EN ISO 10545-2**	± 0.75 / (-0.3, +0.6)	± 0.5 / (-0.3, +0.6)	± 0.5 / (-0.3, +0.6)
	Deviation from Average Size (%)		± 0.5 / (± 0.25)	± 0.3 /(± 0.25)	± 0.3 / (± 0.25)
2. Thickness (mm)		To be decided by the SO	± 0.5	± 0.5	± 0.6
3. Minimum thickness (mm)			4	5.5	-
4. Straightness of sides (%)		**BS EN ISO 10545-2**	± 0.3	± 0.3	± 0.3
5. Rectangularity (%)			± 0.5 / (± 0.3)	± 0.5 / (± 0.3)	± 0.5 / (± 0.3)
6. Surface flatness	Centre curvature (%)		- 0.3, + 0.5 (-0.2 / +.8 mm)	- 0.3, + 0.5 (-0.2 / +0.8 mm)	- 0.3, + 0.5 (-0.2 / +0.8 mm)
	Edge curvature (%)		- 0.3, + 0.5 (-0.2 / +0.8 mm)	- 0.3, + 0.5 (-0.2 / +0.8 mm)	- 0.3, + 0.5 (-0.2 / +0.8 mm)
	Warpage (%)		±0.5 / (±0.5 mm)	±0.5 / (±0.5 mm)	±0.5 / (±0.75 mm)
7. Surface quality (%) free from visible defects that would impair the appearance of a major area of tiles			= > 95	> = 95	> = 95
8. Tile with spacer lugs	Width of tile grout at tiled surface (mm) (G)	To be decided by the SO	-	-	G = 3 mm ± 20%

Note: Values in brackets are for tiles with spacer lugs only.

(b) Physical properties:

Test Items		Test Method	Acceptance Standards		
Nominal Size (mm)			108 x 108	152 x 152	200 x 200
BS EN 14411 Classification			BIII	BIII	BIII
1. *Water absorption (%)	Average	**BS EN ISO 10545-3**	= > 10 & < = 20	= > 10 & < = 20	= > 10 & < = 20
2. *Modulus of rupture (N/mm^2)	Thickness <7.5 mm	**BS EN ISO 10545-4**	> = 15	> = 15	> = 15
	Thickness >=7.5mm		>=12	>=12	>=12
3. *Scratch hardness of surface (Moh's Scale)		to be decided by the SO	> = 3	> = 3	> = 3
4. *Abrasion resistance	Surface abrasion (Class1-4)	(PEI Method) **BS EN ISO 10545-7**	Minimum Class 2	Minimum Class 2	Minimum Class 2
5. *Coefficient of linear thermal expansion ($x10^6$ °C)		**BS EN ISO 10545-8**	< = 9.0	< = 9.0	< = 9.0
6. *Crazing resistance		**BS EN ISO 10545-11**	Required	Required	Required

Note: For the tests marked with '*', test certificates or reports shall be issued by an accredited laboratory not more than 3 years ago.

(c) Chemical properties:

Test Items		Test Method	Acceptance Standards		
Nominal Size (mm)			108 x 108	152 x 152	200 x 200
BS EN 14411 Classification			BIII	BIII	BIII
1. *Resistance to acids and alkali	Hydrochloric acid	**BS EN ISO 10545-13**	Minimum Class B	Minimum Class B	Minimum Class B
	Citric acid		Minimum Class B	Minimum Class B	Minimum Class B
	Potassium hydroxide		Minimum Class B	Minimum Class B	Minimum Class B
2. *Resistance to household chemicals	Ammonium chloride		Minimum Class B	Minimum Class B	Minimum Class B
	Standard cleaning agent (See Note 2)		Minimum Class B	Minimum Class B	Minimum Class B
3. *Resistance to swimming pool salts	Sodium hypochlorite		Minimum Class B	Minimum Class B	Minimum Class B
	Copper sulphate		Minimum Class B	Minimum Class B	Minimum Class B
4. *Resistance to staining	Methylene blue	**BS EN ISO 10545-14**	Minimum Class B	Minimum Class B	Minimum Class B
	Potassium permanganate		Minimum Class B	Minimum Class B	Minimum Class B

Note: 1. For the tests marked with '*', test certificates or reports shall be issued by an accredited laboratory not more than 3 years ago.

2. The cleaning agent used is "Bathroom Magiclean" available in supermarkets.

Unglazed vitreous mosaic wall tiles

18.186 The quality tests for unglazed vitreous mosaic tiles shall be as follows:

(a) Dimensions and surface quality:

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			20 x 20, 50 x 50
BS EN 14411 classification			BIb
1. Length and Width	Deviation from Work Size (%)	**BS EN ISO 10545-2**	± 1.2
	Deviation from Average Size (%)		± 0.75
2. Thickness (%)			± 10
3. Minimum thickness (mm)		To be decided by the SO	4 (20 x 20)
			5 (50 x 50)
4. Straightness of sides (%)		**BS EN ISO 10545-2**	± 0.75
5. Rectangularity (%)			± 1.0
6. Surface flatness	Centre curvature (%)		± 1.0
	Edge curvature (%)		± 1.0
	Warpage (%)		± 1.0
7. Surface quality (%)free from visible defects that would impair the appearance of a major area of tiles			> = 95

(b) Physical properties:

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			20 x 20, 50 x 50
BS EN 14411 classification			BIb
1. *Water absorption (%)	Average	**BS EN ISO 10545-3**	0.5> & < = 3
	Individual		< = 3.3
2. *Modules of rupture (N/mm^2)	Average	**BS EN ISO 10545-4**	> = 30
	Individual		> = 27
3. *Scratch hardness of surface (Moh's Scale)		to be decided by the SO	> = 6
4. *Abrasion resistance	Deep abrasion (mm^2)	**BS EN ISO 10545-6**	< = 175
5. *Coefficient of linear thermal expansion ($x10^{-6}$ / °C)		**BS EN ISO 10545-8**	< = 9.0

Note: For the tests marked with '*', test certificates or reports shall be issued by an accredited laboratory not more than 3 years ago.

(c) Chemical properties:

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			20 x 20, 50 x 50
BS EN 14411 classification			BIb
1. *Resistance to acids and alkali	Sulphuric acid	**BS EN ISO 10545-13**	Required
	Lactic acid		Required
	Potassium hydroxide		Required
2. *Resistance to household chemicals	Ammonium chloride		Required
	Standard cleaning agent		Required
3. *Resistance to swimming pool salts	Sodium hypochlorite		Required
	Copper sulphate		Required

Note: For the tests marked with '*', test certificates or reports shall be issued by an accredited laboratory not more than 3 years ago.

Glass mosaic tiles **18.187** The quality tests for glass mosaic tiles shall be as follows:

(a) Dimensions and surface quality:

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			20 x 20
1. Length & Width	Deviation from Work Size (%)	**BS EN ISO 10545-2**	± 1.2
2. Thickness (%)			± 10
3. Minimum thickness (mm)		to be decided by the SO	4
4. Surface flatness	Centre curvature (%)	**BS EN ISO 10545-2**	± 1.0
	Edge curvature (%)		± 1.0
5. Surface quality (%) free from visible defects that would impair the appearance of a major area of tiles			> = 95

(b) Physical properties:

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			20 x 20
1. *Water absorption (%)	Average	**BS EN ISO 10545-3**	0.5< & < = 3
	Individual		< = 3.3
2 *Modules of rupture (N/mm^2)	Average	**BS EN ISO 10545-4**	> = 30
	individual		> = 27
3. *Scratch hardness of surface (Moh's Scale)		to be decided by the SO	> = 6
4. *Coefficient of linear thermal expansion ($x10^{-6}$ / °C)		**BS EN ISO 10545-8**	< = 9.0

Note: For the tests marked with '*', test certificates or reports shall be issued by an accredited laboratory not more than 3 years ago.

(c) Chemical properties:

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			20 x 20
1. *Resistance to acids and alkali	Sulphuric acid	**BS EN ISO 10545-13**	Required
	Lactic acid		Required
	Potassium hydroxide		Required
2. *Resistance to household chemicals	Ammonium chloride		Required
	Standard cleaning agent		Required
3. *Resistance to swimming pool salts	Sodium hypochlorite		Required
	Copper sulphate		Required

Note: For the tests marked with '*', test certificates or reports shall be issued by an accredited laboratory not more than 3 years ago.

Homogenous coved tile skirting

18.188 The quality tests for homogenous coved tile skirting shall be as follows:

(a) Dimensions and surface quality:

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			200 x 75 x 7
BS EN 14411 classification			BIb
1. Length & width	Deviation from Work Size (%)	**BS EN ISO 10545-2**	± 1.0
	Deviation from Average Size (%)		± 0.5
2. Thickness (%)			± 10(or to be decided by the SO)
3. Surface quality (%) free from visible defects that would impair the appearance of a major area of tiles			> = 95

(b) Physical properties:

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			200 x 75 x 7
BS EN 14411 classification			BIb
1. *Water absorption (%)	Average		0.5=< & < = 3
	Individual	**BS EN ISO 10545-3**	< = 3.3
2. *Scratch hardness of surface (Moh's Scale)		to be decided by the SO	> = 6
3. *Abrasion resistance	Deep abrasion (mm^3)	**BS EN ISO 10545-6**	< =175
4. Coefficient of linear thermal expansion ($x10^{-6}$ / °C)		**BS EN ISO 10545-8**	< = 9.0

Note: For the tests marked with '*', test certificates or reports shall be issued by an accredited laboratory not more than 3 years ago.

(c) Chemical properties:

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			200 x 75 x 7
BS EN 14411 classification			BIb
1.*Resistance to acids and alkali	Sulphuric acid	**BS EN ISO 10545-13**	Required
	Lactic acid		Required
	Potassium hydroxide		Required
2.*Resistance to household chemicals	Ammonium chloride		Required
	Standard cleaning agent		Required
3.*Resistance to swimming pool salts	Sodium hypochlorite		Required
	Copper sulphate		Required

Note: For the tests marked with '*', test certificates or reports shall be issued by an accredited laboratory not more than 3 years ago.

Homogenous wall tiles

18.189 The quality tests for homogenous wall tile shall be as follows:

(a) Dimensions and surface quality:

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			100 x 100
BS EN 14411 classification			BIb
1. Length & width	Deviation from Work Size (%)	**BS EN ISO 10545-2**	± 1.0
	Deviation from Average Size (%)		± 0.5
2. Thickness (%)			± 10
3. Straightness of sides (%)			± 0.5
4. Rectangularity (%)			± 0.6
5.Surface flatness	Centre curvature (%)		± 0.5
	Edge curvature (%)		± 0.5
	Warpage (%)		± 0.5
6.Surface quality (%) free from visible defects that would impair the appearance of a major area of tiles			= > 95

(b) Physical properties:

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			100 x 100
BS EN 14411 classification			BIb
1. *Water absorption (%)	Average	**BS EN ISO 10545-3**	0.5<= & < = 3
	Individual		< = 3.3
2. *Modules of rupture (N/mm^2)	Average	**BS EN ISO 10545-4**	> = 30
	Individual		> = 27
3. *Scratch hardness of surface (Moh's Scale)		to be decided by the SO	> = 6
4. *Abrasion resistance	Deep abrasion (mm^3)	**BS EN ISO 10545-6**	< = 175
5. *Coefficient of linear thermal expansion ($x10^{-6}$ / °C)		**BS EN ISO 10545-8**	< = 9.0

Note: For the tests marked with '*', test certificates or reports shall be issued by an accredited laboratory not more than 3 years ago.

(c) Chemical properties:

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			100 x 100
BS EN 14411 classification			BI
1. *Resistance to acids and alkali	Sulphuric acid	**BS EN ISO 10545-13**	Required
	Lactic acid		Required
	Potassium hydroxide		Required
2. *Resistance to household chemicals	Ammonium chloride		Required
	Standard cleaning agent		Required
3. *Resistance to swimming pool salts	Sodium hypochlorite		Required
	Copper sulphate		Required

Note: For the tests marked with '*', test certificates or reports shall be issued by an accredited laboratory not more than 3 years ago.

External facing tiles **18.190** The quality tests for external facing tiles shall be as follows:

(a) Dimensions and surface quality:

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			45 x 45 x 7 & 45 x 95 x 7
BS EN 14411 classification			BIb
1. Length and width	Deviation from Work Size (%)	**BS EN ISO 10545-2**	± 1.2
	Deviation from Average Size (%)		± 0.75
2. Thickness (%)			± 10
3. Straightness of sides (%)			± 0.75
4. Rectangularity (%)			± 1.0
5. Surface flatness	Centre curvature (%)		± 1.0
	Edge curvature (%)		± 1.0
	Warpage (%)		± 1.0
6. Surface quality (%) free from visible defects that would impair the appearance of a major area of tiles			= > 95

(b) Physical properties:

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			45 x 45 x 7 & 45 x 95 x 7
BS EN 14411 classification			BIb
1. *Water absorption (%)	Average	**BS EN ISO 10545-3**	0.5<= & < = 3
	Individual		< = 3.3
2. *Modules of rupture (N/mm^2)	Average	**BS EN ISO 10545-4**	> = 30
	Individual		> = 27
3. *Scratch hardness of surface (Moh's Scale)		to be decided by the SO	> = 5
4. *Abrasion resistance	Surface abrasion (Class1 – 4)	(PEI Method) **BS EN ISO 10545-7**	Minimum Class 3
5. *Coefficient of linear thermal expansion ($x10^6$ / °C)		**BS EN ISO 10545-8**	< = 9.0
6. *Crazing resistance		**BS EN ISO 10545-11**	Required

Note: For the tests marked with '*', test certificates or reports shall be issued by an accredited laboratory not more than 3 years ago.

(c) Chemical properties:

Test Items		Test Method	Acceptance Standards
Nominal Size (mm)			45 x 45 x 7 & 45 x 95 x 7
BS EN 14411 classification			BIb
1.*Resistance to acids and alkali	Hydrochloric acid	**BS EN ISO 10545-13**	Minimum Class B
	Citric acid		Minimum Class B
	Potassium hydroxide		Minimum Class B
2.*Resistance to household chemicals	Ammonium chloride		Minimum Class B
	Standard cleaning agent (See Note 2)		Minimum Class B
3.*Resistance to swimming pool salts	Sodium hypochlorite		Minimum Class B
	Copper sulphate		Minimum Class B
4.*Resistance to Staining	Methylene blue		Minimum Class 2
	Potassium permanganate (See Note 2)		Minimum Class 2

Note: 1. For the tests marked with '*', test certificates or reports shall be issued by an accredited laboratory not more than 3 years ago.

2. The cleaning agent used is "Bathroom Magiclean" available in supermarkets.

Tile adhesives **18.191** The quality tests for the approved tile adhesive shall be in accordance with **BS EN 12004-1**. Where cementitious tile adhesive is specified, the quality test for tensile strength shall be in accordance with **BS EN 12004-2**.

Tile grouting **18.192** The quality tests for tile grouting shall be as follows:

Test Items	Test Method	Acceptance Standards	Remarks
1. *Linear Shrinkage	ANSI A–108/A118/ A136.1-2011	1 day shrinkage < 0.1% 7 days shrinkage < 0.2%	Cast and store grout specimens at 21° - 25°C, 45 - 55% R.H.
2. *Water Absorption	ANSI A108/A13601-2011	From 50% R.H. to immersion < 5% From immersion to dry < 7%	Determine water absorption from 50% R.H. to immersion and from immersion to dry.
3. *Characteristics of cementations adhesive	**BS EN 12004-2**	≥=0.5N/mm^2	cl. 8.3.3.2 initial tensile adhesion strength cl. 8.3.3.3 Tensile adhesion strength after water immersion
	BS EN 12004-2	≥=0.5N/mm^2	Open time: Tensile adhesion strength
4. *Resistance to Mould Growth	To be decided by the SO	No sign or evidence of mould growth on tile grout.	3 mm thick tile grout is applied over biscuit side of test piece tile and the assembly be placed in Petri dishes for incubation at 29° ± 1°C for 24 hrs after addition of potato dextrose agar. Aspergillus niger is inoculated into the grout. The whole assemble is incubated for 14 days at 29° ± 1°C.

Note: For the tests marked with '*', test certificates or reports shall be issued by an accredited laboratory not more than 3 years ago.

SURVEILLANCE TESTS FOR TILE ADHESIVES AND TILE GROUTING

Laboratory tests by approved laboratory **18.193**

(a) Employ an approved laboratory to carry out the following tests at the Contractor's own expense:

(i) Quality tests for every 60 tonnes of tile adhesive delivered to Site or as instructed by the SO;

(ii) On site pull off test on samples selected from the tile finished wall as instructed by the SO.

(b) Provide attendance on the Site, deliver and collect samples etc. as directed by the SO or as specified;

(c) Sample for tests shall be selected by the SO.

Non compliance **18.194**

(a) Where any of the specimens for each sample fails to meet the testing requirements of quality tests as specified, all materials manufactured on the same day shall be removed off the Site;

(b) Bear all costs of such further tests and rectification works and no extension of time shall be allowed;

(c) Where any of the specimens for each sample selected from the tile finished wall for the on the Site pull off test fails to meet the acceptance standards, remove and rectify all the tiles and tile adhesive used on the same floor.

ON SITE DELIVERY CHECK

Non-slip homogenous floor tiles **18.195**

(a) When instructed by the SO, provide all necessary and calibrated equipment and carry out the following tests for non-slip homogenous floor tiles upon delivery on the Site in the presence of the SO's representatives:

Test Items	Test Method	Acceptance Standards
1. Dimension Check	By measurement	
2. Surface Quality Check	Visual	No discolouration, no damage, no staining, no blemish, acceptable colour consistency
3. Check Identification Mark	Visual	Same as the SO's Approved sample

In case of doubtful results, carry out laboratory tests for confirmation;

(b) Sampling frequency for the above tests for non-slip homogenous floor tiles upon delivery on the Site shall be as follows:

Test Items	Sampling Frequency	Representative Consignment
1. Dimension Check	3 samples for each delivery per each type	One delivery per each type
2. Surface Quality Check	3 samples for each delivery per each type	One delivery per each type
3. Check Identification Mark	3 samples for each delivery per each type	One delivery per each type

(c) In the event of samples fail to meet the requirements for test upon delivery on the Site, remove the representative consignment off the Site.

Glazed ceramic wall tiles **18.196**

(a) When instructed by the SO, provide all necessary and calibrated equipment and carry out the following tests for glazed ceramic wall tiles upon delivery on the Site in the presence of the SO's representatives:

Test Items	Test Method	Acceptance Standards
1. Dimension Check	By measurement	
2. Surface Quality Check	Visual	No discolouration, no damage, no staining, no blemish, acceptable colour consistency
3. Check Identification Mark	Visual	Same as the SO's Approved sample

In case of doubtful results, carry out laboratory tests for confirmation;

(b) Sampling frequency for the above tests for glazed ceramic wall tiles upon delivery on the Site shall be as follows:

Test Items	Sampling Frequency	Representative Consignment
1. Dimension Check	3 samples for each delivery per each type	One delivery per each type
2. Surface Quality Check	3 samples for each delivery per each type	One delivery per each type
3. Check Identification Mark	3 samples for each delivery per each type	One delivery per each type

(c) In the event of samples fail to meet the requirements for test upon delivery on the Site, remove the representative consignment off the Site.

Unglazed vitreous mosaic wall tiles **18.197**

(a) When instructed by the SO, provide all necessary and calibrated equipment and carry out the following tests for unglazed vitreous mosaic tiles upon delivery on the Site in the presence of the SO's representatives:

Test Items	Test Method	Acceptance Standards
1. Dimension Check	By measurement	
2. Surface Quality Check	Visual	No discolouration, no damage, no staining, no blemish, acceptable colour consistency
3. Check Identification Mark	Visual	Same as the SO's Approved sample

In case of doubtful results, carry out laboratory tests for confirmation;

(b) Sampling frequency for the above tests for unglazed vitreous mosaic tiles upon delivery on the Site shall be as follows:

Test Items	Sampling Frequency	Representative Consignment
1. Dimension Check	3 samples for each delivery per each type	One delivery per each type
2. Surface Quality Check	3 samples for each delivery per each type	One delivery per each type
3. Check Identification Mark	3 samples for each delivery per each type	One delivery per each type

(c) In the event of samples failing to meet the requirements for test upon delivery on the Site, remove the representative consignment off the Site.

Glass mosaic tiles **18.198**

(a) When instructed by the SO, provide all necessary and calibrated equipment and carry out the following tests for glass mosaic tiles upon delivery on the Site in the presence of the SO's representatives:

Test Items	Test Method	Acceptance Standards
1. Dimension Check	By measurement	
2. Surface Quality Check	Visual	No discolouration, no damage, no staining, no blemish, acceptable colour consistency
3. Check Identification Mark	Visual	Same as the SO's Approved sample

In case of doubtful results, carry out laboratory tests for confirmation;

(b) Sampling frequency for the above tests for glass mosaic tiles upon delivery on the Site shall be as follows:

Test Items	Sampling Frequency	Representative Consignment
1. Dimension Check	3 samples for each delivery per each type	One delivery per each type
2. Surface Quality Check	3 samples for each delivery per each type	One delivery per each type
3. Check Identification Mark	3 samples for each delivery per each type	One delivery per each type

(c) In the event of samples fail to meet the requirements for test upon delivery on the Site, remove the representative consignment off the Site.

Homogenous coved tile skirting **18.199**

(a) When instructed by the SO, provide all necessary and calibrated equipment and carry out the following tests for homogenous coved tile skirting upon delivery on the Site in the presence of the SO's representatives:

Test Items	Test Method	Acceptance Standards
1. Dimension Check	By measurement	
2. Surface Quality Check	Visual	No discolouration, no damage, no staining, no blemish, acceptable colour consistency
3. Check Identification Mark	Visual	Same as the SO's Approved sample

In case of doubtful results, carry out laboratory tests for confirmation;

(b) Sampling frequency for the above tests for homogenous coved tile skirting upon delivery on the Site shall be as follows:

Test Items	Sampling Frequency	Representative Consignment
1. Dimension Check	3 samples for each delivery per each type	One delivery per each type
2. Surface Quality Check	3 samples for each delivery per each type	One delivery per each type
3. Check Identification Mark	3 samples for each delivery per each type	One delivery per each type

(c) In the event of samples fail to meet the requirements for test upon delivery on the Site, remove the representative consignment off the Site.

Homogenous wall tiles **18.200**

(a) When instructed by the SO, provide all necessary and calibrated equipment and carry out the following tests for homogenous wall tiles upon delivery on the Site in the presence of the SO's representatives:

Test Items	Test Method	Acceptance Standards
1. Dimension Check	By measurement	
2. Surface Quality Check	Visual	No discolouration, no damage, no staining, no blemish, acceptable colour consistency
3. Check Identification Mark	Visual	Same as the SO's Approved sample

In case of doubtful results, carry out laboratory tests for confirmation;

(b) Sampling frequency for the above tests for homogenous wall tiles upon delivery on the Site shall be as follows:

Test Items	Sampling Frequency	Representative Consignment
1. Dimension Check	3 samples for each delivery per each type	One delivery per each type
2. Surface Quality Check	3 samples for each delivery per each type	One delivery per each type
3. Check Identification Mark	3 samples for each delivery per each type	One delivery per each type

(c) In the event of samples fail to meet the requirements for test upon delivery on the Site, remove the representative consignment off the Site.

External facing tiles 18.201

(a) When instructed by the SO, provide all necessary and calibrated equipment and carry out the following tests for external facing tiles upon delivery on the Site in the presence of the SO's representatives:

Test Items	Test Method	Acceptance Standards
1. Dimension Check	By measurement	
2. Surface Quality Check	Visual	No discolouration, no damage, no staining, no blemish, acceptable colour consistency
3. Check Identification Mark	Visual	Same as the SO's Approved sample

In case of doubtful results, carry out laboratory tests for confirmation;

(b) Sampling frequency for the above tests for external facing tiles upon delivery on the Site shall be as follows:

Test Items	Sampling Frequency	Representative Consignment
1. Dimension Check	3 samples for each delivery per each type	One delivery per each type
2. Surface Quality Check	3 samples for each delivery per each type	One delivery per each type
3. Check Identification Mark	3 samples for each delivery per each type	One delivery per each type

(c) In the event of samples fail to meet the requirements for test upon delivery on the Site, remove the representative consignment off the Site.

Tile adhesives **18.202** (a) When instructed by the SO, carry out the following checks for tile adhesive upon delivery on the Site in the presence of the SO's representatives:

Test Items	Test Method	Acceptance Standards
1. Manufacturer's Certificate of Origin & Delivery Note	Document Check	From an Approved origin with information of product identification numbers
2. Product Identification Number	Document Check	As Approved
3. Expiry Date	Check information printed on the packing	Not expired

(b) In the event of the checking results fail to meet the checking requirements upon delivery on the Site, remove the failed consignment off the Site.

Tile grouting **18.203** (a) When instructed by SO, carry out the following checks for tile grouting upon delivery on the Site in the presence of SO's representatives:

Test Items	Test Method	Acceptance Standards
1. Manufacturer's Certificate of Origin & Delivery Note	Document Check	From an Approved origin with information of product identification numbers
2. Product Identification Number	Document Check	As Approved
3. Expiry Date	Check information printed on the packing	Not expired

(b) In the event of the checking results fail to meet the checking requirements upon delivery on the Site, remove the failed consignment off the Site.

SEALING UP VOIDS WHERE PIPES PASS THROUGH FIRE RATED WALLS AND FLOORS

Fire separation seal **18.204** Sealing system shall be applied as specified in Clause 19.18 to properly seal up the voids formed where pipes, ducts, cables and wires, etc. pass through fire rated walls or floors.

SECTION 19

SANITARY APPLIANCES

GENERAL

Generally **19.1** All plumbing work shall be in compliance with the Water Authority's requirements and Waterworks Regulations.

The water usage for all products shall meet the Grade 1 water efficiency rating for Showers for Bathing, Water Taps, Water Closets, Urinal Equipment and Flow Controllers of the Voluntary Water Efficiency Labelling Scheme (WELS) of the Water Supplies Department, unless otherwise specified, or product with other water efficiency ratings is required to meet particular functional purpose as approved by the SO / as specified in the Particular Specification.

All products shall not contain heavy metals like lead, cadmium, mercury or hexavalent chromium and organically bound halogens.

Scope of Work **19.2** This Section covers all sanitary appliances supplied by the Contractor and the installation of all sanitary appliances, including those supplied by the Employer.

This part of the GS shall be read in conjunction with the **General Specification for Building Services Installation in Government Buildings of the Hong Kong Special Administrative Region** published by the Architectural Services Department, HKSAR.

MATERIALS

Generally **19.3** Inspect pipes and fittings inside and out before fixing. Reject any which are defective.

Certain standard sanitary appliances may be supplied by the Employer, as scheduled on the drawings. These may include brackets, waste fittings, traps, taps, valves, chains and plugs & all fittings which relate to fixtures.

Provide all other sanitary appliances as specified. Submit samples of all sanitary fittings for approval.

(a) All sanitary fittings unless specified otherwise shall be white, from an approved manufacturer, generally ensuite and complete with all necessary fittings.

(b) Wastes, outlets and overflows to **BS EN 274,** exposed surfaces shall be either chromium plated or other non-chromium plated alternatives subject to approval by the SO. Cr-Ni coating shall comply with **BS EN 248**.

(c) Taps and combination tap assemblies to **BS EN 200,** exposed surfaces shall be either chromium plated or other non-chromium plated alternatives subject to approval by the SO. Cr-Ni coating shall comply with **BS EN 248**.

Baths **19.4** Baths shall be vitreous enamelled sheet steel to **BS 1390** with adjustable feet for 75 mm seal trap holed at end for and including combined waste and overflow to **BS EN 274** complete with plug and chain if applicable and chromium plated brass taps to **BS EN 200**.

Shower trays **19.5** Shower trays shall be prefabricated to **BS EN 251** and **BS EN 14527+A1** made from glazed ceramic or resin-stone with solid surface. Any solid surface shall comply with **BS EN ISO 19712-1, BS EN ISO 19712-2 & BS EN ISO 19712-3.**

Shower fittings **19.6**

Shower fittings shall be either chromium plated brass or other non-chromium plated alternatives subject to approval by the SO, and approved easy clean valve, thermostatic valve or as specified fitted with one of the following:

(a) Concealed or exposed shower fittings for lever with flexible hose 1500 to 1800 mm long c/w chrome plated sliding bar and head.

(b) Time-delayed control for adjust 15 – 30 seconds cold or mixer.

(c) Self-cleansing swivel-jointed rose with an adjustable spray.

The nominal flow rate of the shower shall be less than or equal to 9 L/min. Cr-Ni coating shall comply with **BS EN 248**.

Taps **19.7**

Taps shall be:

(a) Operating pressure for sensor tap shall be between 0.3 – 10 bar. Max. water temp. 80°C. Aerator. Self-cleaning. Turn-off control pre-set 0 – 3 seconds.

(b) Sensor mixer or cold.

(c) Self-closing tap for time delay function.

(d) Bib tap.

The nominal flow rate shall be less than or equal to 2 L/min for non-mixing type water taps and shall be less than or equal to 5 L/min for mixing type water taps. Alternatively, mixing type water taps with nominal flow rate less than 7 L/min to match the minimum flow of connected appliance shall also be accepted subject to approval by the SO.

Ceramic wash basins **19.8**

Ceramic wash basins shall be to **BS 1188** and shall be made from vitreous china to **BS 3402** of the following types as specified:

(a) Under counter basin with overflow.

(b) Wall hung basin with or without pedestal as specified.

(c) Semi-recessed basin with or without overflow as specified.

(d) Counter top basin with or without overflow as specified.

Solid surfacing wash basins **19.8A**

Solid surfacing wash basin shall comply with **BS ISO 19712-1, BS ISO 19712-2 & BS ISO 19712-3** with drain, with or without overflow as specified and to size and configuration shown on the drawings.

Kitchen sinks **19.9**

Sinks shall be to **BS EN 695** and **BS EN 13310+A1** and to the size and configuration shown on the drawings with overflow and sound deadening pads under the sink and drainers.

Sinks shall be provided with an effective means of attaching a bonding conductor which shall be accessible to the electrician after the sink has been installed.

Stainless steel sinks **19.9A**

All sinks, shall be fabricated of not less than 1.6 mm polished stainless steel except hand basins of at least 1.2 mm, with stainless steel grade 316, and of the size and design as specified.

Solid surfacing sinks **19.9B**

Solid surface shall comply with **BS ISO 19712-1**, **BS ISO 19712-2 & BS EN ISO 19712-3.**

Cleaner's sinks **19.10**

Fireclay cleaner's sink shall conform to **BS 1206** in white colour. Fireclay with a 38 mm hole for chrome plated waste. To be provided with or without overflow as specified.

Close-coupled suits, one piece and independent W.C.s **19.11**

Close-coupled suites, one-piece and independent W.C. pans with integral trap shall be vitreous china to **BS 3402** and with horizontal outlet to **BS EN 997**, white plastic single ring seat and cover with plastic fixing bolts all to **BS 1254**.

Squat type W.C **19.11A**

Vitreous china Squat type W.C. pans to Singapore Standard **SS 379**.

Flushing cistern **19.11B**

The toilet should be dual-flush type, and the maximum flushing-water volume should be less than or equal to 3.2 L per reduced flush and less than or equal to 4.8 L per full flush**,** complete with flushing apparatus, discharge pipe, ball valve and overflow, of one of the following types as specified:

(a) Low level plastic.

(b) High level plastic.

(c) Low level vitreous china.

(d) Close coupled vitreous china.

Sensor valve where specified for automatic flushing shall be copper alloy bronze (gunmetal) or other materials approved by the SO. Operating pressure shall be 0.5 – 10 bar rinse. Time-off control approx. 10 seconds and remote adjust from 1.5 – 30 seconds. The sensor shall either be operated by 6 V Lithium battery or 220 V AC power step down to 6 V.

Sensor fittings shall be suitable for use in salt water application.

Urinals **19.12**

Wall hung urinals shall be to **BS EN 13407+A1**. Vitreous china bowl type to **BS 5520** with 50 mm diameter of waste outlet, complete with vitreous china automatic flushing cistern to **BS 1876** or automatic flushing sensor valve, chromium plated flush pipes and spreaders to suit the number of appliances. The flush volume of urinal and trough urinal shall be less than or equal to 1.5 L for every basin or stall, and every 0.5 m of a trough urinal respectively.

Sensor valve shall be copper alloy bronze (gunmetal) or other materials approved by the SO. Operating pressure shall be 0.3 – 10 bar rinse. Time-off control approx. 9 seconds and remote adjust from 7 - 22 seconds. The sensor shall either be operated by 6 V Lithium battery or 22 0V AC power step down to 6 V.

Sensor fittings shall be suitable for use in salt water application.

Glazed ceramic slab urinal **19.13**

Glazed ceramic slab urinal shall be fireclay or vitreous china in white colour to the size and configuration shown on the drawings and comply with **Building (Standards of Sanitary Fitments, Plumbing, Drainage Works and Latrines) Regulations 16**. The length of urinal slab shall be as approved by the SO.

Fireclay and vitreous china are defined in Clauses A2.2 and A2.1 of Annex A, **BS EN 14516+A1** respectively. Vitreous china shall be to **BS 3402**.

Stainless steel slab urinal **19.14**

Stainless steel slab urinal shall be to **BS 4880-1** grade 316 as specified in Clause 17.9, 1.5 to 1.6 mm thick, with satin finish to the size configuration shown on the drawing with sound deadening pads behind the slab, and comply with **Building (Standards of Sanitary Fitments, Plumbing, Drainage Works and Latrines) Regulations 16**. Custom made size slab urinal may be straight, L-shaped or U-shaped as shown on the drawings with joints and length of the slab as approved by the SO.

Storage **19.15**

Store appliances under cover and keep dry. Separate with dust sheets or polythene sheets when not in manufacturer's own packing.

Store all metal sinks etc. on a level surface to prevent twisting. Prevent contact with cement or lime.

Traps **19.16** Traps shall have 80 mm seal, unless otherwise specified.

Cast iron traps shall be to **BS EN 274**.

Plastic waste traps shall be to **BS EN 274-1**, **274-2 and BS EN 274-3** or to be of an approved proprietary brand.

Silicone sealant **19.17** Silicone sealants shall be to **BS EN ISO 11600+A1.**

Type F Class 25 in white colour or to match sanitary fixtures and to **BS EN ISO 846**.

All sealants shall comply with VOC content limit stipulated in the **Air Pollutions Control (VOC) Regulation of Hong Kong** and shall not contain the following substances regulated in the Montreal Protocol on Substances that Deplete the Ozone Layer (particularly CFCs, HCFCs, 1,1,1-trichloroethane and carbon tetrachloride). The products shall contain no more than 0.01% by wet weight of formaldehyde and no more than 0.5% by wet weight of the sum total of aromatic compounds, which include benzene, toluene, xylenes, and ethylbenzene.

WORKMANSHIP

Fixing generally **19.18** Provide all necessary jointing compound, mortar, lead plugs and other accessory materials. Cut and pin, or plug and screw brackets, and make all necessary connections to water supply services, overflows, wastes and ventilating pipes.

All sanitary appliances shall be adequately supported when being fixed. Where build-in types of brackets are used, the tails of such supports shall be built into the wall at least 75 mm and where wall fixing types are used, the wall finish shall have been arranged to make provision for them.

All fittings shall be pointed as necessary with the following:

(a) White or coloured cement.

(b) White or coloured silicone sealant. All fittings shall be de-greased and dried before the application of sealant.

Install discharge pipes and water supply pipes before fixing the appliances.

Retain protective coverings during and after fixing when practicable and clean off when required.

Replace any appliances which are chipped or scratched either before or after fixing.

Waste outlets **19.19** Bed waste outlets to wash basins, sinks, baths and showers in proprietary jointing compound.

Fixing taps **19.20** Fix taps to make a water tight seal with the sanitary appliance. Place hot tap to left of cold tap as viewed by the user. Ensure that Hot/Cold markings are correctly applied and located.

Connections **19.21** Provide connectors for service and waste pipes.

Fixing wash basins **19.22** Wash basins shall be supported on approved proprietary brackets to suit the basins or counter top as shown on drawings or manufacturer's details.

Water tight seal between the walls and the basins shall be made by using silicone sealant.

Fixing W.C. pans **19.23** Fix W.C. pans as follows:

(a) Pedestal type

(i) Bed W.C. pans on concrete floors in other non-hardening compound. If cement mortar is used for bedding, it shall be not richer than 1:6, and a thin layer shall be applied only to that part of the pedestal which is in contact with the floor. Fix with No. 14 SG round-headed brass screws 70 mm long with domed plastic inserts in colour to match to fixture.

(ii) Joint W.C. pans to soil or drain pipes with approved PVC W.C. pan connectors to **BS 5627** or other approved type.

(b) Squatting type

(i) Bed W.C. pans in concrete floors in cement and sand mortar 1:3 and joint to soil or drain pipes in similar mortar.

(c) Wall hung type

(i) Fix wall hung type WC pans to load bearing walls or support frame by non-ferrous fixing bolts. Water tight seal between the walls and the edge of the W.C. pans shall be made by appropriate sealant.

Fixing urinals **19.24** Fix urinals as follows:

(a) Slab type

(i) Bed channel outlet to waste connector in proprietary jointing compound.

(ii) Bed treads in cement and sand mortar 1:3 with fall towards channel.

(iii) Completely fill space behind slabs with cement and sand mortar 1:5.

(iv) Joints shall be 3 mm (maximum) wide. Rake out joints to a depth of 5 mm and point flush with an approved proprietary white grout.

(b) Stall type

(i) Bed outlet to waste connector in proprietary jointing compound.

(ii) Bed base and overlap facing in cement and sand mortar 1:3.

(c) Wall type

(i) Fix bowl and division to wall with brackets, concealed hangers or screws, as required.

Fixing baths **19.25** Supports for the bath shall be adjustable to permit the bath to be properly levelled when installed. Bearing plates shall be provided under bath feet. A permanent watertight seal between the wall and the edge of the bath shall be made by using silicone sealant. Ensure that all bath surfaces are properly protected up to completion stage.

SECTION 20

GLAZING

Generally **20.1** This section is predominantly intended for glazing in doors and windows and should therefore be read in conjunction with Section 16 when curtain walls and window walls are the subject of the glazing requirement.

Ordinances, Regulations, Codes and standards **20.1A** Comply with the Ordinances, Regulations, Codes of Practice, Standards and PNAPs relevant for Curtain Walls and Glazing under Section 16 and Section 20. All Standards and Codes of Practice are to be the latest issue. If there is any conflict between the standards and codes listed, the more onerous is to apply.

MATERIALS

Glass generally **20.2** Glass generally shall be in accordance with **BS 952-1, BS 952-2** or **ASTM C1036**.

Glass shall be from a manufacturer with quality assurance systems covering all aspects from manufacturing, testing and inspection. For each batch of glass supplied to site, submit a certificate from the glass manufacturer confirming compliance with the requirements detailed in this Specification.

Glass functioning as protective barrier shall be subjected to impact test by the glass manufacturer to satisfy Class 1 requirement in accordance with **BS EN 12600** without glass breakage. For laminated glass of different pane thickness or insulating glass unit of different types of glass panes, impact test shall be carried out on both faces unless the risk of impact is from one side only.

The thermal capacity of the window glass / curtain wall for the room provided with air conditioning system shall not exceed the heat transfer coefficient (U-value) of 1.4 W/m^2K except the school building.

The product components (including frame, glass, paint, surface treatment, etc.) shall not be formulated with the following substances or their compounds:

(a) Arsenic
(b) Cadmium
(c) Hexavalent chromium
(d) Lead
(e) Mercury
(f) Organic tin
(g) Phthalates

Tempered & laminated glass **20.2A** Tempered and laminated glass shall conform to the relevant safety class requirements of **BS 6262-4** and shall be determined by testing to **BS EN 12600** although tests in accordance with **ANSI Z97.1** are acceptable.

Edge quality **20.2B** Edge quality finish for all glass, irrespective of heat treatment, is important. Heat treated glass may be rejected, and annealed glass will be rejected, if it does not conform to the following criteria:

(a) Shark teeth shall not penetrate more than half of glass thickness.

(b) Serration hackle may occur only within 150 mm of corners.

(c) Flare shall not exceed 1.0 mm as measured perpendicular to glass surface across the edge. Flare shall not occur at setting blocks.

(d) Bevel shall not exceed 1.6 mm.

(e) Flake chips may occur only within 200 mm of corners; depth shall not exceed 0.8 mm and length or diameter shall not exceed 6.0 mm.

(f) Rough chips shall not be permitted. Rough chips shall be those which exceed any of the dimensional limits for flake chips.

(g) Shells on the face of the glass are not permitted on annealed glass and are only acceptable for heat treated glass if they were present prior to heat treatment and are covered by a glazing bead or glass stop. They are not permitted for glass that will be structurally glazed with silicone.

Insulating glass **20.2C**

(a) Insulating glass shall have double edge seals. Primary seal shall be extruded polyisobutylene continuously bonded to glass surfaces and desiccant filled metal spacer, including corners. Minimum width of primary seal shall be 3.0 mm. Secondary seal shall be a 2 part neutral cure structural sealant. Secondary seal shall completely cover spacer with no gaps or voids, and shall be continuously bonded to both plates of glass. Tin side of the glass panes shall be located on the outermost surfaces of insulating glass units for future surface stress measurement. Submit the following quality documents produced by the glass manufacturer:

(i) Details of insulating glass units, including construction details, primary and secondary seals, gas filling, corner treatment, nature of spacers, evacuation and assembly process provided by the glass manufacturer.

(ii) Test report/certificate indicating compliance with **ASTM E2190** with respect to specification and seal durability for insulating glass units.

(b) Where non-pyrolytic Low-E coatings are used, edge deletion of the coating is required unless specifically stated as not being required by the glass manufacturer.

Flatness **20.2D**

In addition to conforming to **BS 952-1, BS 952-2** and **ASTM C1048**, monolithic heat strengthened and tempered glass shall conform to the following flatness tolerances:

(a) Bow and warp have the same meaning. They are both defined as deviation of a glass surface from a true plane, with the glass free-standing or installed in a frame and positioned in a vertical plane.

(b) Localized bow refers to any straight line segment with a length of 300 mm on a glass surface.

(c) Overall bow refers to any straight line segment on a glass surface which extends between opposite edges across the smaller glass dimension and is perpendicular to at least one edge. The length of the line segment is the gauge length.

(d) Localized bow shall not exceed 1.6 mm.

(e) Overall bow shall not exceed: 1.0 mm per 300 mm for gauge length in the range zero to 1 m; 0.75 mm per 300 mm for gauge length in the range 1 m to 2.40 m; one half of the values listed in **ASTM C1048**, Table 2 for gauge lengths exceeding 2.40 m.

(f) Where heat treating results in essentially parallel ripples or waves, the maximum peak-to-valley deviation shall not exceed 0.127 mm. Requirements for localized bow and overall bow shall also be satisfied. Direction of ripples shall be consistent throughout the building and approved by the SO.

(g) The specified bow and ripple tolerances are intended as manufacturing quality control limits.

Inclusions in tempered glass **20.2E** Tempered glass shall be subject to quality control measures (i.e. heat soaking) to minimize inclusions that could result in spontaneous breakage. Such inclusions are defined as a material defect by this specification. Installed tempered glass which experiences spontaneous breakage shall be replaced (material and labour) under the warranty provisions.

Plastic films **20.2F** Plastic films used to opacify glass shall conform to the following requirements:

(a) Minimum nominal thickness of polyester shall be 0.08 mm. Film shall be pigmented and have a black colour unless otherwise stated.

(b) The bonding surface shall be completely coated with a solvent based adhesive.

(c) Monolithic opacified glass shall have a safety backing for fallout resistance.

Vision glass **20.2G** Vision glass shall be as specified in the Particular Specification.

Spandrel glass **20.2H** Spandrel glass shall be as specified in the Particular Specification.

Criteria for glass **20.2I** Performance requirements for glass shall be as follows:

(a) Structural design of glass shall be in accordance with the **Code of Practice for Structural Use of Glass** including its latest amendments and revisions issued by the Buildings Department.

(b) Provide heat strengthened glass where annealed glass would be vulnerable to thermal breakage.

Glass replacement **20.2J** Glazing details shall permit glass replacement after initial construction, shall permit reuse of original gaskets, shall permit replacement glass of the same nominal size as original glass, and shall not require cutting of framing members or removal of interior finishes. Vision glass in conventional frames shall be replaceable from the interior. Spandrel glass shall be replaceable from the exterior. Silicone supported vision glass shall be replaceable from the exterior and/or interior.

Glazing materials **20.2K** The minimum service life of all gaskets, weather stripping and other glazing accessories shall be 15 years. Gaskets and weather-strips, except at structural sealant glazing shall, as a minimum, conform to **BS 6262** except:

(a) Sponge gaskets shall be extruded black neoprene with a hardness of 40 +5/-4 durometer Shore A and conforming to **ASTM C509**. Design sponge gaskets to provide 20% to 35% compression. Sponge gaskets are only to be used as gap fillers and must not be used where the performance relies on compression resistance.

(b) Dense gaskets shall normally be black extrusions with a Shore A hardness of 70 +5/-4 for hollow profiles and 60 +5/-4 for solid profiles, and conforming to **ASTM C864** or **BS 4255-1**. Outdoor and indoor gaskets shall be silicone, EPDM, neoprene or a Thermoplastic Elastomer (TPE). However TPE gaskets are not permitted to be used where their performance is dependent upon compression resistance. Where the colour of the gasket is other than black, only heat cured silicone rubber is to be used.

(c) Where compatible with the installation procedures, all corners are to be vulcanized by transfer/injection moulding.

(d) Interior and exterior gasket profiles shall be designed to produce a glass edge pressure of not less than 0.70 N/mm, nor more than 1.75 N/mm.

Gaskets at structural sealant **20.2L** Gaskets at structural sealant glazing shall be as follows:

(a) Glazing gaskets, sealant backers within glazing pockets and continuous glass spacer pads at structural sealant shall be black heat cured silicone rubber.

(b) Notwithstanding these requirements, in recognition of the reliance on the resistance to compression for the performance of gaskets, the maximum in service compression set is limited to 25% over a time period equivalent to 1.15 times the design life of the building.

(c) Gaskets which maintain glass face clearance while serving as a backer for a silicone weather seal may have a friction fit. All other gaskets and weather strips, including backers for structural sealant, shall have a continuous spline or a continuous groove which engages a matching groove or leg on the aluminium frame.

(d) Double sided tape is acceptable as a glass spacer pad when used in conjunction with structural sealant, subject to verification of compatibility.

Thickness & weights of glass **20.2M** Thickness and weights shall be as in Table 20.1

TABLE 20.1
Thickness and Weights of Glass

Nominal thickness (mm)	Approximate weight (kg/m^2)		Minimum weight (kg/m^2)		
	Sheet	Float	Cast	Polished Wired	Cast or Figure Rolled
3	7.5	7.5	-	-	6.0
4	10.0	10.0	-	-	7.5
5	12.5	12.5	-	-	9.5
6	15.0	15.0	17	15.9	11.5
10	-	25.0	-	-	21.5
12	-	30.0	-	-	-

Glass to be of accurate size, with clean undamaged edges and surfaces which are not disfigured. In addition, the glass thickness shall comply with manufacturing specification and shall not be less than the minimum thickness adopted in design calculation.

Applied films **20.2N** Post applied films can constitute a risk to the integrity of the glass, either from a risk of increasing thermal stress or by damage caused to the glass during the application of the film. Therefore no post applied application of adhesive film, whether of solar control, security or decoration is permitted without the express written permission of the glass manufacturer.

Float glass **20.3** Unless otherwise specified glass shall be considered as clear float annealed glass of a minimum Q3 quality in accordance with **ASTM C1036** or **BS EN 572-2**.

Sheet glass **20.4** Unless specifically requested and confirmed in writing drawn sheet glass is not permitted to be used. Clear sheet glass shall be drawn of ordinary quality for glazing where it is permitted to be used.

Translucent & obscured glass **20.5**

Translucent glass is considered as having:

(a) For monolithic glass
An acid etch or a sand blasted pattern or complete coverage on part or on the entire face of the glass.

(b) For laminated glass
A coloured sheet or gel as part of the interlayer makeup that provides a reduction in transparency.

Obscured glass is considered as being cast or rolled such that a raised pattern is formed that provides a reduction in the transparency of the glass. This pattern is an integral part of the glass.

Fire rated glass **20.6**

Wired and other specialist glasses must have been successfully tested in accordance with the relevant clauses of **BS 476**.

(a) Wired cast glass and wired polished glass shall have a square mesh wire 13 mm square electrically welded at each intersection that is embedded into the glass to a depth equivalent to half the glass thickness.

(b) Wired glass is not considered a safety glass and can only be used in a non-fire rated installation with express permission.

(c) Non-insulating fire rated glass, other than wired soda lime glass should be borosilicate glass.

(d) Insulating fire rated glass can be of any composition if the relevant fire certificate can be provided.

Mirror glass **20.7**

Mirror glass shall be selected float glass suitable for silvering and a minimum Q2 quality in accordance with **ASTM C1036**.

Mirrors shall have square or bevelled edges. Exposed edges are to be ground or polished smooth with an arrised edge.

Heat strengthened glass **20.8**

(a) Heat strengthened glass shall be glass that has been heat treated to give increased strength, in accordance with the requirements of **ASTM C1048**, to approximately twice the strength and impact resistance of untreated float glass. Heat strengthened glass shall be manufactured by a factory with ISO 9001 quality assurance certification.

(b) To be defined as Heat Strengthened glass, the residual surface compression must be between 24 and 52 MPa. Submit the glass manufacturer's quality control record on measurement of surface compressive stress by Grazing Angle Surface Polarimeter (GASP) with valid calibration certification in accordance with **ASTM C1279**.

(c) Glass with a surface compression in excess of 45 MPa is to be subjected to heat soak testing in accordance with the relevant procedures set out in **BS EN 14179-1**. Submit the compliance certificate for the glass delivered to site. The compliance certificate should include the following information:

(i) Identification of the batch;

(ii) Quantity and configuration of thermocouples used to measure the glass surface temperatures in the oven;

(iii) Graphs of the heat soak process cycle associated with each of the thermocouples indicating the glass surface temperatures at representative glass locations and time duration of the heating phase, holding phase and cooling phase of the process;

(iv) Name of the glass manufacturer;

(v) Location and identification number of the oven;

(vi) Calibration report of the oven;

(vii) Date of carrying out the heat soaking process;

(viii) Quantity and size of glass subject to the heat soaking process and records of breakages of panels in the tests with corresponding oven numbers; and

(ix) Minimum dimension of glass separation in the oven.

(d) Heat strengthened glass is not to be considered a safety glass.

Fully tempered glass **20.9**

(a) Fully tempered glass shall be glass that has been heat treated to give increased strength, in accordance with the requirements of **ASTM C1048**, to approximately four times the strength and impact resistance of untreated float glass. Fully tempered glass shall be manufactured by a factory with ISO 9001 quality assurance certification.

(b) To be defined as Fully Tempered glass, the residual surface compression must be a minimum of 69 MPa, however it is recommended that the glass supplied as fully tempered has a minimum of 75 MPa. The manufacturer's quality control records during glass production shall include the following:

(i) Measurement of surface compressive stress by GASP with valid calibration certification in accordance with **ASTM C1279**.

(ii) Fragmentation test carried out to each batch of tempered glass in accordance with **BS EN 14179-1** after the heat soak treatment.

(c) It must also be noted that heat soak testing in accordance with **APP-37**, **APP-53** and **APP-110** where applicable to the satisfaction of the SO, which is based upon the methodology of **BS EN 14179-1**, must be undertaken for glass supplied as fully tempered. Therefore, it is to be subjected to heat soak testing in accordance with the relevant procedures set out in **BS EN 14179-1**. The Contractor shall submit for approval the following items:

(i) A quality supervision plan for the quality supervision of manufacturer's heat soak process of the tempered glass to be used.

(ii) The name, experience and qualification of the TCP who shall be appointed by the Contractor to provide full time continuous supervision of the heat soak process of all tempered glass panes in the factory.

(iii) The compliance certificate for the glass delivered to site. The compliance certificate should include the information as mentioned in Clause 20.8(c) and the manufacturer's quality control records as stated in Clause 20.9(b).

(d) Fully tempered glass is considered a safety glass as upon fracture it would break into small fragments.

Tinted glass **20.10**

Tinted glass shall be body tinted of the colour and intensity specified. This type of glass is to be considered as a heat absorbing glass when used externally and is to have a heat treatment that conforms to the 'heat strengthened' category of **ASTM C1048** as a minimum.

Coated glass **20.11** Coated Glass

(a) Coated glass shall be an approved proprietary product with either

(i) A metallic mirror-like reflective coating on the designated surface to the colour and of the type and performance specified or

(ii) A pyrolytic or vacuum deposition low emissivity (Low-E) coating of the colour and of the type and performance specified in the Particular Specification.

(b) All coated glass must conform to the requirements of **BS EN 1096-1** to **4** as a minimum but shall also conform to the requirements of the Particular Specification.

(c) The thermal performance and other properties of the glass shall conform to the criteria in the Particular Specification.

Laminated safety and security glass **20.12** Laminated Glass, dependent upon its composition can be regarded as a safety glass or a security glass.

(a) Laminated glass shall be an approved proprietary product comprising of two or more sheets of glass bonded together and incorporating a plastic interlayer, or other method of bonding, to ensure the performance specified.

(b) Glass must conform to **BS 6262-4** as a minimum and is considered a safety glass if it has been tested to **BS EN 12600** and is in conformance with the category 1 as a minimum, or categories 2, 3 when specified by design requirement.

(c) Other national standards that are equivalent to **BS EN 12600** are also acceptable but must be submitted and approved before the glass can be considered as a safety glass.

(d) Where non-pyrolytic Low-E coatings are used, edge deletion of the coating is necessary unless specifically stated as not being required by the glass manufacturer. Reference can be made **ASTM C1172** or other equivalent international standards for non-pyrolytic Low-E coatings.

(e) When laminated glass is used in a sloped condition, that is at angle from the vertical in excess of 10°, and heat treated glass is required for thermal or strength reasons, the inner lite is to heat strengthened and not fully tempered.

(f) Where laminated glass is used as a security glass to protect persons, it must have been tested to ensure compliance with the relevant threat level.

(g) Certification is required for glass used in bullet resistance or blast resistant installations.

(h) The addition of an applied adhesive film, either to the external face or the internal face will not be considered as, and does not constitute, an upgrading of the glass from that originally supplied.

(i) Laminated glass shall be subjected to boil test by the glass manufacturer in accordance with the requirements in Clause 8.1.6 of the **Code of Practice for Structural Use of Glass** issued by the Buildings Department to confirm the lamination quality before the production of glass. Submit the compliance test report for the glass delivered to site.

Plastic glazing **20.13** All plastic glazing installations are subject to the same test and certification requirements as for conventional glass.

(a) Plastic sheet glazing material shall be an approved proprietary product of one of the following types:

(i) Polycarbonate.

(ii) Polycarbonate with surface hardened treatment.

(iii) Other plastics as specified in the Particular Specification.

(b) All plastic materials are to be suitable for outdoor exposure and are to be UV resistant.

(c) All materials used at ground level or other areas of high traffic or exposure to damage are to be 'mar resistant'.

(d) Plastics shall be cut in conformance with the manufacturer's requirements, including the removal of protective tapes and papers. All surfaces shall be free from irregularities and defects.

Samples **20.14** Submit samples 150 mm (minimum) square of all types of glass for approval before ordering. Due to size constraints it is recognized that samples of heat treated glass may not be possible. The amount of roller wave distortion should therefore be confirmed prior to the production of the glass.

Storage **20.15** Keep glass and plastic sheets dry and clean during delivery and store vertically in a well vented location, carefully protected from condensation and other moisture. There shall be air between stored glass sheets to allow air circulation unless the manufacturer has stated in writing that glass tightly packed with lining paper can be stored as delivered. In this case a time limit must be given until glass is unpacked.

Setting blocks **20.16** Setting blocks shall be heat cured silicone, EPDM or neoprene. Setting blocks are to support the glass for a minimum of 80% of the glass thickness and are to be 80 - 90 Shore A hardness. They shall have a length equivalent to 25 mm for every 1 m^2 of glass area, with a minimum length of 100 mm, and a minimum width suitable to the glass thickness, a minimum of 80% of the glass width shall be fully supported.

Locating blocks shall be heat cured silicone, EPDM or neoprene. Location blocks are to cover a minimum of 80% of the glass thickness and are to be 60 - 70 Shore A hardness.

Thermoplastic elastomers, such as Santoprene and PVC or similar materials are not permitted.

Glazing compounds **20.17** Glazing compounds are to be selected to suit the frame and glazing substrates.

(a) The following compounds are permitted to be used:

(i) Silicone – gunnable neutral cure silicone one part weather type sealant if glass is retained mechanically. One or two-part structural sealant for glass not retained on all edges.

(ii) Polysulphide – is permitted only if the glass is positively retained on all edges.

(iii) Putty – is permitted for glazing into wooden frames only. Putty for glazing to softwood and absorbent hardwoods shall be linseed oil putty to **BS 544**. Putty for glazing to non-absorbent hardwoods shall be an approved proprietary brand recommended by the window manufacturer for the particular application and with setting properties and unpainted life to suit the construction programme.

(b) Compounds for glazing plastic sheets shall be compatible with the proprietary sheets and are to be either silicone or polysulphide.

(c) All sealing compounds are to be tested for adhesion and the test reports submitted prior to the commencement of glazing.

WORKMANSHIP

Generally **20.18** The workmanship on glazing shall be generally in accordance with **BS 8000-7** and **BS 8000-0** and also conform to the glazing manual published by the Glass Association of North America (**GANA** – formerly **FGMA**).

Glazing shall be carried out from inside the building whenever possible. Glass and glazing materials shall be compatible with each other and the glass shall be protected from damage and staining of any kind.

Glass shall be new. Glass shall be of the specified type and quality with cleanly cut edges and sharp corners. Inspect glass before installation. Do not install defective glass.

Installation of safety glazing **20.18A** Provide tempered and/or laminated glass at the following locations:

(a) Doors.

(b) Fixed and operable glazing with a vertical edge within 300 mm of a door in the closed position and with the bottom edge less than 1500 mm above the walking surface.

(c) Fixed glazing with area exceeding one square meter, and with the lowest edge less than 450 mm above a walking surface, which is within 900 mm of such glazing; tempered and/or laminated glass is not required if there is a horizontal member with minimum 40 mm width located between 600 and 900 mm above the walking surface.

(d) Any additional locations required by relevant Ordinances, Regulations, Codes of Practice and Practice Notes.

Installation of heat treated glass **20.18B** Provide heat strengthened glass where required by design wind pressures, anticipated thermal stress, and use in a spandrel area.

Provide fully tempered and/or laminated glass only where required by Hong Kong regulations, Codes of Practice or where design pressures are beyond the capacity of heat strengthened glass.

Safety glass or safety plastic is also to be used at locations where safety is a concern. Refer to **BS 6262-4**.

Edge cover (or Glass bite) **20.18C** Before setting glass, inspect frame for proper dimensions and squareness. Adjust frame and/or glass size as required to meet specified requirements for edge cover dimensions and glass edge clearance.

Except as otherwise specified, comply with **BS 6262**. Where joint movement shall result in variable edge cover (or glass bite), increase nominal edge cover to provide 10.0 mm minimum cover and 6.0 mm minimum edge clearance. In no case shall the front and back clearances be less than 5.0 mm. Refer to the **GANA** manual (glass bite) for further information.

Location of setting blocks **20.18D** Thoroughly clean glazing pocket before setting glass. Solvents shall be compatible with finished aluminium, glass and glazing materials. Setting blocks shall be equidistant from the glass centreline. Location of setting blocks at glass quarter points is acceptable. The distance from the vertical glass edge to the nearest edge of the setting block shall not be less than 150 mm, or 0.125 times glass width,

		whichever is greater. Side blocks shall be located between the midheight and top corner of the glass. Side blocks, setting blocks and chairs shall be positively retained in position.
Fasteners in glazing pocket	**20.18E**	Fasteners shall not penetrate glazing pockets.
Glass stops and application of sealants	**20.18F**	Remove and replace stops and apply sealants as required for a complete glass installation.
Replacement of damaged glass	**20.18G**	Leave glass in crates until just prior to installation. Replace any glass which breaks or sustains edge damage, surface damage or damage to reflective coating as defined in the Particular Specification.
Structural sealant	**20.18H**	Clean, prime and mask at structural sealant joints a maximum of 8 hours before applying the silicone. Temporarily clamp glass during cure of structural sealant. After sufficient cure, remove clamps and fill any gaps in silicone. Mask glass and aluminium during application of structural sealant. Remove masking immediately after tooling sealant. Structural sealant shall not be applied to edges of insulating glass units, or to edges of laminated glass units. Sealants used as weather seals shall not be adhered to, or placed against, the edge of a laminated glass unit inter-layer.
Preparation of surrounds	**20.19**	The preparation of the surrounds for acceptance of the glazing is important. All surrounds are to be free of any foreign matter and be cleaned to accept the sealing compound in accordance with the requirements of the sealant manufacturer. The application of sealant to unprepared substrates is not permitted. Aluminium surrounds are to be anodized or painted with an Architectural factory applied finish. Alternatively a chromate conversion coating is acceptable. For all other materials, including stainless steel, details of the finish and cleaning procedures are to be submitted prior to commencement of glazing.
External glazing generally	**20.20**	External glazing shall be wind tight and watertight on completion whether the glazing has been carried out with glazing compounds or gaskets.
Glass orientation	**20.21**	Where the glass has an integral cast or rolled pattern on one surface, that surface should be glazed facing outward. Where the glass has a sand blasted or acid etch pattern on one surface, that surface should be glazed facing inward. For glass with metallic coatings, reflective and Low-E, confirmation of the correct orientation is to be made by the glazing supervisor.
Alignment of wired glass	**20.22**	Fix directionally patterned or wired glass with the pattern or wires parallel to surround and align wire in adjacent panes. Cut edges of wired glass shall be painted with black bituminous paint to inhibit rusting.
Edge clearance	**20.23**	Edge clearance shall be in accordance with the recommendations of the manufacturer or **GANA**, subject to a minimum clearance of 3 mm.
Setting and location blocks	**20.24**	Setting blocks are to be used for all glass panes and are to be located at quarter points of the bottom edge of the glass.

To minimize bending of the transom under dead load, the setting blocks may be moved to eighth points but must not be closer than recommended by **GANA**.

Bedding & tooling **20.25**

The application and tooling of all sealants and glazing compounds is important.

Ensure that no voids or spaces are left in backing or bedding compounds and that there is no metal or wood to glass contact

Tool sealing compound as follows:

(a) To top and side edges-flush with top of rebate or bead.

(b) To bottom edges-with a suitable angle to shed water.

Glazing with putty **20.26**

Within the limits of pane size and wind loading, putty can be used for glazing certain types of glass into wood rebates and galvanized steel surrounds. Refer to **BS 6262** for recommendations.

Seal putty within the time recommended by manufactures, but not less than 7 days for the putty to cure.

Structural sealant glazing **20.27**

Structural sealant glazing shall comply with **Code of Practice for Structural Use of Glass** and **APP-37** issued by Buildings Department. It shall be applied according to **BS 6262-6**, **BS EN 13022-1** and **BS EN 13022-2**. Only structural sealant recommended by manufacturer shall be used.

Glazing with beads **20.28**

Ensure there is no break in the air seal at the rear face of the glass and if necessary, bed beads in glazing compound for external glazing.

Secure wood beads with rustproofed panel pins or with countersunk brass screws and cups at 200 mm (maximum) centres and 75 mm (maximum) from each corner.

Remove and refix metal beads supplied with metal windows.

Sealing **20.29**

When specified seal the joint between the glass and bead with an approved silicone sealant. Ensure all manufacturer-recommended cleaning processes are followed.

Tapes and gaskets **20.30**

Refer to Section 16 – Curtain Walls in regard to the use of preformed tapes, shims and compression gaskets for glazing in accordance with the manufacturer's recommendations.

Glazing aluminium windows **20.31**

Aluminium windows may be glazed by the specialist supplying and fixing the windows.

Louvre blades **20.32**

Louvre blades shall have edges parallel, and ground to remove sharp arises.

Plastic sheets **20.33**

Cut plastic sheets with a fine tooth saw and smooth or chamber edges. Allow edge clearance and edge cover as recommended by the manufacturer, normally with the minimum edge cover of 15 mm, refer to **BS 6262-3**. Only remove sufficient of the protective covering around edges to allow installing and remove the remainder just prior to practical completion.

However, if this would result in leaving the tape in place for longer than the recommended time, advise the SO in writing and follow his instructions.

Cleaning **20.34**

Remove all smears and excess glazing compound.

Remove mortar, plaster or concrete spillage and paint drips whilst wet.

Leave clean inside and out, and free from scratches.

Making good **20.35**

Replace glass or fixing materials broken or damaged before practical completion, and redecorate area if necessary.

Environmental Green Requirements

20.36 Green requirements of adhesives and sealants:

(a) The product of adhesive and sealant shall comply with the VOC content limits on regulated adhesives stipulated in the Air Pollution Control (VOC) Regulation of Hong Kong.

(b) The product shall not contain the following substances regulated in the Montreal Protocol on Substances that Deplete the Ozone Layer (particularly CFCs, HCFCs, 1,1,1-trichloroethane and carbon tetrachloride).

(c) The product shall contain no more than 0.01% by wet weight of formaldehyde.

(d) The product shall contain no more than 0.5% by wet weight of the sum total of aromatic compounds, which include benzene, toluene, xylenes, and ethylbenzene.

SECTION 21

PAINTING

MATERIALS

Generally **21.1** All paints and decorative materials shall be of approved type, brand and colour.

Obtain approval of the SO in respect of the painting system which shall include the type, brand and colour of all materials before starting work.

Supply all proprietary brand materials in sealed containers each containing the manufacturer's brand label and printed instructions. Destroy the tins immediately after use of the contents.

Paint shall be supplied in sealed containers. Each container shall be marked on the side to show the following:

(a) The name of the manufacturer,

(b) The paint manufacturer's reference number,

(c) Intended purposes, type of pigment and binder,

(d) Batch number, date of manufacture, expiry date and pot life, and

(e) Colour, gloss, drying times and flash point.

Where possible, all the materials in any coating system shall be obtained from the same manufacturer. Furnish the SO with two copies of the manufacturer's data sheets for the paints proposed to be used.

Store materials on the Site or in the Contractor's workshops, etc in cool, well ventilated, covered storage space. Label tins of paint for "External Use" and for "Internal Use", "Undercoating" and "Finishing" respectively.

Where flammable paints or solvents are used, no smoking shall be permitted. Appropriate signs as required by the SO should be displayed.

Priming paints in general **21.2** Priming paints to be as follows:

(a) For synthetic finishing paints on internal and external woodwork, use aluminium primer to **BS 4756**, Type 1.

(b) For synthetic finishing paints on internal and external metalwork, use zinc phosphate primer to **BS 5193, ISO 6745** or metallic zinc-rich primer to **BS 4652**, as specified.

(c) For synthetic or non-toxic paints on galvanized metal surfaces, use an approved etching primer with a zinc-chromate base, or calcium plumbate primer to **BS 3698**.

(d) For polyurethane paint on internal and external metalwork, use polyurethane red lead primer.

Priming paints for Structural Steel **21.3** For painting on structural steelwork, comply with Section 15.

Sealers **21.4** Sealers for plaster, masonry and the like shall be an approved stabilizing solution or oil-based plaster sealer.

Anti-mould liquid **21.5** Anti-mould liquid shall be an approved fungicidal solution.

Water repellent liquid **21.6** Water repellent liquid shall be silicone or other approved water repellent.

Limewash **21.7** Lime wash shall be composed of 15 kg of tallow to 1 m^3 of quicklime for walls, ceilings, etc. and 55 kg of tallow to 1 m^3 of quicklime for bituminous felted or asphalt roof surfaces.

Emulsion paint **21.8** Emulsion paint shall be plastic, vinyl or latex emulsions of approved brands. Do not use alkyd resin based emulsion paints without prior approval.

Textured emulsion paint **21.9** Textured emulsion paint shall be acrylic based emulsion paint textured with a finely dispersed aggregate.

Anti-mould acrylic emulsion paint & Anti-mould performance **21.10** Anti-mould emulsion paint shall be acrylic based emulsion incorporating an approved fungus resistant chemical.

Painted surfaces with exposure to indoor environment shall comply with Rating 0 requirement of **BS 3900-G6**.

Multi-colour paint **21.11** Multi-colour paint shall be an approved brand comprising a base and hardwearing top coat incorporating a pigmented splatter coat used as recommended by the manufacturer.

Cement paint **21.12** Cement paint shall be waterproof cement base paint supplied in drums. Do not mix lime or other adulterants with cement paints.

External textured paint **21.13** External textured paint shall be an approved heavy duty masonry paint incorporating a fine aggregate filler.

Fire retardant paints **21.14** Fire retardant paints shall be paints which, when used alone or in conjunction with other paints applied to combustible substrates in accordance with a manufacturer's tested system, achieve Class 1 spread of flame rating to **BS 476-7**.

Synthetic paint **21.15** Unless expressly specified otherwise, all paint for internal and external use shall be synthetic paint of alkyd resin base combined with drying oils and pigments. Undercoats and finishing coat shall be of properly matching type and the finishing coat shall give a hard gloss finish or as otherwise specified.

Cold cure epoxy paint **21.16** Cold cure epoxy paint shall be of an approved Two Pack Type.

Polyurethane paint **21.17** Polyurethane paint shall be of the Two Pack Type and part of an approved system.

Black bitumastic paint **21.18** Black bitumastic paint shall be tar base paint complying with the requirements of **BS 1070**, Type B (quick drying).

Black bitumen coating solution **21.19** Black bitumen coating solution shall be to **BS 3416**, Type 1 for general purposes.

Marking paint for ballcourts, playgrounds etc. **21.20** Marking paint for basketball courts, playground, etc. shall be an approved purpose made synthetic non-skid marking paint, with a drying time not exceeding 30 minutes.

Marking materials for roads, carriageways and car parks **21.21** Road marking materials shall be hot applied thermoplastic materials with either plasticised synthetic hydrocarbon resin or alkyd resin as the binder as specified.

(a) Type 'A' - Standard hot applied thermoplastic material

(i) The material shall comply with **BS 3262-3, BS EN 1824** and **BS EN 1871** except for the following modifications to the material properties:

Softening point measured in accordance with Annex F to **BS EN 1871** shall be not less than 85ºC, and

(ii) The luminance factor when tested in accordance with Annex E of **BS EN 1871** shall be Class LF4 for white material and Class LF2 for yellow material.

(b) Type 'B' - Alkyd resin hot applied thermoplastic material

(i) The material shall comply with **BS EN 1824** and **BS EN 1871** except for the following modifications to the material properties:

Softening point measured in accordance with Annex F to **BS EN 1871** shall be not less than 85ºC, and

(ii) The binder for alkyd resin thermoplastic road marking materials to consist of maleic-modified glycerol ester of wood resin. The binder shall not contain petroleum based hydrocarbon resins, tall oil resins, blends of tall oil and wood resin or similar derivatives.

(iii) The luminance factor when tested in accordance with Annex E of **BS EN 1871** shall be Class LF4 for white material and Class LF2 for yellow material.

Fluorescent paint **21.22** Fluorescent paint to **BS EN ISO 11507, BS 3900-F16** and **BS EN 927-6** where appropriate shall be water based or oil based, as specified. Use fluorescent paint in conjunction with white flat water or oil base undercoat, and priming coat to suit the surface being painted.

Reflecting paint **21.23** Reflecting paint shall consist of white synthetic paint with a high gloss finish and a surface coating of fine grain reflective aggregate, applied at the rate of not less than 0.6 kg/m^2 while finishing coat is still wet.

Metallic paint **21.24** Metallic paint shall be composed of acrylic resin solution base mixed with finely divided aluminium to give a bright finish, or finely divided copper or copper alloy to give a bronze finish.

Heat resisting paint **21.25** Heat resisting paint shall be an approved heat resisting enamel paint. Priming coat and undercoats used in conjunction with the enamel finishing coat shall be similarly heat resisting.

Chemical resisting paint **21.26** Chemical resisting paint and thinner shall be of an approved brand resistant to attack by all commonly used commercial acids and alkalis.

Black enamel **21.27** Black enamel shall be high grade, quick drying black japan and to dry to a perfectly smooth, hard and elastic surface in not more than 12 hours at a temperature of 16ºC.

Non-toxic paint **21.28** Non-toxic paint for use on water tanks, water collecting roofs etc. shall be proprietary brands and one of the following types:

(a) Petroleum or asphaltic bitumen based coatings, or

(b) Epoxy based coatings

Pesticidal coating **21.29** Pesticidal coating shall contain an approved pesticide.

Wood preservative **21.30** Wood preservative to offer complete protection against termites, wood boring insects, fungi, wood rot and decay. It shall be of an approved proprietary brand exterior grade, where completely concealed or not decorated, and colourless, coloured or suitable for overpainting where likely to be exposed or be in contact with a painted finish.

Knotting **21.31** Knotting for metal pipes coated with bitumen shall be an approved proprietary brand of patent knotting intended for this purpose. Knotting for woodwork shall be to **BS 1336**.

Stopping **21.32** Stopping for internal woodwork, plywood, hardwood and fibreboard shall be poly putty or linseed oil putty**,** tinted if required. Stopping for external woodwork shall be poly putty or white lead paste and gold size, well mixed.

White spirit **21.33** White spirit shall be to **BS 245**.

Linseed oil **21.34** Linseed oil shall be to **BS EN ISO 150**.

Stain **21.35** Stain for woodwork shall be an approved water or spirit stain suitable for use under varnish or wax polish.

Self finished stains shall be an approved proprietary make.

Varnish **21.36** Varnish shall be one of the following types:

(a) Copal Varnish shall be No. 1 Extra Pale quality for internal use only.

(b) Synthetic Varnish shall be the Long Linseed Oil Alkyd type for internal or external use.

(c) Polyurethane Varnish for internal or external use shall be either:

(i) Moisture Cure Oil Modified One Pack Type, or

(ii) Isocyanate Cure Two Pack Type.

Wax polish **21.37** Wax polish for floors, furniture and joinery shall be an approved proprietary brand.

Chalkboard paint **21.38** Chalkboard paint shall be an approved hard drying flat black or deep green paint, containing a fine abrasive.

Cellulose lacquer **21.39** Cellulose lacquer shall be of an approved brand.

Stone cleaner **21.40** Chemical solutions for cleaning and sealing stonework shall be from an approved manufacturer.

Floor seal **21.41** Floor seals shall be an approved resin based sealer.

WORKMANSHIP

Painting in general **21.42** Painting generally shall be in accordance with **BS 6150**, **BS 8000-0** and **BS 8000-12** and as described in the following clauses:

(a) Do not carry out work in wet humid or foggy weather, direct sunlight, or on surfaces which are not thoroughly dry, or if there is excess dust in the air.

(b) Ensure that all holes, cracks and other defects in surfaces have been made good prior to painting.

(c) Brush each coat well into the surface so that every part, including joints, junctions, angles, etc. is adequately covered, but take care to avoid excessive or uneven thickness of paint film, particularly at edges, angles and junction.

(d) Before applying coatings check that the moisture content of the substrate shall not adversely affect the completed work.

Apply coatings only to clean, dry surfaces after any previous coatings have hardened, and rub down smooth with fine glass paper before the subsequent coat is applied.

(e) Successive coats of paint shall be of slightly differing tints, and the intercoating time shall not exceed the limits recommended by the paint manufacturers.

(f) Apply coatings with approved bristle brushes of suitable size. Flat wall brushes shall be not less than 150 mm wide.

(g) Do not use rollers, cloths or gloves unless recommended by the paint manufacturers and/or approved by the SO.

(h) Do not use mechanical spraying machines unless recommended by the paint manufacturers and/or approved by the SO.

(i) Where required, prime and paint the unexposed surfaces prior to fixing the surfaces which would become inaccessible.

(j) Remove all articles of ironmongery, hardware, etc. before painting and replace with matching screws (and plugs, if required,) of suitable size, after completion.

Leave everything clean and completely free from all paint stains, splashes, etc.

(k) Do not paint weatherstripping on metal windows or doors.

(l) Touch up coated surfaces on completion, where ordered.

(m) Carry out decoration in colours to **BS 4800** as selected by the SO.

(n) Provide paint finish sample panels in accordance with the paint system in layers from the sealer coat, priming coat, under coat and finish coat as appropriate and obtain approval before carrying out work.

General protection and cleaning **21.43** Protect surfaces, fittings, furniture, and the like by suitable and approved means.

Protect freshly applied surface coatings from damage.

Exhibit “Wet Paint”, in English and Chinese signs and provide protective barriers where necessary.

Protect surfaces adjacent to those being coated.

Cleanliness **21.44** Keep surfaces clean and free from dust during coating and drying.

Remove and clean off all splashes whilst work is in progress, make good any damage, and leave work, and all areas in which work is executed, clean and perfect on completion.

Preparatory work in general **21.45** Unless specifically stated to the contrary, the descriptions of “Painting” work shall be understood to include all preparatory work required and necessary to produce a first class finish, free from all blemishes, brush marks, blisters and weeping and the following definitions are to apply where preparation is to be carried out:

(a) “Wash down” shall mean either:

(i) The removal with clean water of all dirt, etc. not absorbed into the surface of a material not previously decorated, or

(ii) the removal with clean water of existing limewash, non-washable distemper or similar material not absorbed into the decorated surfaces, or

(iii) the removal of dirt, etc. from and cleaning down of, existing washable distempered, cement painted, synthetic painted and similarly decorated surfaces with sugar soap powder mixed with water, followed by further applications of clean water.

(b) "Broom down" shall mean the thorough dry brushing of any surface with a stiff broom or brush so as to remove all cobwebs, dust or loose particles.

(c) "Scrape" shall mean the removal of all existing coats of paint, limewash, colourwash, distemper, etc. by scraping tools without the use of chemical solvents or heat and without damage to the underlying material. Any damage so caused shall be made good. The surface shall be washed down on completion.

(d) "Wire brush" shall mean the thorough brushing of the surface with a stiff wire brush.

(e) "Strip" shall mean the complete removal, without damage to the underlying surface, of all existing coats of limewash, distemper, paint or other decorative material by means of washing and scraping together with the use of chemical solvents or heat, if necessary. After the use of chemical solvents the surfaces shall be washed down and neutralised in accordance with the manufacturer's recommendation.

(f) "Stop" to plaster shall mean carefully trimming the edges of all holes, cracks or crevices of any description and filling with an approved proprietary brand of filler or with Plaster of Paris to produce an even, flat surface, and touching up all patches with a coat of sealer prior to repainting.

(g) "Stop" to woodwork shall mean the cleaning out and filling of all holes, cracks and crevices, etc.

(h) "Knot" to metal pipes shall mean the application of one coat of patent knotting to surface of any bitumen coated pipe.

(i) "Knot" to woodwork shall mean the application of a sufficient number of coats of "knotting" over all knots in the timber to prevent the bleeding of resin, etc. through the subsequent decoration.

(j) "Rub down" shall mean the rubbing of newly prepared surfaces, or surfaces of existing paint remaining after preparation for redecoration, with approved waterproof glass paper, pumice stone or similar, to give a true and keyed surface for new paint.

(k) "Fill" shall mean filling of grain with approved surface filler.

Preparation of new surfaces **21.46** Remove all dust, dirt, stains, efflorescence, grease and loose material and, unless otherwise specified, prepare new surfaces for decoration as follows:

(a) Plaster, cement render, and similar surfaces - Wash down, stop and rub down.

(b) Concrete, brick, block, stone roof tiling and similar surfaces - Broom down.

(c) Structural steelwork preparation shall be in accordance with the requirements set out in Section 15.

(d) Metalwork:

(i) Chip off and remove all scale and rust, wire brush to leave non-galvanised iron or steel bare and clean, and apply rust inhibitor at least twelve hours prior to painting with zinc chromate or other specified primer.

(ii) Clean down and apply calcium plumbate primer or etching primer as specified to zinc-sprayed or galvanised iron or steel.

(iii) Clean down and knot coated pipes.

(iv) Where exposed copper is specified to be painted, wash with soap and warm water, rub down with coarse emery cloth and apply one coat of a solution of 1 part acetone to 2 parts benzole prior to priming.

(e) Woodwork:

(i) Knot, prime, stop and rub down surfaces shall be painted with synthetic paint.

(ii) Broom down surfaces shall be treated with wood preservative or pesticidal coating.

(iii) Rub smooth and brush clean surfaces shall be treated with linseed oil.

(iv) Rub down and fill surfaces shall be stained, varnished, wax polished or lacquered.

(v) Wash down surfaces shall be painted with chalkboard paint.

(f) Soft or hard fibreboard, insulating board, acoustic tile and similar surfaces - Broom down, punch nail heads, stop all nail and screw holes, rub down and leave with texture to match surrounding surfaces.

(g) Asbestos cement surfaces - Broom down taking care to prevent the inhalation and spread of asbestos dust.

Keep dust down by spraying with water and encourage workers to wear half mask (orinasal) dust respirators.

(h) Fill surfaces shall be painted with polyurethane paint or cold cure epoxy paint with an approved epoxy filler.

Concrete and cementitious surfaces

21.47 Where coatings are required to resist carbonation, chloride exposure, and/or aggressive chemical attack, as specified and subject to the above, the following conditions are required:

(a) The manufacturer of the paint shall supply health and safety data relating to the storage and application of all components of the paint system.

(b) Particular attention shall be paid to the effects of solvent and vapour build-up upon the environment around the paint applicator.

(c) Guidance shall be given by the manufacturer on the long term effects of volatile or leachable components of the paint system upon the environment, with particular reference to leachable heavy metal contents such as mercury based algicides or lead driers.

(d) The in-service performance of the paint under conditions of fire shall be given by the manufacturer, making particular reference to surface spread of flame, and toxicity and opacity of combustion products.

(e) The manufacturer shall provide information on the methods of preparation to be used in the event of recoating of painted surfaces being required.

(f) Surfaces to receive coatings shall be sound, free from laitance and contamination such as oils and grease, and normally be at least 28 days old.

(g) Areas of contamination shall be removed by use of appropriate solvents, followed by thoroughly cleaning the concrete.

(h) Shrinkage cracks, blow holes or other defects in the finished concrete surface shall be filled with a levelling compound compatible with the paint system to be applied; the compound shall be knifed into defects and tight-trowelled to remove all surplus materials.

(i) Wide shrinkage cracks in concrete or joints between concrete and blockwork, are liable to move under thermal or moisture movement processes. Such cracks or joints shall be opened out by saw cutting and detailed as a movement joint. Care shall be taken so as not to over-paint the sealant used in the joints, which may be effected by masking off with tape. Alternatively, the cracks may be sealed by resin injection.

(j) Where the prepared surface shall be left for extended periods (i.e. over 1 week) before coating, it shall be protected against contamination.

(k) Compatibility tests shall be undertaken to establish whether new paint shall bond to existing paint. A trial area of 5 m^2 shall be prepared and tested in accordance with the requirements of the SO.

Complete stripping of existing decoration

21.48 Where ordered by the SO, strip existing decoration which is in poor condition, or which shall be replaced by a different type of decoration.

After stripping the decoration, prepare surfaces as required for the type of decoration to be applied.

(a) All concrete surfaces to receive paint shall be dry at the time of application. Sufficient drying time shall be allowed either after construction or after wet preparation methods, to satisfy one of the following requirements:

(i) moisture meter readings shall be consistently less than 5% (concrete scale).

(ii) there shall be no retained moisture behind polythene taped to the concrete for 24 hours.

(iii) internal humidity measurements within concrete shall be < 75% (e.g. Seared probe),

(b) Prior to applying the paint to new surfaces sample area not less than 5 m^2 shall be prepared on the structure to be painted.

(c) The actual consumption in L/m^2 of the various coats of the paint system shall be recorded in the test area, in order that due allowance may be made for rough, irregular or exceptionally absorbent concrete, or render.

(d) When the paint system has cured for 14 days, a test of surface adhesion shall be made in accordance with the requirements of the SO.

(e) In the absence of satisfactory bond strength results, the concrete surface shall be cleaned using high pressure water jetting followed by re-application and re-testing of the coating.

(f) The DFT (dry film thickness) shall be as specified to the requirement of the SO, and should the minimum and mean DFT values be less than those

specified, the coverage rates for the paint shall be proportionally increased for the duration of the Contract.

(g) Coatings shall only be applied during favourable weather periods, when rainfall is not expected for the following 12 hours.

(h) The dew point shall be at least 5ºC lower than the temperature of the concrete surface before painting can commence.

(i) Painting using water based paints, shall not commence whilst the relative humidity is above 85% or where it may be expected to exceed 90% during the 12 hour curing period.

(j) Primers, undercoats and finish coats shall be applied in accordance with the manufacturers' instructions using brush, roller, spray or other technique to achieve the desired surface finish. Brush application of primers is the preferred method, working the paint into the concrete pores.

(k) Where brush or roller techniques are used, the brushes or roller beads shall be used for the day only and then discarded. The equipment shall not be cleaned for re-use, owing to the risk of solvent/water dilution.

(l) Where spray equipment is used, all cleaning fluid shall be purged from the lines using undiluted paint. All such contaminated paint used for purging lines shall be discarded and not used in the works.

(m) Where two-component materials are used, each component shall be thoroughly stirred before mechanically mixing the whole units together; part batches shall not be used. The exception is where airless spray equipment is used, incorporating a nozzle mixing device.

(n) For multiple coat applications, manufacturers stated minimum and maximum overcoating times shall not be breached for the prevailing weather conditions.

(o) For multiple coat applications, successive coats shall have slightly different colour shades to assist in achieving uniform coverage.

Preparation of existing decorated surfaces

21.49 Remove all dust, dirt, stains, efflorescence, grease and loose material and, unless otherwise specified, prepare existing decorated surfaces for decoration as follows:

(a) Limewashed or whitened surfaces - Scrape, broom down, stop, apply and bring forward bare spots with new material.

(b) Chinese distempered washable sealer or non-washable distempered surfaces - Strip off completely, wash down, stop, seal and prepare to receive emulsion paint or other paint as specified.

(c) Emulsion or textured emulsion painted surfaces - Scrape, wash down, stop, and bring forward bare spots with new material.

(d) Cement painted and external textured painted surfaces - Scrape, wash down, stop, bring forward bare spots with new material and dampen surface immediately prior to painting.

(e) Synthetic painted surfaces other than metal or wood - Scrape, wash down, stop, rub down and apply primer to and bring forward bare spots with undercoat.

(f) Black bituminous coated surfaces - Spot prime bare areas with black bituminous coating.

(g) Metalwork:

(i) Painted non-galvanised iron and steel - Wash down, scrape, chip off, and wire brush to remove all scale and rust, rub down, apply rust inhibitor and primer to bare areas or such additional areas as directed and bring forward with undercoat.

(ii) Painted zinc-sprayed or galvanised iron and steel – Wash down, scrape and remove all scale and rust, rub down and apply calcium plumbate primer or etching primer as specified and bring forward bare spots with undercoat.

(h) Woodwork:

(i) Synthetic painted surfaces - Wash down, scrape, rub down, knot, prime and stop and bring forward bare spots with undercoat.

(ii) Polyurethane or cold cure epoxy painted surfaces - Wash down, scrape, rub down, stop and apply epoxy filler to and bring forward bare spots with undercoat.

(iii) Varnished surfaces - Wash down, scrape and rub down and bring forward bare spots with varnish.

(iv) Waxed or lacquered surfaces other than waxed floors - Rub down, fill, and again rub down to produce a smooth surface ready for re-waxing or re-lacquering.

(v) Waxed floors - Clean with wire wool or sand down as specified.

Complete stripping of existing decoration **21.50** Where ordered by the SO, strip existing decoration which is in poor condition, or which shall be replaced by a different type of decoration.

After stripping the decoration, prepare surfaces as required for the type of decoration to be applied.

Surfaces containing asbestos **21.51** Obtain instructions from the SO before commencing any preparatory work on surfaces containing asbestos. Do not disturb asbestos-containing substrates.

Unsound surfaces and substrates **21.52** If, during the course of the preparatory work, any surfaces or substrates are found to be unsound, report and obtain instructions from the SO.

Application in general **21.53** Mix and apply paints in accordance with the manufacturer's recommendations.

Paints shall only be thinned in accordance with the manufacturer's recommendations and with the approval of the SO.

Apply the coating carefully so that the finished surface is free from imperfection or brush marks.

Cut in neatly and cleanly. Do not splash or mark adjacent surfaces.

The thickness of individual coats of paint and total thicknesses of paint systems shall be within the standard thickness recommended by the manufacturers unless otherwise specified.

Ensure that there shall be adequate ventilation for all painting processes.

Priming in general **21.54** Work primer into surface, joints, angles and end grain.

Ensure that priming coats are of adequate thickness and suit the surface porosity.

Ensure that any primed surfaces that have deteriorated on site or in transit are touched up or re-primed.

Apply priming coats on new work before the articles are fixed in position.

		Apply primer to metal surfaces on the same day as they have been cleaned. Allow 'wash' or 'etch' priming coats to harden before applying subsequent priming coats.
Undercoating	**21.55**	Apply undercoats in an even film over all surfaces. Avoid uneven thicknesses at edges and angles. If the undercoating of a particular painting system is only available in white, apply an additional finishing coat in lieu of a second undercoat.
Finishing coat	**21.56**	Apply finishing coats in an even film over all surfaces. Avoid brush marks, sags, runs and other defects. Where two hard gloss finishing coats are specified, apply second coat within 48 hours of first coat. Rub down with medium/fine glass paper between coats to provide key.
Anti-mould liquid	**21.57**	On surfaces subject to mould or similar growth, wash down with one coat of anti-mould liquid before preparation of surface for decoration. Ensure that surfaces are entirely clean of old mould growth and spores.
Water repellent liquid	**21.58**	Brush, clean down and apply one coat of water repellent liquid in accordance with the manufacturer's recommendations.
Cement paint	**21.59**	Before applying cement paint to absorbent surfaces, thoroughly damp the surfaces so as to provide even suction. Use cement paints within one hour of mixing. Allow a minimum drying time of 12 hours between coats.
External textured paint	**21.60**	Allow a minimum drying time of 12 hours between coats or in accordance with the manufacturer's recommendations.
Pesticidal coating	**21.61**	Apply over entire surface or in bands of 75 mm wide, as specified.
Wood preservative	**21.62**	Apply wood preservative over entire surface of timber. The timber shall have the correct moisture content before application of the preservative. Treatment shall comply with the manufacturer's recommendations, and be carried out after cutting to size. Stack the treated timber to dry out before priming and fixing.
Black bitumen coating solution	**21.63**	Blind coating which is to receive plaster, rendering or screeds with clean, sharp sand while still tacky. The final covering shall be laid as soon as possible after the black bitumen coating.
Black enamel	**21.64**	Work the material well under the brush and when the enamel is dry, it shall be hard and elastic.
Linseed oil	**21.65**	Allow a minimum drying time of 2 hours between coats.
Wax polish	**21.66**	On joinery and furniture, apply with a soft cloth and allow a minimum drying time of 4 hours between coats. Brush surface with a soft brush to obtain an eggshell finish. On floors, apply with weighted felt pad or electric polisher.
Cellulose lacquer	**21.67**	Apply undercoats and rub down with "flour-grade" glass paper and apply final coat and polish to produce a hard, high gloss finish free from marks and imperfections.

Rebates, glazing beads and putty	**21.68**	Apply suitable primer for glazing compounds specified in Clause 20.19 to rebates and beads before glazing. Seal putty ensuring that it has had sufficient curing time (5/7 days) but before it hardens as specified in Clause 20.28 with suitable primer and paint.
Writing	**21.69**	Unless otherwise specified, paint letters, characters, figures, etc. to the required sizes and styles in thick coat of synthetic paint so that they stand out boldly and solidly, free from brush marks.
Type and number of coats	**21.70**	Unless otherwise specified, prepare and apply the type and number of coats and use primers, sealers, etc. as Tables 21.1, 21.2, 21.3 & 21.4. Unless otherwise stated within Tables 21.1, 21.2, 21.3 & 21.4, the treatment of internal and external surfaces is the same.

TABLE 21.1
Number of Paint Coats
on Plaster, Render, Concrete, Brick, Block, Tarmacadam and Similar Surfaces

Type of Treatment	Number of Coats	
	On New Surfaces	Redecoration of Existing Surfaces
Lime wash	Two coats.	One or two coats, as specified.
Emulsion paint	One coat thinned with water in accordance with the manufacturer's recommendations etc. and two full (unthinned) coats.	One or two full (unthinned) coats, as specified.
Textured emulsion paint	One coat thinned with water in accordance with the manufacturer's recommendations etc. and two full (unthinned) coats.	One or two full (unthinned) coats, as specified.
Anti-mould acrylic emulsion paint	One coat thinned with water in accordance with the manufacturer's recommendations* and two full (unthinned) coats.	One or two full (unthinned) coats, as specified.
Multi-colour paint	One coat recommended primer by brush. One binder coat and one finishing coat by spray.	One binder coat and one finishing coat by spray.
Synthetic paint	One coat alkali resisting primer, one undercoat and one finishing coat.	One finishing coat, or one undercoat and one finishing coat, as specified.
Cement paint	Two coats.	One or two coats, as specified.
External textured paint	Two coats.	One or two coats, as specified.
Cold cure epoxy paint	One undercoat and one finishing coat.	One finishing coat, or one undercoat and one finishing coat, as specified. (Note: If existing finish is not cold cure epoxy paint,. completely strip and prepare as for new surfaces).
Pesticidal coating	One coat.	One coat.
Tar	One or two coats, as specified.	One or two coats, as specified.
Marking paint	Two thick coats.	One or two coats, as specified.
Fluorescent paint	One coat alkali resisting primer, one undercoat of flat synthetic paint and one finishing coat.	One undercoat of white synthetic paint, if specified, and one finishing coat.
Reflecting paint	One coat alkali resisting primer, one undercoat of white synthetic paint, and one finishing coat of white synthetic paint finished gloss with fine grain reflective aggregate.	One undercoat as described for new surfaces, if specified, and one finishing coat of white synthetic paint finished gloss with fine grain reflective aggregate.

* When applied to new lime based plaster, substitute one coat of water based lime-resistant primer instead of the thinned-down coat.

TABLE 21.2
Number of Coats
on Metal Surfaces

Type of Treatment	On New Surfaces	Redecoration of Existing Surfaces.
Synthetic paint	One coat recommended primer, two undercoats and one finishing coat.	One finishing coat, or one undercoat and one finishing coat.
Metallic paint	One coat recommended primer, two undercoats and one finishing coat.	One finishing coat, or one undercoat and one finishing coat, or two undercoats and one finishing coat, as specified.
Heat resisting paint	One coat recommended primer, two undercoats and one finishing coat.	One finishing coat, or one undercoat and one finishing coat, or two undercoats and one finishing coat, as specified.
Chemical resisting paint	One coat recommended primer, two undercoats and one finishing coat.	One finishing coat, or one undercoat and one finishing coat, or two undercoats and one finishing coat, as specified.
Black enamel	One coat recommended primer and one coat.	One coat.
Non-toxic paint	One coat recommended primer and two coats.	Two coats.
Polyurethane paint	One coat polyurethane red lead primer, one undercoat and one finishing coat.	One finishing coat, or one undercoat and one finishing coat, as specified. (Note: If existing finish is not polyurethane, completely strip and prepare as for new surfaces).
Cold cure epoxy paint	One coat epoxy red oxide chromate primer, one undercoat and one finishing coat.	One finishing coat, or one undercoat and one finishing coat, as specified. (Note: If existing finish is not cold cure epoxy paint, completely strip and prepare as for new surfaces).
Black bitumastic	One or two coats, as specified.	One or two coats, as specified.

TABLE 21.3
Number of Coats
on Wood Surfaces

Type of Treatment	On New Surfaces	Redecoration of Existing Surfaces
Synthetic paint	Internally: One coat recommended primer, one undercoat and one finishing coat. Externally: One coat recommended primer, two undercoats and one finishing coat.	Internally or externally: One finishing coat, or one undercoat and one finishing coat, as specified.
Polyurethane paint	One undercoat and one finishing coat.	One finishing coat, or one undercoat and one finishing coat, or two finishing coats externally as specified. (Note: If existing finish is not polyurethane paint, completely strip and prepare as for new surfaces) .
Pesticidal coating	One coat.	One coat.
Wood preservative	One or two coats, as specified.	One or two coats, as specified.
Linseed oil	Three coats.	Two coats.
Stain	Two or more coats, as specified, to obtain approved colour.	Two or more coats, as specified, to obtain approved colour.
Varnish	Two or three coats, as specified.	One or two coats, as specified.
Wax polish	On joinery and furniture: Three coats (minimum). On floors: Two coats.	On joinery and furniture: One or two coats, as specified. On floors: One or two coats, as specified.
Chalk-board paint	Two coats.	One or two coats, as specified.
Cellulose lacquer	Three coats (minimum).	One or two coats, as specified.

TABLE 21.4
Number of Coats
on Building Boards and Roof Covering etc.

Type of Treatment	On New Surfaces	Redecoration of Existing Surfaces
Emulsion paint on soft or hard fibreboard, insulating board, acoustic tiles and similar surfaces	One coat thinned with water in accordance with the manufacturer's recommendations and two full (unthinned) coats.	One or two full (unthinned) coats, as specified.
Plastic emulsion paint on asbestos surfaces	One coat alkali resisting primer and one coat thinned with water in accordance with the manufacturer's recommendations and two full (unthinned) coats.	One or two full (unthinned) coats, as specified.
Textured emulsion paint on soft or hard fibreboard, insulating board, acoustic tiles similar surfaces	One coat thinned with water in accordance with the manufacturer's recommendations and two full (unthinned) coats.	One or two full (unthinned) coats, as specified.
Anti-mould acrylic emulsion paint on asbestos surfaces	One coat alkali resisting primer and one coat thinned with water in accordance with the manufacturer's recommendations and two full (unthinned) coats.	One or two full (unthinned) coats, as specified.
Synthetic paint on soft or hard fibreboard, insulating board, acoustic tiles and similar surfaces	One coat recommended sealer, one undercoat and one finishing coat.	One finishing coat or one undercoat and one finishing coat, as specified.
Synthetic paint on asbestos surfaces	One coat alkali resisting primer, one undercoat and one finishing coat.	One finishing coat, or one undercoat and one finishing coat, as specified.

Preparation for road marking materials **21.71**

(a) The road surface shall be clean, dry and free from any loose detritus, mud and old flaking road marking materials. When directed by the SO, oil and grease shall be removed by high pressure water jetting, shot blasting, grinding or other approved methods.

(b) Where road markings shall be laid on a bituminous road surface which has not yet been opened to traffic, no surface preparation shall be required.

(c) Where road markings shall be laid on a concrete road surface which has not yet been opened to traffic, the curing compound and laitance shall be removed from the road surface.

(d) Where existing markings shall be relaid with a type of material other than that of the existing, the existing material shall be removed by the high pressure water jetting, shot blasting, grinding or other approved methods.

(e) Where existing markings shall be replaced with the type of material similar to the existing, the existing marking shall be roughened by approved methods.

(f) When road markings shall be applied on concrete road surfaces, a tack coat shall be applied on the road surface prior to application of road marking

materials. The primer shall be compatible with the road marking material and applied in accordance with the manufacturer's recommendations.

(g) The removal or roughening of existing road markings adjacent to any longitudinal or transverse joint shall be carried out by approved method in order to avoid damaging the joint.

Supply, delivery, storage and laying of road marking materials

21.72 Hot Applied Thermoplastic Road Marking Materials, Type 'A' and 'B'

(a) Thermoplastic road marking materials shall be supplied and delivered in accordance with the manufacturer's recommendations.

(b) Thermoplastic road marking materials shall be prepared on site, and laid in accordance with Clauses 4 and 5 of **BS 3262-3**.

(c) Thermoplastic road marking shall not be laid when the road surface is wet or when the air temperature is below 10ºC.

Reflectorization of road marking materials by surface application

21.73 For types 'A' and 'B' road marking materials, surface retro-reflectivity shall be accomplished as follows:

(a) Solid glass beads shall be incorporated in the road marking materials prior to application on site. Solid glass beads to comply with Glass Bead Medium Grading requirements of **BS 1423**.

(b) The retro-reflectivity of all road markings shall be enhanced by the application of solid glass beads at the rate of 400 to 500 g/m^2. The beads shall be applied concurrently with the line. The solid glass beads shall comply with Class B requirements of **BS 1423**.

(c) Solid glass beads shall be applied on site by mechanical means to the SO's satisfaction. Where solid glass beads cannot be satisfactorily applied by mechanical means they may, with prior approval, be applied by manual methods.

Thickness of road marking materials

21.74 The thermoplastic material to fall within the following tolerances:

	Type	*Thickness*
(i)	Screed markings	4.0 $\pm$ 1.0 mm
(ii)	Sprayed marking other than yellow edge lines	not less than 1.5 mm
(iii)	Sprayed yellow lines	not less than 0.8 mm
(iv)	Width and length	+10% -5%

The thickness specified is exclusive of surface applied solid glass beads. The method of thickness measurement shall be in accordance with Appendices B & C of **BS 3262-3**.

The apparatus for laying the thermoplastic material shall be capable of producing a marking to a uniform thickness and width with clean edges and free from streaks, lumps and blisters.

Test Certificate and routine testing of road marking materials

21.75 When required by the SO, a test certificate prepared and signed by an independent laboratory shall be submitted prior to the commencement of the Works certifying that samples taken from the materials shall be used in the Works to comply with **BS EN 1824** and **BS EN 1871**.

Concealed pipes & ducts **21.76** Insulated pipes and ducts concealed in false ceilings or ducts not normally accessible need not be painted but must be colour coded.

Insulated pipes and ducts run in accessible vertical ducts and in normally visible positions shall be plastered or wrapped with specified insulating materials and painted in the appropriate colour code or with appropriate colour code bands.

Uninsulated pipes and ducts, whether concealed or normally visible, shall be painted either in the appropriate colour code or as required by the SO and with appropriate colour code bands.

Machinery and pipework **21.77** All machinery, unless otherwise specified, shall be finished in green to **BS 4800** (14 E 51).

All pipework in the machinery rooms shall be finished generally in accordance with the Table 21.5.

All exposed service pipework outside the machinery rooms, shall be painted either as in the machinery room or to match the surrounding surface with distinguishing colour code bands and flow arrows in the specified colour scheme as directed by the SO.

Visible copper pipes and fittings for refrigerant which are not insulated shall be polished bright and lacquered.

All metalwork inside cold stores, mortuary body chambers and similar refrigerator spaces shall be finished in mould resistant paint suitable for low temperature application to the satisfaction of the SO.

Identification of Pipelines **21.78** Pipes and pipelines shall be painted in colours either in accordance with Table 21.5 or as directed by the SO, complete with the identification colour code indication. The basic identification colour or the decorative colour shall be applied over the whole length of the pipe. In the case of a decorative colour being applied, colour code indications must be placed at all junctions, at both sides of valves, service appliances, bulkheads, wall penetrations and at any other places where identification is necessary and as directed by the SO.

Valves may be painted with the identification colour except in the case where the pipelines have been coded with safety colour for fire fighting, the valves shall be painted red.

The direction of flow of fluid shall be indicated by an arrow over the basic identification colour and painted white or black in order to contrast clearly with the identification colour.

TABLE 21.5
Colour Banding Identification of B.S. Pipelines

Description of Service	Basic Colour 150 mm approx.	Colour Code Indication 100 mm approx.			Basic Colour 150 mm approx.
Water					
Drinking	Green (12 D 45)		Blue (18 E 53)		Green (12 D 45)
Cooling (Primary)	Green (12 D 45)		White		Green (12 D 45)
Boiler feed	Green (12 D 45)	Crimson (04 D 45)	White	Crimson (04 D 45)	Green (12 D 45)
Condensate	Green (12 D 45)	Crimson (04 D 45)	Emerald Green (14 E 53)	Crimson (04 D 45)	Green (12 D 45)

Chilled	Green (12 D 45)	White	Emerald Green (14 E 53)	White	Green (12 D 45)
Mains supply, cold	Green (12 D 45)	White	Blue (18 E 53)	White	Green (12 D 45)
Mains supply, hot	Green (12 D 45)	White	Crimson (04 D 45)	White	Green (12 D 45)
Central heating lower than 100°C	Green (12 D 45)	Blue (18 E 53)	Crimson (04 D 45)	Blue (18 E 53)	Green (12 D 45)
Central heating higher than 100°C	Green (12 D 45)	Crimson (04 D 45)	Blue (18 E 53)	Crimson (04 D 45)	Green (12 D 45)
Sea, river, untreated			Green (12 D 45)		Green (12 D 45)
Fire fighting	Green (12 D 45)		Safety Red (04 E 53)		
Compressed Air (including, air ducts)			Light Blue (20 E 51)		
Vacuum	Light Blue (20 E 51)		White		Light Blue (20 E 51)
Steam			Silver Grey (10 A 03)		
Drainage			Black		
Electrical Conduits and Ducts			Orange (06 E 51)		
Town Gas					
Manufactured gas	Yellow Ochre (08 C 35)		Emerald Green (14 E 53)		Yellow Ochre (08 C 35)
Natural gas	Yellow Ochre (08 C 35)		Yellow (10 E 53)		Yellow Ochre (08 C 35)
Refrigerant gas or liquid	Yellow Ochre (08 C 35)	Code Number of the Refrigerant (in black)			Yellow Ochre (08 C 35)
Oil					
Diesel fuel	Brown (06 C 39)		White		Brown (06 C 39)
Furnace fuel			Brown (06 C 39)		
Lubricating	Brown (06 C 39)		Emerald Green (14 E 53)		Brown (06 C 39)
Acids & Alkalines	Violet (22 C 37)		Black & Yellow Stripes		Violet (22 C 37)
Medical Gases					
Oxygen	Yellow Ochre (08 C 35)		Terracotta (02 C 37)	White	Yellow Ochre (08 C 35)
Nitrous oxide	Yellow Ochre (08 C 35)		Terracotta (02 C 37)	French Blue (20 D 45)	Yellow Ochre (08 C 35)

Chemical cleaning and sealing of stonework

21.79 Chemical solutions for cleaning and sealing stonework shall be used strictly in accordance with the manufacturer's instructions.

Cleaning "Shanghai" plaster **21.80**

Scrub surface with a hard bristle brush while applying a solution of an approved detergent in warm or cold water. Rinse off surface with clean fresh water applied by high pressure hose.

Cleaning terrazzo and rubbed granolithic work **21.81**

Scrub surface with a hard bristle brush, using fresh water and a non-caustic fine scouring powder. Rub down with pumice block, where specified. Rinse with fresh water and apply an approved wax emulsion.

Cleaning thermoplastic, vinyl, cork and similar flooring **21.82**

Apply a solution of approved detergent and water and scrub with a soft bristle brush. Mop with a damp mop and remove excess liquid. Apply one coat of liquid wax emulsion, where specified.

Sealing flooring **21.83**

Floor seal shall not be applied without the specific written instruction of the SO. Where specified, sweep floor clean and apply two coats of sealer as follows or in accordance with the manufacturer's recommendations:

(a) Apply first coat until absorption has ceased

(b) Remove any surplus sealant

(c) Allow several hours drying time

(d) Apply second coat in sufficient quantity to form a thin film over the surface

Seal shall not be applied under damp weather conditions.

Cleaning glazed and mosaic wall tiling and flooring **21.84**

Clean surface with a 10% solution of hydrochloric or oxalic acid and rinse with fresh water.

Cleaning synthetic paint and varnish work **21.85**

Clean surface with soft soap or a solution of approved detergent and water, with admixture of disinfectant, where specified, and dry off with washleathers.

Cleaning glazed sanitary fittings **21.86**

Clean with hot water and spirits of salts, and rinse with fresh water.

Cleaning water tanks **21.87**

Empty galvanized steel or concrete cisterns or tanks. Scrape and wire brush all internal surfaces. Remove all growth, rust or scale, scrub out, and clean with a solution of chloride of lime (not less than 1 kg chloride of lime to 6 m^3 of water) and wash and flush with fresh water.

Paint the inside surface with two coats of approved non-toxic black paint, where specified.

High quality finishes **21.88**

Approved textured high quality finishes comprising an epoxy, silica, acrylic or similar base with an epoxy or polyurethane top coat or coats shall be applied by approved applicators. (See also Clause 18.38)

Prepare surfaces to receive these materials and supply all necessary scaffolding, protection, storage and the like.

Health and safety **21.89**

Do not apply lead based primers and calcium plumbate primers by spraying.

Wear respirators which supply clean air during blasting cleaning, paint spraying or in a situation where toxic fumes are generated.

Take precautions to avoid skin and eye contact with paints and their solvents. Follow all precautionary measures as recommended by the paint manufacturers.

Environmental Green Requirements **21.90**

(a) All paint products shall comply with the VOC content requirements on regulated paints stipulated in the **Air Pollution Control (VOC) Regulation of Hong Kong**.

(b) Green requirements of Varnish and Wax Polish:

(i) The products shall not contain the following substances regulated in the Montreal Protocol on Substances that Deplete the Ozone Layer (particularly CFCs, HCFCs, 1,1,1-trichloroethane and carbon tetrachloride).
(ii) The product shall contain no more than 0.01% by wet weight of formaldehyde.
(iii) The product shall contain no more than 0.5% by wet weight of the sum total of aromatic compounds, which must include benzene, toluene, xylenes, and ethylbenzene.

(c) Green requirement of Paint and Thinner:

(i) The product shall contain no more than 0.01% by wet weight of formaldehyde.

(d) Green requirement of Paint and Varnish Remover:

(i) The VOC content of the product shall be less than 5% by volume.

QUALITY CONTROL TESTING

Emulsion paint **21.91** The quality tests for emulsion paint shall be as follows:

Test Items		Test Method	Acceptance Standards
Preliminary examination of paint	Surface skin	**BS EN ISO 1513**	- No surface skin
	Consistency		- No gelling
	Colour separation into layers		- No colour separation
	Visible impurities		- No visible impurities
	Sediment		- No hard settling
Drying times	Hard drying (min)	**BS EN ISO 9117-1**	< = 1 hour
Fineness of grind (μm)		**BS EN ISO 1524**	< = 50 μm
Hiding power (contrast ratio %)		**BS EN ISO 2814; BS 3900-D4**	> = 75%
Gloss value (GU) (at 85° specular reflection)		**BS EN ISO 2813**	< = 20
Viscosity (procedure B)		**ASTM D562**	65 - 85 KU
Scrub resistance (cycle)		**ASTM D2486**	> = 400 cycles

Synthetic paint **21.92** The quality tests for synthetic paint shall be as follows:

Test Items		Test Method	Acceptance Standards
Preliminary examination of paint	Surface skin	**BS EN ISO 1513**	- No surface skin
	Consistency		- No gelling
	Colour separation into layers		- No colour separation
	Settling		- No hard settling
	Extraneous matter		- No extraneous matter
Viscosity (Flow Cup No.6) (sec)		**BS EN ISO 2431**	45 to 60 sec
Drying times	Surface drying (hour)	**BS EN ISO 9117-3**	< = 4
	Hard drying (hour)	**BS EN ISO 9117-1**	< = 18
Fineness of grind (μm)		**BS EN ISO 1524**	< = 25 μm
Hiding power (contrast ratio %)		**BS EN ISO 2814; BS3900-D4**	> = 85%
Gloss value (GU) (at 60° specular reflection)		**BS EN ISO 2813**	> 80
Bend test		**BS EN ISO 1519**	No coating crack at 3 mm mandrel
Scratch test (g)		**BS EN ISO 1518-1**	> = 600

Multi-layer acrylic paint **21.93** The quality tests for multi-layer acrylic paint shall be as follows:

Test Items	Test Method	Acceptance Standards	Remarks
1. Low Temperature Stability	Table 2 **JIS A 6909**	No lumps and free from separation and aggregation of the composing materials	Respective coatings of primer coating, main coating and top coating are regarded as the samples.
2. Change in Consistency	Clause 5.6 **JIS A 6910** Table 2 **JIS A 6909**	± 15%	Respective coatings of primer coating, main coating and top coating are regarded as samples.
3. Cracking Resistance due to Initial Stage Drying	Clause 5.7 **JIS A 6910** Table 2 **JIS A 6909**	No cracking shall occur.	
4. Adhesion Strength	Table 2 **JIS A 6909**	Standard condition > = 68.6 N/cm^2 Immersion in water > = 49.0 N/cm^2	
5. Repeated Warming and Cooling	Table 2 **JIS A6909**	No peering, cracking and blistering and remarkable discolouration and degradation in luster on the surface.	
6. Permeability	Table 2 **JIS A 6909**	< = 0.5 ml	

7. Impact Resistance	Clause 5.11 **JIS A 6910** Table 2 **JIS A 6909**	Cracking, remarkable deformation and peeling shall not occur.	
8. Weather Resistance	**ASTM G154-16**	Cracking and peeling shall not occur and the discolouration shall be No.3 or subject to approval by the SO.	The test conditions: Fluorescent UV Lamp: UVA-340 Cycle: 24 hours UV at 60°C Total exposure time: 500 hours
9. Determination of Resistance to humid atmospheres containing sulphur dioxide	**BS EN ISO 3231;** **BS 3900-F8**	No blistering, loss of adhesion, rust staining, change of colour, embrittlement and other signs of deterioration.	The amount of sulphur dioxide to be used in testing is one litre. The test cycle to be 12 cycles.
10. Resistance to Fungal Growth	**BS 3900-G6**	Rating 0, no fungal growth.	

Notes:

1. The colour of paint to be tested shall be selected by the SO;
2. The base plate for testing to be 20 mm thick cement mortar board.

SURVEILLANCE TESTS FOR MULTI-LAYER ACRYLIC PAINT

Laboratory tests by approved laboratory **21.94**

(a) Provide attendance on the Site, deliver and collect samples etc. as directed by the SO or as specified;

(b) Sample for tests shall be selected by the SO.

Non compliance **21.95**

(a) Where any of the specimens for each sample fails to meet the testing requirements as specified, all materials manufactured on the same day shall be removed off the Site;

(b) Bear all costs of such further tests and no extension of time shall be allowed.

ON SITE DELIVERY CHECK

Emulsion paint **21.96**

(a) When instructed by the SO, carry out the following checks for emulsion paint upon delivery on the Site in the presence of the SO's representatives:

Test Items	Test Method	Acceptance Standards
1. Manufacturer's Certificate of origin & Delivery Note	Document check	From Approved origin with information of product identification number
2. Colour Code/Label/Serial Number	Check information printed on the packing	As Approved
3. Expiry Date	Check information printed on the packing	Not expired

(b) In the event of the checking results failing to meet the checking requirements upon delivery on the Site, remove the failed consignment off the Site.

Synthetic paint **21.97**

(a) When instructed by the SO, carry out the following checks for synthetic paint upon delivery on the Site in the presence of the SO's representatives:

Test Items	Test Method	Acceptance Standards
1. Manufacturer's Certificate of origin & Delivery Note	Document check	From Approved origin with information of product identification number
2. Colour Code/Label/Serial Number	Check information printed on the packing	As Approved
3. Expiry Date	Check information printed on the packing	Not expired

(b) In the event of the checking results failing to meet the checking requirements upon delivery on the Site, remove the failed consignment off the Site.

Multi-layer acrylic paint **21.98**

(a) When instructed by the SO, carry out the following checks for multi-layer acrylic paint upon delivery on the Site in the presence of the SO's representatives:

Test Items	Test Method	Acceptance Standards
1. Manufacturer's Certificate of Origin & Delivery Note	Document Check	From an Approved origin with information of product identification numbers
2. Color Code/Label serial number	Check information printed on the packing	As Approved
3. Expiry Date	Check information printed on the packing	Not expired

(b) In the event of the checking results failing to meet the checking requirements upon delivery on the Site, remove the failed consignment off the Site.

SECTION 22

INTERNAL FITTINGS AND FIXTURES

DEMOUNTABLE PARTITIONS

Generally

Construction of the system **22.1**

The system shall be simple and strong in construction, readily adaptable to suit different office layouts and be capable of being assembled and erected with high speed and efficiency. It shall include a range of module types incorporating varying proportions of solid panels and glazed areas ranging from full height (floor to ceiling) solid panel to full height glass (including low and half height screens).

All adhesives shall comply with VOC content stipulated in the Air Pollutions Control (VOC) Regulation of Hong Kong and shall not contain the following substances regulated in Montreal Protocol on Substances that Deplete the Ozone Layer, particularly CFCs, HCFCs, 1,1,1-trichloroethane and carbon tetrachloride. The products shall contain no more than 0.01 % by wet weight of formaldehyde and no more than 0.5% by wet weight of the sum total of aromatic compounds, which include benzene, toluene, xylenes, and ethylbenzene.

All painting shall be anti-mould paints. For details of anti-mould paint, refer to Section 21 - Painting.

Partitions **22.2**

The partitions shall be fully demountable and provide maximum recovery of components including panel finishes and involve minimum amount of effort, time and disturbances of wall, floor and ceiling when alteration and resiting either in part or in whole is required. Any module shall be capable of being demounted and replaced with one of a different type or with a door.

Completed partitions shall be free from exposed bolts, nuts, nail heads and rivets. The overall thickness of a completed partition shall not be more than 100 mm.

Module **22.3**

The partitions shall be constructed of standard module units so assembled that individual units can be easily dismantled without disturbance to adjoining units and the partition cavity may be exposed from one face without disturbing the opposite face.

Module design of varying door heights and low level screens shall also be available in addition to the capability of the design to readily accommodate special size doors, doors with vision panels or louvers, double action doors, etc.

Accommodation for building services items **22.4**

The system shall have suitable room and sufficient provision within the thickness of the partition to accommodate normal electrical, telephone and computer network wiring and conduits, and also the related fittings including electrical switches, power points and network nodes, etc.

Approval **22.5**

Any particular system proposed shall be subject to the approval of the SO, samples and details of the system shall be submitted for approval if required by the SO.

Materials

Framework **22.6**

The framework shall be either galvanised and coated rolled steel sections to **BS EN 10162** or anodised extruded aluminium sections to **BS EN 515, BS EN 573-3** and **BS EN 755-1** to **9, BS EN 12020-1** and **BS EN 12020-2** or a combination of both. All sections shall be of a size and shape which shall give adequate strength to the framing. Galvanised steel sections shall be not less than 0.56 mm thick. All framework (vertical and horizontal studs and furring channels) shall have suitably placed holes formed of an appropriate size to facilitate installation of electrical and computer network and wiring.

Lining panels **22.7**

Panels shall be of 12.50 mm (minimum thickness) gypsum plasterboard or plywood or chipboard and shall be securely fixed to both sides of the partition.

(a) Gypsum plasterboard shall comply with **BS EN 520+A1** and consist of a core of set gypsum plaster in accordance with **BS EN 13279-1** and **BS EN 13279-2** sandwiched between two layers of heavy paper.

(b) Plywood shall be Grade 2 lauan plywood for internal use as specified in Clause 13.12**.**

(c) Chipboard shall comply with **BS EN 309** and **BS EN 312**.

Doors **22.8**

Doors shall be 45 mm thick hollow or 50 mm solid core flush doors covered with selected hardwood veneer or laminated plastic sheet on both sides and hung to rebated timber frames.

All wood panels shall be of Class E1 under **EN13986** in respect of formaldehyde emission.

The product shall not contain any heavy metals or their compounds as listed below:

(a) Arsenic
(b) Cadmium
(c) Copper
(d) Lead
(e) Mercury

The following substances shall not be added during manufacturing: elemental chlorine, fluorine, PCP (pentachlorophenol) and tar oils containing benzo(a)pyrene

The product shall have no flame retardant of polybrominated biphenyls (PBBs), polybrominated diphenyl ethers (PBDEs) or short-chain chlorinated paraffins added as formulated components.

Appropriate number and types of door hinges shall be provided depending on the size and weight of doors used.

When specified, hardwood or powder coated aluminium louvre and frame shall be fitted to the door.

Glass for glazed panel **22.9**

Glass for glazed panel shall be 6 mm thick minimum, of the qualities specified in **BS 952**, free from bubbles, smoke vanes, air holes, scratches and other defects and cut to fit the openings, with due allowance made for expansion, and securely fixed to the trim sections by approved fixing materials and method as well as manufacturer's instructions.

Washable matt-finished vinyl cloth **22.10**

Washable matt-finished vinyl cloth for panel facing shall be either plain or textured fabric-backed vinyl cloth of approved quality applied in one full width (minimum 1200 mm) to each panel with approved adhesive and as specified in Clause 22.1 prior to installation in accordance with the manufacturer's instructions. Samples with at least 5 choices of colour showing the surface texture and pattern shall be submitted for the SO's approval.

Hessian fabric **22.11**

Hessian fabric shall be interior design, wall lining quality, close weave to a colour chosen by the SO fixed in full widths with approved adhesive and as specified in Clause 22.1. A sample panel shall be made up for the SO's approval before use.

Skirtings **22.12**

Skirtings shall be 15-100 mm high of baked enamel steel or anodised extruded aluminium sections of minimum 1 mm thick.

Pinboards **22.13**

Pinboards shall be of 13 mm softboard to comply with **BS EN 316, BS EN 622-1** and **BS EN 622-4**, finished with Hessian wall paper to be approved by the SO.

Finishings and Colours, generally

Colours of finishings, anodic frame coatings, plastic stops of cover strips, together with fabrics and all other finishings shall be to the requirements of the SO.

Workmanship

Studdings **22.14**

Vertical studdings shall be in one continuous length extending from floor to ceiling and shall be positioned at maximum 600 mm centres for partitions not exceeding 3.5 m high and at maximum 400 mm for partitions exceeding 3.5 m high. Joints and fixing within the framing shall be performed in such a manner that shall, when erected, produce a rigid and stable and yet fully demountable framing. The vertical and horizontal stud channels shall be able to support the various fittings to the system such as glazing panels, doors and shelvings as required.

Fixing **22.15**

Floor channels shall be securely fixed of maximum 600 mm centres by means of:

(a) 12 mm concrete nails to concrete or screed floor.

(b) No. 6 self tapping screws to steel or chipboard floor.

(c) No. 6 wood screws to timber floor.

Ceiling channels shall be securely fixed of maximum 600 mm centres by means of:

(d) No. 6 self tapping screws to the rigid suspension system along the metal grid of suspended ceiling.

(e) No. 6 self tapping screws and approved plastic plugs to concrete ceiling soffit.

(f) No. 6 wood screws to timber or plywood ceiling.

Wall channels shall be securely fixed of 750 mm centres by means of:

(g) No. 6 self tapping screws and approved plastic plugs to concrete or brick walls.

(h) No. 6 wood screws to timber or plywood.

Ceiling and wall channels shall be fitted with an applied foam plastic gasket to form a light and sound seal. Partitions other than full height shall be provided with either floor to ceiling stabilizer posts or buttress panels to ensure adequate rigidity and stability.

Full height panels (floor to structural ceiling) shall generally be applied in one piece. Where ceiling height exceeds 2700 mm and/or where building access restrict the size of panels, then a horizontal aluminium channel trim joint shall be permitted. Such joint shall line up with door head level.

Top edge of panels shall be securely fitted into the ceiling channel and bottom edges retained by the skirting fixing. Vertical edges of panels shall be retained to the vertical studs by means of continuous clip or screw fixed aluminium cover strips or by other approved method. Vertical panel edges at wall junctions shall be fitted into the wall channel. Centre of panels shall be fixed to the framing by means of suitable stud adhesive, spot applied at maximum 600 mm centres or by other approved method.

The covering ‘tee’ bar shall be held continuously by friction and not by clips.

Door frames **22.16**

Timber door frames shall be securely fixed to the partition framework with diagonal braces on each side to stabilize mid-height point of the frame.

Door frames at corners and tee junctions shall be positioned so as to allow sufficient clearance between back of door and the intersecting partition to allow the mounting of a surface mounted door closer and enable the door to open a full 90º without the closer body striking the intersecting partition face.

Glazed panels **22.17** Glass panels shall be securely fixed into the system by means of extruded aluminium vertical and horizontal trim section with vinyl strips, and so designed that the glass panels may be removed and replaced without dismantling the panel trim or framework. The system shall be capable of providing double glazing. All exposed edges and corners of glass screens shall be rounded and polished.

Skirtings **22.18** Skirtings shall be securely fixed to the partition framing by approved fixing materials and method. External corners in skirtings shall be formed from a continuous length. Mitred out or butted corners shall not be permitted.

Finishes **22.19** Gypsum plasterboard panels shall be faced with an approved fabric vinyl cloth as described in Clause 22.10. When required to be painted, gypsum plasterboard panels shall be prepared and two coats of anti-mould paint applied.

Plywood and chipboard surfaces may either be painted or faced with laminated plastic sheet or with 3.2 mm selected hardwood veneer. When required to be painted, plywood, chipboard and hardwood surfaces shall be knotted, primed, stopped and two coats of anti-mould paint applied.

Sound insulation **22.20** Where additional sound insulation is required, a layer of 50 mm thick fibreglass quilt or plastic foam slabs of an approved proprietary brand shall be placed close butt jointed within the partition framing. Detailing may vary depending on the proprietary system employed and the sound reduction factor specified. Airborne sound insulation shall be tested to **BS EN ISO 10140-1, 2 & 5** or **ASTM E413** and **ASTM E90**.

Alteration and resiting **22.21** During alterations to and re-installation of existing partitions, every care and precaution shall be exercised to avoid unnecessary waste and damage of the partition components and the erection and fixing to be executed in a workmanlike manner as previously described.

When partition components shall be transported from one building to another or to Government Store, they shall be adequately protected and every care and precaution shall be taken during loading, unloading and during the course of transportation to avoid damages to components.

Make good disturbed areas **22.22** Immediately upon completion of the Works and before handing over, clean up all partitions and doors and also floor, ceiling and walls upon which partition work has been carried out.

All disturbance to the floor, ceiling and wall structure and/or finishes during the course of partition work shall be made good to match existing.

LOWER LEVEL DEMOUNTABLE PARTITION (OPEN PLAN OFFICE LAYOUTS)

Generally **22.23** The system shall be simple and strong in construction, readily adaptable to suit different office layouts and be capable of being assembled and erected with high speed and efficiency.

The system shall also be fully demountable and shall provide maximum recovery of components including panel finishes and involve minimum amount of effort, time, and disturbances on wall and floor finishes when alterations and repositioning either in part or in whole are required. Any module shall be capable of being dismantled and replaced by one of the different types of panels in the series.

Completed partitions shall be free from exposed bolts, nuts, nail heads, screws heads and rivets.

Module **22.24** The partitions shall be constructed of standard module units, so assembled that individual panel can easily be dismantled or attached at a connection point being spanned by a component without removing components from adjacent panels and without upsetting the integrity of the system.

Accommodation for building services items **22.25** The system shall have suitable room and sufficient provision to conceal within the thickness of the partitions to accommodate normal electrical, communication and computer network wiring, and also the related fittings including electrical switches, power points and network nodes, etc.

Panels frames and posts **22.26** Panels, frames and posts shall be anodised extruded aluminium sections or equivalent. All panel post sections shall be of a size and shape which shall give adequate strength to the panel framing. The aluminium frames or equivalent shall contain fastening devices to accept a variety of decorative inserts including glass panels, veneer, fabric, and acoustic materials, etc. Cut sections of panel posts shall be covered with plastic top caps and be flushed with panel tops. Joints and fixings for the panels shall be performed to produce a rigid, stable and fully demountable system.

Screen panels **22.27** The nominal thickness of the screen panels shall be within the range of 38 mm to 50 mm thick overall. Panel sizes shall vary from 1020 mm to 1650 mm high overall and shall be available in such widths that, when used in conjunction with connectors, a centreline to centreline dimension shall be 600 mm, 900 mm, 1000 mm, 1200 mm or as specified.

Screen panels shall be covered with fabric and foam layer on both sides. Centre cores shall be kiln-dried wood frames covered both sides with pinboard or plywood boarding. Each screen panel shall be finished and protected on all exposed edges with impact resistant anodised aluminium moulding or equivalent. Round corners shall be used for all exposed edges.

The tops of panels shall be suitably protected with anodised aluminium sections or equivalent against cleaning and maintenance equipment and against damages during changes.

Hanging components **22.28** Screen panels shall be designed and constructed for hanging components such as work tops, shelf units and storage components, etc. All hang-on components shall be fixed securely by a locking mechanism but can be slot-fixed into patented panel posts by support brackets or metal clips.

The screen panel assembly shall be capable of carrying a total load of 454 kg minimum.

Screen fabric **22.29** Total thickness of the fabric shall be at least 3 mm. The fabric and the foam layer shall comply with the flammability standard **BS 7176+A1** Specification for resistance to ignition or its international equivalent if polyurethane foam material is adopted. For other materials, fabric and form shall meet Class 1 rate of surface spread of flame, **BS 476: Part 7**. The fabric shall be available with a reasonable choice of colours, and shall be specially designed for covering office screens.

Wall mounted rails **22.30** Wall mounted rails shall be of metal construction with sufficient strength and shall be suitable for mounting panels to walls with connectors to ensure continuous connections and stability of the panel system.

Panel connector **22.31** The panel connector assembly shall be a single piece unit, able to connect two, three or four panels together. It shall be in metal construction and finished with anti-mould paint coating. Self adjusting mechanism shall be provided with the connector to take up any tolerance variations to ensure tight connections and to adjust to various heights of panel at each joint.

Panel connector assembly shall be designed to carry vertical load of 454 kg minimum.

Support legs **22.32** Support legs shall be bronze anodised aluminium or equivalent. Ends of support legs shall be clipped and locked securely into the bases of screen panels. They shall be adjustable for levelling without disengaging from the internal components of the screen panels.

Skirting **22.33** Skirting shall be 1.0 mm thick (minimum) anodised extruded aluminium section or equivalent. Mitred or butted corners shall not be permitted.

Samples **22.34** Samples of fabric, foam, hinges and anodised aluminium section with the support of valid testing certificates for fabric and foam shall be submitted for the approval of the SO. Mock up sample of the system shall be provided if required.

VENETIAN BLINDS

Generally **22.35** The materials used to manufacture venetian blinds shall comply with **BS EN 13120+A1** and shall be free from visible defects e.g. dents, scratches, etc.

Blinds shall be installed in accordance with manufacturer's instructions.

Materials

Headrail **22.36** Headrail shall be enamel coated galvanised steel section to **BS EN 10162** of sufficient strength and thickness to support the completed blind without visible sagging or twisting.

Brackets **22.37** Blinds shall be supplied with galvanised steel fixing brackets able to support the blind and retain it securely.

Slats **22.38** The blinds shall be constructed with enamel coated flexible aluminium slats of 25 mm wide and 0.18 mm thick (finished thickness) ± 5% tolerance in thickness. The material and profile of any slat in the assembled blind shall be such as to provide the strength and flexibility in accordance with **BS EN 13120+A1**.

Slat widths within a blind shall be consistent to within + 0.2 mm or - 0.5 mm. Slats shall have radiused ends or corners and shall be free from burrs and sharp edges.

Bottom rail **22.39** The bottom rail shall be constructed from enamel coated galvanised steel section to **BS EN 10162** rigid throughout its length in the mounted blind. The ends of the bottom rail shall be enclosed with plastic end-caps.

Ladder tapes/cords **22.40** Ladder tapes or cords shall be constructed from polyester fibre.

Samples **22.41** Technical pamphlets and a sample of the venetian blind shall be submitted for the approval of the SO.

Workmanship

Headrail **22.42** The headrail shall not deviate from the horizontal by more than + 5 mm when the blind is mounted beneath a plane surface, and no part of the operating mechanism, within the headrail, shall make contact with that surface.

Unless specifically intended for installation within a recess or box, the ends of the headrail shall be closed off by plastic end caps.

Fixing brackets **22.43** Brackets shall be pre-bored to allow for end or top or face fixing. A minimum of 2 Nos. for blinds with widths not exceeding 1200 mm and 1 additional bracket for every increment of 600 mm in width. It shall be possible to remove the headrail from the brackets when they are fixed.

Fixing slats **22.44** Holes and slots cut into each slat shall be positioned symmetrically across the width of the slat and their width shall not exceed the width of the cord passing through them by more than 3 mm to minimize light penetration of the finished blind, consistent with satisfactory operation. The holes and slots in slats of the same blind shall align to within 1 mm, to minimize abrasion of cords and tapes passing through them.

In a finished, assembled blind, the slats shall be capable of tilting through an angle of not less than 70º to the horizontal in each direction and each slat shall overlap the adjoining slat by at least 10% of the slat width in each of the fully closed positions at any point of drop of the blind. The top slat shall be within 5 mm of the headrail in the fully closed position.

Unless specifically designed to clear an obstruction at the point of installation, the length of any slat shall be within ± 2 mm of the overall width of the blind, and the

alignment of slat ends at any position of the blind, shall not deviate from vertical by more than ± 2 mm.

Bottom rail **22.45** Unless specifically designed to clear an obstruction at the point of installation, the length of the bottom rail including end-caps shall be within ± 3 mm of the overall width of the blind.

Tape or cord securing points shall be in alignment to within 3 mm with the holes for these in the slats. Tape or cord anchorage shall withstand a force of 400 N applied directly to the tape or cord.

Control action **22.46** The rise and fall control mechanism shall ensure quick release and a smooth raising and lowering action at any position, with no fluctuation greater than ± 10% in the graduation of the force required to raise or lower the blind completely.

A cord locking control mechanism shall be released by drawing the control cord across the face of the blind and shall be locked when the cord is in a vertical position. The cord locking system shall be so designed that it shall not be possible to drop a blind accidentally.

Lift cords of 2 mm diameter shall have a breaking force of not less than 400 N when tested in accordance with the method given in Section 9 of **BS EN ISO 2307**.

Cords shall be secured together so as to prevent horizontal misalignment of the blind by pulling the individual rise and fall cords.

Tilt control **22.47** The tilt control shall be able to hold the suspended slats securely in any tilted position.

Control rods ("wand") shall have a breaking force of not less than 400 N when tested in accordance with the method given in Section 9 of **BS EN ISO 2307** and the "wand" shall be of solid core transparent plastic rods.

Ladder tape/cord **22.48** When tested in accordance with the method given in Section 9 of **BS EN ISO 2307**, vertical sections or supports of the tape or cord shall have a breaking strength of not less than 250 N; and the horizontal sections or cross-web of the tape or cord shall have a breaking strength of not less than 50 N. The cross web shall be securely joined to the vertical supports and shall withstand a force of not less than 50 N without separation. The interval between tapes in a finished blind shall be such that the horizontal deflection of the slats between ladders does not exceed 3 mm.

Tapes shall be distributed symmetrically across the blind width, and shall be provided at 225 mm from edge of blind and at 650 mm (maximum) centres.

Vertical blinds **22.49** Vertical blind louvres shall be made of 100 mm wide glass fibre slats or impregnated fabric of a colour and quality approved by the SO and shall be installed complete with all necessary accessory materials in accordance with the manufacturer's instructions.

The vertical blinds shall enable operation and rotation of slats in 180° upon a vertical axis to both sides by drawing of an endless cord or a chromium plated ball chain.

STRONGROOM DOORS

Generally **22.50** Strongroom doors are classified as follows:

Treasury Grade A	shall be as specified and comply with Director of Accounting Services requirements.
Treasury Grade B	shall be as specified and comply with Director of Accounting Services requirements.
Treasury Grade C	tough steel door with 25 mm thick door plate.

Treasury Grade D tough steel door with 10 mm thick door plate.

Treasury Grade E tough steel door with 8 mm thick door plate.

Treasury Grade C door

Door **22.51** The door shall have an overall thickness of 157 mm, of which the outer door plate to be 25 mm thick tough steel. The door plate of solid steel shall be further reinforced over the locks and vital parts. The lock and essential parts of the boltwork shall be protected by hardened steel plate to give overall metal protection of 38 mm thick.

Door frame **22.52** Door frame shall be made from substantial angles at the sides and top with a flat frame at the bottom. The frame shall be welded to form a complete structure of uniform strength. For securing the frame into the wall, three pairs of grip lugs shall be provided to suit a minimum wall thickness of 225 mm. The door shall be hung in the frame by hardened steel pivots working in steel carriages. Vertical thrust from the door shall be taken on a hardened steel ball bearing, vertical adjustment shall be provided.

Boltwork **22.53** There shall be six solid steel bolts at the front edge with six fixed dog bolts on the back edge of the door. All these bolts shall be 38 mm in diameter. The moving bolts and fixed dog bolts shall be engaged behind the solid rebates of the frame.

Locking **22.54** The lever-operated bolts throwing mechanism shall be secured by a 7-lever lock with monitor action to ensure that the door is always properly locked. The door shall also be fitted with a three wheel keyless combination lock to ensure maximum security. All locks shall be protected by a drill resistant plate.

Explosive protection **22.55** Anti-explosive protection devices shall be provided, which shall be designed to automatically re-lock the door if an attempt is made to dislodge the lock by explosive or other means.

Fire protection **22.56** A steel panel of 44 mm overall thickness incorporating proven fire resisting materials shall be fitted over the whole area of the lock chamber.

Treasury Grade D door

Door **22.57** The door shall have an overall thickness of 135 mm, of which the outer door plate to be 10 mm tough steel. The door plate of solid steel shall be further reinforced over the locks and vital parts. The lock and essential parts of the boltwork shall be protected by hardened steel plate.

Door frame **22.58** Door frame shall be made from 75 x 75 mm steel angles at the sides and top with a 10 mm flat steel frame at the bottom. The frame is welded to form a complete structure of uniform strength. For securing the frame into the wall, three pairs of grip lugs shall be provided to suit a minimum wall thickness of 225 mm. The door shall be hung in the frame by hardened steel pivots working in steel carriages. Vertical thrust from the door shall be taken on a hardened steel ball bearing, vertical adjustment shall be provided.

Boltwork **22.59** There shall be six 25 mm diameter solid steel sliding bolts engaged behind the 25 mm square rebate of the door frame. The edge of the door shall be hinged with a 40 mm x 20 mm full door height bar engaged behind the solid rebates of the frame.

Locking **22.60** The lever-operated bolts throwing mechanism shall be secured by a 6-lever lock with monitor action to ensure that the door is always properly locked. The door shall also be fitted with a three wheel keyless combination lock to ensure maximum security. All locks shall be protected by a drill resistant plate.

Explosive protection **22.61** Anti-explosive protection devices shall be as Clause 22.55.

Fire protection **22.62** A steel panel of 44 mm overall thickness incorporating proven fire resisting materials shall be fitted over the whole area of the lock chamber.

Treasury Grade E door

Door **22.63** The door shall have an overall thickness of 108 mm, of which the outer door plate to be 8 mm tough steel. The door plate shall be further reinforced over the locks and vital parts. The lock and essential parts of the boltwork shall be protected by hardened steel plate.

Door frame **22.64** Door frame shall be as Clause 22.58.

Boltwork **22.65** Four 25 mm diameter solid steel moving bolts shall be fixed at the front edge and four fixed bolts shall be engaged behind the 25 mm square rebate of the door frame.

Locking **22.66** The bolt-throwing mechanism shall be operated by a lever handle which shall be secured by a 6-lever lock or a three-wheel keyless combination lock as specified.

Explosive protection **22.67** Explosive protection shall be as Clause 22.55.

Fire protection **22.68** Fire protection of the strongroom door shall be as Clause 22.62.

Installation

Generally **22.69** Strongroom doors and frames shall not be installed unless the building is roofed or other protection provided and the strongroom has been constructed.

Doors must not be opened until the frame is securely strutted against falling forward. Door frame must not be fixed without the door.

Installation **22.70** Doors shall be positioned perfectly level and perpendicular in the wall opening and grip bolts to be attached.

Check and adjust the door by wedging until it swings freely, easily and shuts without binding.

Door frame positioning wedges shall only be driven between side frames and floor and not between sill and floor.

On no account shall any part of the door be chipped or filed.

Secure the door in position by grouting in the grip lugs. Before grouting, place vertical and horizontal wooden struts across the inside of the frame opening to prevent distortion of the frame during the grouting and setting process and the door shall be open at right angles and wedged to take the weight of the door off the frame.

LOCKERS

Compartments **22.71** Multi-tier lockers shall comprise a maximum of six-tier compartments and shall not be more than 2000 mm in overall height including the supporting frame or base.

Stacks of lockers may be connected together to form a block.

Material and construction **22.72** Sides, back and shelves of locker shall be manufactured from 24 SWG cold rolled galvanised steel sheet, jointed together to form the locker housing.

Door frames shall be manufactured from 20 SWG cold rolled galvanised steel sheets.

Doors and reinforced ribs shall be manufactured from 24 SWG cold rolled galvanised steel sheet. Doors shall be reinforced top and bottom with vertical rib for rigidity and security; and shall be mounted in a formed framework to the front of the locker housing.

All components shall be finished with baked enamel of colour as specified prior to final assembly.

Door fittings **22.73** Doors shall be fixed with door buffers for quietness. Door hinges shall be concealed self-closing type. PVC number plate with engraved numbers shall be fixed on each door.

Ventilation **22.74** Lockers shall be designed to allow free internal air circulation using perforated door and/or back panel, without impairing the security of locker compartments.

Safety **22.75** Lockers shall be free from any sharp points, edges and corners.

Door lock **22.76** Door lock may be one of the following:

(a) Cylinder spring bolt lock with large cylinder and 2 keys.

(b) Cylinder refund locks with detachable lockset, entirely made of stainless steel, controlled by master key.

The lock mechanism shall be securely protected to interlock with the frame upright.

CUBICLE SYSTEMS

Cubicle systems generally **22.77** Cubicle system shall comprise of pilaster panel, division panel, door and lock system, ledge wall if applicable, and the associated works in the installation of the system inclusive of all components, fixings, ledge wall behind sanitary fixtures if applicable, and ironmongery necessary for the erection of the works.

Cubicle systems to consist of panels with light weight core material and high-performance surface veneer which shall be impervious to water, easily cleaned and with a durable finish.

Panels shall be designed to be bolted or screwed together and may be raised on posts or wall brackets above floor level, floor mounted, or suspended from above.

Construction and Material **22.78** Panels, doors, pilasters, ledge walls and vanity top of cubicle system shall be either:

(a) Metal construction of baked enamel or vinyl finish constructed with hot-dipped galvanised steel sheets formed and bonded with a cellular honeycomb core, or polyurethane core, or other approved light weight core materials. Edges shall be tack welded around the perimeter and sealed with interlocking moulding. Moulding corners shall be welded to each other and to face sheets and ground smooth to form a rigid frame around the component.

(b) Plastic construction fabricated of high pressure laminate on cores of particle board or plywood. Composition core shall be multi-ply to resist warping and assure surface smoothness. Face laminate shall overlap edge laminate to assure water run-off and enhance adhesive bonding.

(c) Solid Laminate or phenolic panel of min. 12 mm thick for all components and complied with **BS EN 438**.

Doors and panels supplied under sub paragraphs (a) and (b) above shall be completely moisture resistant and 20 mm thick (minimum) and pilasters shall be 32 mm thick (minimum).

Colour, pattern, and texture of decorative surfaces shall be approved by the SO. Full spectrum of colour, pattern and texture shall be available for the SO's selection.

Door fittings **22.79** Doors shall be fixed with stainless steel or chromium-plated self-closing hinges which shall be adjustable to allow the door to open to different degrees.

Door latch shall be slide latch indicator bolt or concealed latch knob with indicator, or other proprietary product approved by the SO. Locking devices shall have emergency release mechanism.

Buffer hook also serving as clothes hook shall be fixed to each door.

Door stop and door keeper with full height rubber strip shall be fixed to the lock side of the pilaster.

All stainless steel ironmongeries shall be Grade 316. The ironmongeries shall include door hinges, thumb turn bolt with engaging indicator, coat hook with buffer and door stopper.

Fixing of cubicle systems **22.80** Cubicle system may be floor supported, wall mounted, overhead braced or ceiling hung. Overhead braced compartments shall be braced with anti-grip headrail.

Panels and headrails shall be screw-fixed to wall and pilaster with stainless steel brackets or aluminium channels.

Edges of pilaster shall be screw-fixed to wall with stainless steel brackets or aluminium channels.

Ceiling mounted pilaster shall be fixed to the overhead structural members by means of stainless steel inverted stirrup brackets and adjustable threaded stud and shall be covered with stainless steel plinth or other approved coverings.

Base of pilaster shall be screw-fixed to the floor by means of stainless steel inverted stirrup brackets with adjusting devices for levelling during installation and permanent height adjustment of the partitions. Connection between base of pilaster and floor shall be covered with stainless steel plinth or other approved coverings.

The fixings shall include adjustable foots for floor levelling, angle brackets and panel holder on the recessed aluminium powder coated head rail system. All stainless steel fixings shall be Grade 316.

FOLDING/SLIDING PARTITIONS

Folding Partitions generally **22.81** Partitions shall be continuously hinged and suspended with swivel hanger either at the end of alternating panels or centrally hung for all panels of a maximum height of 4500 mm. Tracks or guides, where used shall be flush with the floor finish and all ironmongery fittings are to have matched finishes.

Panels **22.82** Panel construction shall be either:

(a) 45 mm thick (minimum) and not exceeding 900 mm in width for end hung partitions or not exceeding 1200 mm for centrally hung partitions, consisting of hardwood frame and selected hardwood edging with plywood facing finished with either veneers, plastic laminate, vinyl cloth or anti-mould paint as specified. When specified, panels shall be infilled with mineral wool.

(b) Proprietary partition panels of aluminium or steel framing with particle board or steel faces. Thickness, width and height of panels shall be in accordance with manufacturer's recommendations.

Vertical seals **22.83** Vertical sound seals between panels shall be tongue and groove configuration incorporated with vinyl acoustical seals.

Horizontal as generally seals **22.84** Horizontal seals, both top and bottom shall be twin-finger contact type vinyl strips sweep seals fixed to the top and bottom edges of the panels.

Pass doors **22.85** Pass door shall be either a swing access door of a maximum height of 3000 mm, provided by the end leaf of a hinged unit consisting of an odd number of leaves or an independently hung leaf.

Alternatively, pass doors can be wicket doors required no thresholds and finish to match the partition panels.

Pass doors shall be fixed with stainless steel hinges and furnished with mortice latches with flush lever handles on both sides of the doors.

Suspension system **22.86** Suspension system shall consist of heavy duty extruded aluminium or hot-dipped galvanised steel track to **BS EN 10143** connected to the structural support by bolts or threaded rods.

Brackets shall be aluminium alloy pressure died castings or other approved bracket types, spaced at centres not exceeding 900 mm and shall be reduced to 600 mm centres for heavy doors.

Hangers shall be steel ball bearing type (lubricated for life) or proprietary trolley assembly: both shall be with vertical adjustment.

Panels shall be continuously hinged with stainless steel butt hinges fitted 3 in height on partition up to 3000 mm.

SECTION 23

PLUMBING AND DRAINAGE

GS for Building Services Installation and T&C Procedure for Plumbing & Drainage Installations

23.1 Comply with the **General Specification for Building Services Installation in Government Buildings of the HKSAR; Testing and Commissioning Procedure for Plumbing Installation in Government Buildings of the HKSAR;** and **Testing and Commissioning Procedure for Drainage Installation in Government Buildings of the HKSAR Edition.**

SECTION 24

EXTERNAL WORKS

ROAD, CAR PARKS AND PAVED AREAS

Generally

Roads, car-parks and paved areas generally **24.1**

The clauses under this sub-heading relate to pedestrian ways, cycle paths, playgrounds and other pedestrian paved areas and also include work in small areas, additional areas and the reinstatement and maintenance of existing surfaces. Where the Works of a more major nature are required and for the construction of roadworks, footways, cycle tracks and paved areas, such work will be specified in accordance with Section 10 on Concrete Carriageways and Section 11 on Miscellaneous Roadworks in the **General Specification for Civil Engineering Works (2020 Edition)**, issued by the Civil Engineering and Development Department, the **Construction Site Safety Handbook** issued by the Works Bureau and any relevant mandatory particular specification clauses in the **Construction Site Safety Manual** issued by the Development Bureau.

Generally unless otherwise specified in Drawings or otherwise approved by the SO, the construction of road, car-parks and paved areas shall comply with the requirements in Section 1 of Highways Department Standard Drawings (Drawing No. H1101 – H1134 latest revision).

For all the clauses and sub-clauses in Section 24 of the **General Specification for Buildings (2022 Edition)**, the **General Specification for Civil Engineering Works (2020 Edition)** shall include the current amendments of the Specification published before the date of the first tender invitation for the Contract.

For all external works that are used as roads, carriageway, car parks or paved areas for the purpose of future handover to the Highways Department for maintenance, such works shall be constructed in compliance with Highways standards as promulgated by the Highways Department.

Insitu concrete paving **24.2**

In-situ concrete paving, channels and kerbs shall be constructed in accordance with Structural Concrete Work - Section 6 or if so specified in accordance with Concrete for Minor and Non-structural Works - Section 8. Where the Works involved are of a major nature or involves the construction of footways, cycle tracks and paved areas, such works need to comply with Section 10 on Concrete Carriageways or Part 6 of Section 11 on Miscellaneous Roadworks in the **General Specification for Civil Engineering Works (2020 Edition)**, issued by the Civil Engineering and Development Department.

Construction of typical concrete pavement construction shall be in accordance with Highways Department Standard Drawing No. H1102 latest version, unless otherwise specified in Drawings or approved by the SO.

Precast concrete paving **24.3**

Precast concrete paving shall be as Clauses 6.42C, 18.112 and 18.126. The materials used for precast concrete paving and the construction of precast concrete paving shall comply with Part 7 of Section 11 on Miscellaneous Roadworks in the **General Specification for Civil Engineering Works (2020 Edition)**, issued by the Civil Engineering and Development Department.

Construction of typical construction details for precast concrete unit paving shall be in accordance with Highways Department Standard Drawing No. 1103 latest revision, unless otherwise specified in Drawings or approved by the SO.

For concrete paving blocks in landscape hard work, they shall be in accordance with Highways Department Standard Drawings No. H5101A and H5102A for concrete

paving blocks type "A" and "B", unless otherwise specified in Drawings or approved by the SO.

The product shall contain recycled aggregates, of which the following requirements shall be complied with:

(a) The aggregates shall contain not less than 70% by weight of recycled aggregates;

(b) The recycled fine aggregates shall constitute not less than 40% by weight of the total recycled aggregates. The recycled glass cullet should be included as recycled fine aggregates and should constitute 20% to 25% by weight of the total aggregates;

(c) The recycled aggregates, except recycled glass cullet, shall be of crushed inert construction and demolition materials produced from the crushing plant of the Civil Engineering and Development Department or other local sources approved by the Engineer.

The concrete paving units made of recycled aggregates should conform to all the specifications and requirements as provided in the Contract and as stated in the "Particular Specification (PS) for Precast Concrete Units for Paving" as incorporated in the Appendix A of the **ETWB Technical Circular (Works) No. 24/2004** on "Specification Facilitating the Use of Concrete Paving Units Made of Recycled Aggregates".

Materials

Bituminous products generally **24.4**

Bituminous materials for roadworks shall be in accordance with "Section 9 - Carriageways: Sub-base Material and Bituminous Materials" of the **General Specification for Civil Engineering Works (2020 Edition)**, issued by the Civil Engineering and Development Department.

The sub-base material shall contain crushed rock, crushed concrete, clean crushed inert demolition material or recycled glass cullet. The product shall conform to the technical requirement for its intended use as specified in Clause 9.03 of the **General Specification for Civil Engineering Works (2020 Edition)**.

Tack coat **24.5**

Tack coat of anionic and cationic emulsions shall be to **BS EN 13808 & BS 434-1: 2011 + A1: 2016** respectively and of the following types:

(a) Anionic bitumen emulsion, Class A1-40 of Table 1, **BS 434-1: 2011 + A1: 2016**

(b) Cationic bitumen emulsion, Class K1-40 as in Clause 4.2 of **BS EN 13808**

Bituminous base and wearing courses **24.6**

Bituminous base and wearing courses shall be as , Table 9.3 ,Section 9 – Carriageways of the **General Specification for Civil Engineering Works (2020 Edition)** referred to in Clause 24.4 and used in accordance with Table 24.1.

TABLE 24.1
Bituminous base and wearing courses

Nominal size (mm)	Use	Thickness per course	
		Min. (mm)	Max. (mm)
37.5	Coarse base course	60	120
28	Fine base course	50	85
20	Wearing course	40	60
10	Wearing course	20	40

The roadbase material shall contain a maximum of 15% of reclaimed asphalt pavement (RAP) by mass of the total mix.

Subject to the SO's approval, the Contractor may use bituminous wearing course and base course materials incorporating reclaimed asphalt pavement (RAP) for carriageway works. The RAP shall comply with the requirements specified in Clause 9.09(3) of the **General Specification for Civil Engineering Works (2020 Edition)**. Wearing course and base course materials incorporating RAP shall be designed, manufactured, laid and tested in accordance with the requirements for these materials using non-recycled materials or otherwise specified by the SO.

Fine cold asphalt **24.7** Fine cold asphalt shall be to **BS EN 13108-1** and **BS EN 13108-7**.

Surface dressing **24.8** Surface dressing aggregate shall be to **BS EN 13043** or RAP referred to in Clause 24.6, subject to the SO's approval.

Workmanship

Generally **24.9** Workmanship for asphaltic roadworks shall be in accordance with "Section 9 - Carriageways: Sub-base Material and Bituminous Materials" of the **General Specification for Civil Engineering Works (2020 Edition)**, issued by the Civil Engineering and Development Department.

Bituminous materials for footways, cycle tracks and paved areas shall be laid and compacted with steel-wheeled and pneumatic-tyred rollers and to be in strict accordance with Clause 11.58 of the **General Specification of Civil Engineering Works (2020 Edition)**, issued by the Civil Engineering and Development Department.

Construction of typical bituminous pavement construction shall be in accordance with Highways Department Standard Drawings H1101 latest revision, unless otherwise specified in the Drawings or approved by the SO.

Temperatures **24.10** Temperatures of bitumen in base and wearing course shall be kept above the minimum stated in Table 24.2.

TABLE 24.2
Temperature requirements for bituminous materials

Type of bituminous material	Roadbase, base course and wearing course		Friction course
Aggregate temperature at mixing (°C)	Min Max	130 175	115 135
Binder temperature at mixing (°C)	Min Max	135 165	115 165
Bituminous mixture temperature after mixing (°C)	Min Max	130 165	115 135
Bituminous mixture temperature at laying (°C)	Min Max		110 135
Bituminous mixture temperature at start of compaction (°C)	Min		85

Preparation of surfaces **24.11** Repeatedly brush surfaces on which materials shall be laid free from standing water, loose material and dust.

Tack coat **24.12** Spray sub-base with bitumen emulsion at the rate of 3 m^2/L. Brush out excess emulsion from minor depressions.

Regulating course **24.13** When specified lay and compact a regulating course to the required levels and profiles.

Machine laying **24.14** Lay the base and wearing course by means of an approved self-propelled paving machine. The paving machine shall produce a smooth uniform surface texture free from segregation, shoving or drag marks. A fully trained and experienced operator shall be in direct charge of the machine at all times.

Compaction plant **24.15** The minimum compaction plant that shall be used to compact bituminous roadbase, base course, regulating course, wearing course and sub-base material, shall be:

(a) A smooth three-wheeled steel-wheeled roller with a mass of between 6 tonne and 12 tonne, or a vibrating tandem steel-wheeled roller with an effective mass of between 6 tonne and 12 tonne, and a smooth pneumatic-tyred roller with a mass of between 12 tonne and 25 tonne, and with not less than seven overlapping wheels which have tyres that are capable of having pressures varying between 300 MPa and 800 MPa, and suitable mechanical rammers and hand-tools.

(b) Other types of rollers, vibrating plant and rammers approved by the SO, or other similar plant approved by the SO, necessary to produce the required degree of compaction.

Compaction **24.16** Commence compaction as soon as the material will bear the weight of the roller. Roll in a longitudinal direction only, each successive pass overlapping the last by at least a half-width of the rear roller. Rollers must not stand on newly laid material. Compact the base and wearing course so that air voids in the mixture are between 3.0 and 5.0% when measured in accordance with Section 9 – Carriageways of the **General Specification for Civil Engineering Works (2020 Edition)**.

Hand laying and consolidation **24.17** Hand operated mechanical compaction plant laying and consolidation by means of an approved mechanical tamper shall be permitted for work executed in patching-in repairs, reinstating surfaces over excavated trenches, surfacing areas inaccessible to the paving machine or roller, and surfacing areas which in the opinion of the SO, are too small to warrant the use of a paving machine and roller.

Wet weather **24.18** Avoid laying bituminous surfacings during wet weather. Do not lay during heavy rains or when free-standing water is present on surfaces to be coated.

Jointing **24.19**

(a) The screed of the paving machine shall overlap previously laid strips of bituminous material by at least 50 mm and shall be sufficiently high that compaction shall produce a smooth dense flush joint. Bituminous materials overlapping the previously laid strip shall be pushed back to the edge of the previously laid strip and the excess material shall be removed.

(b) Longitudinal joints in friction course or wearing course shall be formed coincident with the specified position of the lane-markings unless otherwise permitted by the SO.

(c) A prepared joint shall be formed between hot bituminous material and cold material or existing bituminous material which is at a temperature below the minimum specified laying temperature.

(d) The distance between prepared longitudinal joints in different layers shall be at least 150 mm, and the distance between prepared transverse joints in different layers shall be at least 500 mm.

(e) Prepared joints in base course and wearing course shall be formed by cutting back the face of the cold material or existing bituminous material for a minimum distance of twice the depth of the layer or 100 mm, whichever is greater; a vertical face shall be cut for the full depth of the layer. All loosened materials shall be removed and the face shall be coated with bituminous emulsion; the bituminous emulsion shall not be applied beyond the edges of the joint. The hot bituminous materials shall be laid and compacted against the coated face with a joint formed as stated in this clause.

(f) Unless otherwise permitted by the SO friction course joints shall not be coated with bituminous emulsion.

Accuracy **24.20** The level of each pavement course shall be determined from the surface of the wearing course calculated from the levels, sections, falls and cross falls shown on the drawings and the specified thickness of each course subject to the tolerances stated in Table 24.3, but in no circumstances is the nominal thickness of the wearing coat to be reduced by more than 5 mm.

The maximum deviation permitted in surfaces shall be 6 mm from a 3000 mm straight edge.

TABLE 24.3
Tolerances in level of formation and pavement courses (mm)

Type of surface	Permitted tolerance in level (mm)
Sub-base	+10 -20
Roadbase course	+8 -15
Base course Wearing course Friction course	+6

Use during construction **24.21** Keep the various pavement courses free from deleterious material at all times. Do not permit vehicular traffic on wearing courses or surfaces treated with bituminous material until 6 hours after the initial laying.

Cold asphalt **24.22** Apply tack coat as Clause 24.12 and hand lay and consolidate as Clauses 24.16 and 24.17.

Surface dressing existing areas **24.23** Thoroughly dry and sweep existing areas completely clean of all loose materials. Apply evenly by spray or brush as directed, bitumen or bitumen emulsion at the rate of 3 m^2/L. Immediately after the bitumen has been applied, spread a layer of 3 mm or 6 mm dry granite chipping over the surface and roll in until thoroughly embedded in the bitumen to obtain a uniform compact surface. Approximately one week later, sweep the area clear of all loose chipping and remove this and all debris from the Site.

Cleaning off **24.24** After surfacing or dressing has been executed, clear and clean all channels, kerbs, manhole covers, gratings, etc. free of all excess materials and bitumen.

DEEP BORE WELLS

Materials

Well casing **24.25** Steel well casing shall be 200 mm internal diameter galvanised mild steel tubing to **BS 879-1** and **BS EN 10216-1** & **BS EN 10217-1** with threaded ends for connection.

Thermoplastic tube casing and slotted casing shall be to **BS 879-2** and as shown on the drawings

Well screen **24.26** Well screen shall be 200 mm internal diameter hot dipped galvanised bridge slotted well screen from an approved manufacturer with threaded ends for connection.

Workmanship

Drilling **24.27** Drill the bore hole to a sufficient diameter to accommodate a continuous length of well casing and well screen. Protect the wall of the drill hole with temporary liners.

Stop drilling when water is obtained at the specified rate of 100 L/min with a minimum yield of 20000 L per day on completion unless otherwise specified and depth of drilling shall not be less than 20 m. The drilling of the bore hole well shall be properly vertical.

Test alignment of the bore hole well with a 12 m long dummy, having an outside diameter of 15 mm less than the well casing which shall move freely throughout the depth of the well to the satisfaction of the SO.

Blasting will not be permitted and the Contractor shall allow for drilling through rock or other obstructions.

The method statements and sequences of construction shall be submitted to the SO for approval at least 60 days prior to commencement of site work, unless otherwise specified in the Drawings.

Testing **24.28** Provide all necessary equipment for carrying out tests for rate of water yield, water salinity, presence of other dissolved solids and the pH factor.

Test the borehole well as directed by the SO at specified depths and on completion. Carry out yield tests continuously for eight hours and record yields at hourly intervals at specified depth. Submit results to the SO immediately after each test.

Lining **24.29** Protect the bottom of the well with 0.05 m^3 of coarse river sand. Line the bore hole with well casing for the top 15 m and the remaining depth with well screen all lengths being properly jointed together. Fill any voids around the screen with coarse river sand.

Abandoned bore holes **24.30** If the bore hole is abandoned, withdraw temporary liners and backfill the bore hole with approved material.

EXTERNAL SERVICES

Cable ducts **24.31** Construct cable ducts generally in accordance with Section 5 on Drainage Works in the **General Specification for Civil Engineering Works (2020 Edition)**, as issued by the Civil Engineering and Development Department.

Space pipes which form multiple cable ducts shall be 50 mm (minimum) apart. Leave in position one 6 mm diameter nylon draw cord in each length of duct.

The location and depth (or minimum cover) of underground utilities (including but not limited to cable or cable duct) at roads, carriageways, footways or pavements etc. shall comply with the requirements as specified by the Highways Department.

Draw in pits **24.32** Form temporary draw in pits and backfill with clean sand and provide 50 x 50 x 600 mm long timber location marker. Construct draw-in pits in accordance with drawings.

Record drawings **24.33** Provide all information required by the SO for preparation of record drawings.

FENCING AND GATES

Materials

Fencing wire **24.34** Steel wire for fencing, including chain link and barbed wire shall be to **BS 4102**.

(a) Galvanised steel wire.

(b) Grade A - Plastic coated galvanised steel wire.

(c) Grade B - Plastic coated steel wire.

24.35 Galvanized wire netting shall be to **BS EN 10223-2**, or **BS EN 10223-4,** or **BS EN 10223-5,** or **BS EN 10223-6** or of approved local manufacture according to design requirements.

Steel fence posts and gates **24.36** Steel fence posts and gates shall be constructed in accordance with Section 17.

Workmanship

Fencing generally **24.37** Erect fencing to the lines and levels indicated on the drawings. Fencing shall be erected to a smooth alignment with no abrupt irregularities. The ground shall be trimmed or filled in such a manner that the bottom of the fence will approximately follow the level of the ground. The distance between the bottom of chain link mesh and hoarding and the ground shall not exceed 100 mm.

Fencing wire **24.38** Line wire, chain link mesh and barbed wire for fencing shall be strained tightly between straining posts. Winding brackets shall be used for straining between steel posts. The tension in the wire on each side of straining posts shall be equal. Wire shall be strained until at least 14 days after concrete has been placed in the foundation.

SECTION 25

LANDSCAPE WORK

EARTHWORKS AND SOILING

Materials

Imported soil generally **25.1** Produce adequate samples and obtain approval for all soils and similar materials before importation and use.

Existing soil on site **25.2** The Contractor shall be deemed to have inspected at tender stage both the existing topsoil and subsoil and satisfied himself that both are acceptable for the work as specified. If the existing materials are found unsatisfactory by the SO, they shall be carted off site to a designated disposal area, and subject to prior approval, imported soil materials shall be used. In particular, concrete and building debris shall be removed from all soil on site.

Existing subsoil on site **25.3** The existing subsoil shall consist mainly of granular decomposed rock types, such as decomposed granite (DG) or decomposed volcanics, which are usually derived from original deposits on site. Unsuitable material shall be removed from site as Clause 25.2.

Decomposed granite (DG) **25.4** Imported DG shall be friable, fine grained decomposed granite free from all impurities and other deleterious materials including chemicals, oils, cement, concrete, sticky clay and stones exceeding 25 mm diameter.

Topsoil **25.5** Topsoil: evenly textured, fertile, dark brown or black, free draining, sandy loam with the following properties:

(a) The top 300 mm fertile layer immediately below undisturbed vegetation, and not derived from recent paddy field cultivations;

(b) Containing not less than 7.5% organic matter;

(c) Having a pH value between 5.5 and 7.0;

(d) Free from all kinds of pests, pernicious and/or perennial weeds and roots, grass, clay lumps, non-soil material, brick, cement, concrete and other building materials, foreign matter and contamination;

(e) Maximum stone content % (m/m) as tested under **BS 1377-2**

Stone size in any direction:		
	> 2 mm	30
	> 20 mm	10
	> 25 mm	0

If used in playing field or planting areas within and/or in close proximity to recreational activities areas (such as children playground and fitness station), the top 150 mm shall be free from stones exceeding 20 mm and not sharp-edged in any direction.

(f) Exchangeable sodium percentage (ESP) %: <15.

The source proposal of the Topsoil shall be submitted for the approval by the SO at least 14 days before the relevant work starts.

Fabricated Soil Mix **25.6** Fabricated Soil Mix shall consist of friable, completely decomposed granite (or volcanics) and manufactured soil conditioner in the proportions of 3:1 by volume. The mix shall be mixed evenly and shall be free from grass or weed growth, sticky clay, salt, chemical contamination, and any other deleterious materials and stones

as Clause 25.5(e), and possess the following characteristics as tested under **BS 3882** and **BS 1377-2**

(a) pH value between 5.5 and 7.0;

(b) Organic matter more than 10% (m/m);

(c) Nitrogen content more than 0.2% (m/m);

(d) Extractable phosphorous (P) content more than 25 mg/l of the mix;

(e) Extractable potassium (K) content more than 240 mg/l of the mix;

(f) Extractable magnesium (Mg) content more than 50 mg/l of the mix;

(g) Soil texture content:

Sand (0.06 - 2.0 mm): at the range of 40% - 75%;
Silt (0.002 - 0.06 mm): at the range of < 40%;
Clay (less than 0.002 mm): at the range of < 20%

(h) Maximum stone content % (m/m) as Clause 25.5(e);

(i) Exchangeable sodium percentage (ESP) %: <15.

Manufactured soil conditioner **25.7** Manufactured soil conditioner shall comprise properly composted organic material with the following characteristics:

(a) Fine, free flowing consistency;

(b) In stable condition;

(c) Not capable of raising the temperature of the treated soil more than 5ºC above the temperature of the untreated soil;

(d) Free from impurities and not made with materials that are known to contain pathogens or other toxic materials injurious to plants, humans, or animals;

(e) Giving off neither toxic nor obnoxious fumes/odour;

(f) With a pH value between 6.0 and 8.5;

(g) With a moisture content when saturated between 25-50% (moisture weight as a proportion of overall weight);

(h) With an organic matter content of not less than 50%;

(i) With a carbon nitrogen ratio between 20 and 30;

(j) No weed growth, other foreign matter or contamination.

Test for manufactured soil conditioner **25.8** Certification: prior to first use and for every 300 m^3 delivered to the Site, produce certificates of analysis of the soil conditioner from an approved laboratory within 14 calendar days of taking the samples. An approved laboratory shall mean one of the Employer's laboratories or an Accredited Laboratory. Sampling and tests shall be carried out according to **BS 3882** and **BS 1377**. Test report shall be in the format as per the typical declaration of analysis under **BS 3882**. Each certificate shall state the results of test for the following properties stipulated for compliance in Clause 25.7:

(a) pH (H_2O) value;

(b) Organic matter content (dry weight);

(c) Organic carbon content (using loss of ignition "Ashing" method of testing);

(d) Nitrogen content: ("Kjeldahl" Method);

(e) Carbon: nitrogen ratio;

(f) Moisture content (calculated as the loss in weight between the dry weight and the overall weight as a percentage of the overall weight).

The manufactured soil conditioner to be sampled and tested shall be selected by the SO's supervisory staff at the appropriate level. The sampled soil shall be placed in tamper evident bag, and on the same day, the SO's supervisory staff at appropriate level shall supervise the delivery of the sampled soil to the approved laboratory. Test results must be supplied directly to the SO in sealed envelope, not via the Contractor.

Sand **25.9** Sand shall be clean, sharp graded agricultural or horticultural sand 4 mm down to dust and not collected in brackish water marine environment.

Lightweight Soil Mix **25.10** Lightweight Soil Mix shall consist of 2 parts of decomposed granite as Clause 25.4, 1 part soil conditioner as Clause 25.7 and 1 part vermiculite pellets or volcanic pellets with a particle size of 5 – 10 mm. Maximum stone content % (m/m) shall comply with Clause 25.5(e).

Alginate **25.11** Alginate shall be organic, derived from seaweed as soil improver, to be incorporated into the top 300 mm of soil during cultivation, when directed by the SO.

Soil stabilizer **25.12** Soil stabilizer shall be an approved proprietary type of binding medium applied in an aqueous suspension by spraying onto the surface of the soil to prevent short term erosion and to condition the soil. The binding agent shall not be injurious to plant growth.

Stone chips **25.13** Stone chips shall be clean, sharp graded suitable for horticultural use 4 – 2 mm, with no weed growth, free of other foreign matter or contamination, and not collected in brackish water marine environment.

Test for Topsoil **25.14** Certification: prior to first use of any Topsoil from each approved source and for every 300 m^3 delivered to Site, produce certificates of analysis of Topsoil from an approved laboratory within 14 calendar days of taking the samples. An approved laboratory shall mean one of the Employer's laboratories or an Accredited Laboratory. Sampling and tests shall be carried out according to **BS 3882** and **BS 1377**. Test report shall be in the format as per the typical declaration of analysis in **BS 3882**. Each certificate shall state the results of test for the properties stipulated for compliance in Clauses 25.5.

Topsoil to be sampled and tested shall be selected by the SO's supervisory staff at the appropriate level. The sampled soil shall be placed in tamper evident bag, and on the same day, the SO's supervisory staff at appropriate level shall supervise the delivery of the sampled soil to the approved laboratory. Test results must be supplied directly to the SO in sealed envelope, not via the Contractor.

Test for Fabricated Soil Mix **25.15** Certification: after mixing operation but prior to first use in any planting and/or grassing works and for every 300 m^3 of the mix, produce certificates of analysis of Fabricated Soil Mix from an approved laboratory within 14 calendar days of taking the samples. An approved laboratory shall mean one of the Employer's laboratories or an Accredited Laboratory. Sampling and tests shall be carried out according to **BS 3882** and **BS 1377**. Each certificate shall state the results of test for the following properties stipulated for compliance in Clause 25.6:

(a) pH (H_2O) value;

(b) Organic matter content (dry weight) expressed in %;

(c) Organic carbon content (using loss of ignition "Ashing" method of testing);

(d) Nitrogen content: ("Kjeldahl" Method) expressed in %;

(e) Extractable phosphorous (P) content per litre of the sample;

(f) Extractable potassium (K) content per litre of the sample;

(g) Extractable magnesium (Mg) content per litre of the sample;

(h) Soil texture content expressed in percentage of the following categorization of soil particles sizes:

(i) sand (0.06 - 2.0 mm);
(ii) silt (0.002 - 0.06 mm); and
(iii) clay (less than 0.002 mm).

(i) Stone content % (m/m) as tested under **BS 1377-2**;

(j) Soil salinity;

(k) Moisture content (calculated as the loss in weight between the dry weight and the overall weight as a percentage of the overall weight);

(l) Carbon: nitrogen ratio;

(m) Exchangeable sodium percentage (ESP) %.

Fabricated Soil Mix to be sampled and tested shall be selected by the SO's supervisory staff at the appropriate level. The sampled soil shall be placed in tamper evident bag, and on the same day, the SO's supervisory staff at appropriate level shall supervise the delivery of the sampled soil to the approved laboratory. Test results must be supplied directly to the SO in sealed envelope, not via the Contractor.

Fertilizer generally **25.16** Fertilizers shall be chemical compounds stored in waterproof sealed bags off the ground under shelter, away from direct sunlight and protected from exposure to conditions (such as temperature and humidity) which may adversely affect the fertilizer.

Pre-planting fertilizer **25.17** Pre-planting fertilizer shall be an approved granular slow release compound comprising Nitrogen (N) Phosphorus (P) and Potassium (K) and trace elements in the ratio: 15:9:15:2.

Boulders **25.18** Boulders shall be igneous, sedimentary or metamorphic rock obtained from a local source, rounded, and with a natural, weathered appearance, free from blasting and drill marks and permanent paint marks, and to the colour and shape as specified. Sizes ranging from a minimum of 750 x 600 x 500 mm to a maximum of 3000 x 2500 x 1500 mm.

Serpentine boulders **25.19** Serpentine boulders shall be hard metamorphic rock, normally obtained from Taiwan. The rock shall be strongly veined blue and white, each with a tolerance which shall not deviate from the specified size (in width, depth and height) by more than ± 25 mm in any dimension.

Great Lake Rock **25.20** Great Lake Rock from the Great Lake (Tai Hu) near Suzhou, or from other approved regions of China and shall possess the following characteristics:

(a) Each rock being of one piece naturally;

(b) Slender appearance with folds and a large number of holes on the surface and containing such shapes as "deep hollows", "eye holes", "twists", and "strange grooves", without visual defects;

(c) Size: The size of individual Great Lake Rock to be used shall be determined by the overall composition of the rock formation, to attain a structurally stable and suitable sculptural form, each with a tolerance which shall not deviate from the specified size (in width, depth and height) by more than ± 50 mm in any dimension.

Ying Rock **25.21** Ying Rock shall be selected from the Yingzhou part of Guangdong Province and should possess the following characteristics:

(a) Ying Rock shall have the shapes of pointed or rounded peaks with concavities and eyeholes that twist around and inter-connect. The texture shall be slightly glossy and a faint sound echoes when it is struck. The traditional description of the rock are "slender beauty", "transparent" and "penetrable".

(b) Colours of Ying Rock shall include the following:

(i) Light grey with white veins winding through it;
(ii) Slightly greyish black;
(iii) Pale green.

(c) The size of individual Ying Rock to be used shall be determined by the overall composition of the rock formation, to attain a structurally stable and suitable sculptural form, each with a tolerance which shall not deviate from the specified size (in width, depth and height) by more than ± 50 mm in any dimension.

Yellow Soap Stone **25.22** Yellow Soap Stones shall be hard and metamorphic rock normally obtained from China. The rock shall be yellow / brownish in colour and may have dark brown veins. The rock is normally smooth and without sharp edges. The rock shall be of various size, each with a tolerance which shall not deviate from the specified size (in width, depth and height) by more than ± 25 mm in any dimension.

Workmanship

Clearing ground **25.23** Clear away all weeds with physical means, rubbish, litter, stones exceeding 25 mm diameter and all deleterious material from the surface of the ground within the planting areas. Weeds shall be cleared without using herbicide unless permitted by the SO. If permitted, the herbicide shall be approved by the SO and shall be applied all in accordance with the manufacturer's recommendations and Clauses 25.74(c)(ii) and 25.94.

Grading **25.24** Grade existing subsoil to final formation levels in workmanship all in accordance with **BS 4428**:

(a) 300 mm below finished levels in shrub planting areas;

(b) 125 mm below finished levels in grass planting areas;

(c) Form to free flowing contours without water collecting hollows.

Cleaning existing soil and subsoil **25.25** Clean existing soil to a depth of 400 mm in shrub areas and 250 mm in grass areas and existing subsoil to a depth of 200 mm, free of rubbish, pernicious and/or perennial weeds, metal, deleterious matter, and all stones exceeding 25 mm in any direction.

Contaminated ground **25.26** Excavate all areas contaminated by petrol, oil or other toxic substances to 500 mm below and 500 mm beyond the perimeter of the contaminated ground to be planted or sown and remove excavated material from site to a designated disposal area. Backfill all holes with decomposed granite in subsoil areas and fabricated soil in topsoil areas.

Forming to re-grade	**25.27**	Re-grade the subsoil to the required levels and contours allowing for settlement and an overall even compaction without adversely affecting the soil structure.
Ripping	**25.28**	Rip the ground or subsoil prior to spreading topsoil or fabricated soil mix. De-compact existing ground or subsoil to a depth of 300 mm at 500 mm centres by means of a tractor drawn tine or plough or hand digging. Remove from site all obstructions to cultivation or deleterious material brought to the surface, to a designated disposal area, and backfill any voids with decomposed granite. Ground at a slope exceeding 15º shall not be ripped.
Scarifying	**25.29**	Scarifying shall be carried out by loosening the soil to a depth of between 10 mm and 20 mm using a pronged implement such as a rake but without turning the soil.
Cultivation	**25.30**	Cultivate to a depth of 300 mm. Remove all stones and rubbish exposed during cultivation and dispose off site. Apply soil conditioner at a rate of 0.15 m^3/m^2 and pre-planting fertilizer at 40 g/m^2. Work added materials evenly into the top 250 mm of cultivated soil. Stones exceeding 25 mm diameter in any direction shall be removed from the surface after cultivation.
Protection of prepared ground	**25.31**	Prepared ground shall be protected from compaction, erosion and siltation and shall not be used by constructional plant, vehicles or pedestrian traffic. Restore and replace by methods approved by the SO, any portion of the prepared ground which was compacted, eroded, silted up or otherwise damaged.
Boulder placing, small and medium size	**25.32**	Place small and medium sized boulders less than 1800 mm high, of the type specified, in the required positions during backfilling but prior to planting. Fix the boulders to ensure complete stability, and wedge with small rocks to prevent movement, with 25% by volume of the boulder below finished ground level, all to be approved by the SO.
Boulder placing, large size	**25.33**	Place large sized boulders/ rocks over 1800 mm high of the type specified, in the required positions during backfilling but prior to planting. The boulder shall be set at least 450 mm below the surrounding ground level before concreting in place. Ensure complete stability, and wedge with small rocks to prevent movement. Pour a concrete base 300 mm larger all round than the boulder and a minimum of 500 mm deep, with concrete haunching 200 mm around the sides of the boulder.
Stockpile areas	**25.34**	Approval of stockpile areas from the SO regarding the locations, materials and duration to be stockpiled prior to the commencement of any stockpiling of materials should be sought.
Stockpile stability	**25.35**	Stabilize firmly all soiling materials stockpiled against wind blow and erosion by water, at all times.
Stockpile reclamation	**25.36**	Clean and make good the surface of any stockpile to its original condition at the completion of soil preparation work.
Stockpile maintenance	**25.37**	Maintain the stockpile free from over-compaction and any source of contamination.
Forming, handling and storage of soil heaps	**25.38**	For stripping and storage of Topsoil and all other soiling materials, soil heaps shall be formed and handled in workmanship in accordance with **BS 4428** with reference to **BS 3882**. Should any landscape soiling materials be stored off-site, a method statement specifying the storage location, the amount to be stored, the quantity to be mixed with other materials, sampling and inspection schedule shall be agreed with the SO.
Spreading and filling up soiling materials	**25.39**	All kinds of soiling materials shall be handled carefully during spreading and backfilling/infilling to avoid potential damage to soil structure by machine induced compaction. No soiling works (include mixing, spreading, handling and stockpiling) shall be carried out in wet conditions. All kinds of soiling materials shall be spread and levelled to the depth stated in the Contract. The depth of uncompacted soiling materials shall be sufficient to allow the level of the area to

comply with finished levels after natural settlement has taken place. After soiling, the Contractor shall take all necessary preventative measures to control erosion and siltation and to prevent the area from compaction.

Unsuitable and surplus soiling material **25.40** Remove from site immediately any soiling material which does not comply with the specification in Clauses 25.1 to 25.17 (all inclusive) or which has become contaminated. Surplus material from excavation or backfilling/infilling shall be handled in accordance with Clause 3.10.

DRAINAGE

Materials

Drainage aggregate **25.41** Aggregate shall be:

(a) Clean, rounded stone, 25 – 50 mm diameter, and

(b) Free from weeds, other building materials, foreign matter and contamination.

Drainage aggregates, if so instructed by the SO, shall be subjected to sieve analyses to **BS EN 933-1**.

Lightweight aggregate **25.42** Lightweight aggregate shall be clean clinker, or equal and approved, 20-50 mm in diameter, weighing a maximum of 500 kg/m^3 when compacted.

Filter layer **25.43** Filter layer shall be a permeable non-woven, thermally bonded geotextile filter fabric, which is not affected by acids, alkalis, bacteria, humidity, or rotting, and shall meet performance requirements set out in Table 25.1 in sound performance for minimum 12 years.

TABLE 25.1

Types of Filter Layers

Type	Properties	Test Method	Acceptance Standards (±10%)
A	Mechanical Properties		
	(i) Wide width strip tensile	**BS EN ISO 10319**	
	- Mean peak strength		3.0 kN/m
	- Elongation at peak strength		35 %
	- Strength at 5 % strain		1.3 kN/m
	(ii) CBR puncture resistance	**BS EN ISO 12236**	
	- Mean peak strength		525 N
	Hydraulic Properties		
	(i) Pore size	**BS EN ISO 12956**	
	- Mean AOS O_{90}		300 µm
	(ii) Permeability	**BS EN ISO 11058**	
	- 5cm head		150 L/m^2/s
B	Mechanical Properties		
	(i) Wide width strip tensile	**BS EN ISO 10319**	
	- Mean peak strength		6.0 kN/m
	- Elongation at peak strength		25 %
	- Strength at 5 % strain		2.6 kN/m
	(ii) CBR puncture resistance	**BS EN ISO 12236**	
	- Mean peak strength		1050 N
	Hydraulic Properties		
	(i) Pore size	**BS EN ISO 12956**	
	- Mean AOS O_{90}		180 µm
	(ii) Permeability	**BS EN ISO 11058**	
	- 5cm head		130 L/m^2/s

C	Mechanical Properties (i) Wide width strip tensile - Mean peak strength - Elongation at peak strength - Strength at 5 % strain (ii) CBR puncture resistance - Mean peak strength	**BS EN ISO 10319** **BS EN ISO 12236**	 8.0 kN/m 28 % 3.4 kN/m 1500 N
	Hydraulic Properties (i) Pore size - Mean AOS O_{90} (ii) Permeability - 5cm head	**BS EN ISO 12956** **BS EN ISO 11058**	 150 μm 100 L/m^2/s

Pea gravel **25.44** Pea gravel shall be clean rounded river washed gravel 5 – 12 mm in size.

Gravel **25.45** Gravel shall be clean, broken granite stone, 10 – 30 mm in size.

Workmanship

Filter layer application **25.46** Cover all drainage aggregate with a sheet of filter layer having 200 mm minimum overlaps. Ensure entire filter layer as Clause 25.43 is smooth and free of tension stress, folds, wrinkles and creases. Overlap each successive strip of over previously laid strip by 200 mm minimum over previously laid strip and all in accordance with manufacturer's instructions and recommendations.

Protection of filter layer **25.47** Protect installed filter layer from displacement, damage or deterioration before, during and after placement of drainage system. Do not permit passage of any vehicle or machinery directly on drainage system at any time. No storage or stockpiling of any kind shall be allowed on any part of filter layer. Replace damaged or deteriorated filter layer and/or any part of the subsoil drainage to the satisfaction of the SO.

PLANTING - GENERAL

Materials

Plants **25.48** All plants, seeds etc. shall be true to species; plants shall be healthy and with the habit and size of the plant as specified. Plants and seeds shall be free from pests, diseases, parasites, discolouration, and damage. All plants shall be obtained from an approved cultivated source and not from the wild.

Plant habit **25.49** All plants shall have a vigorous fibrous root system, and have a well developed shape for the species as specified.

Plant name **25.50** In the event of any discrepancy between the scientific name, English common name, and the Chinese common names as specified, the scientific name shall prevail.

Size of trees **25.51** The height of all trees to be measured from immediately above the root collar and the diameter of all stems shall be measured at a height of 1300 mm above the root collar.

Parasitic plants **25.52** Parasitic plants, as defined by the Agriculture, Fisheries and Conservation Department, shall not be present in any form on any plant or soil brought to the Site. Plants and soil found to be affected by parasitic plants shall be removed from the Site and destroyed. The following species are considered as the most common parasitic plants:

(a) *Cuscuta australis* (European Dodder);

(b) *Cuscuta chinensis* (Chinese Dodder, Yellow Colour Thread);

(c) *Cuscuta reflexa* (Yunnan Dodder);

(d) *Cassytha filiformis* (Cassytha).

Noxious weeds **25.53** Species of noxious and invasive weeds, as defined by the Agriculture, Fisheries and Conservation Department, shall not be present in any form on any plant or soil brought to the Site. Such noxious weeds shall be cleared manually from all affected areas within the Site and disposed off site, at the Contractor's expense, all in accordance with the guidelines and practice notes promulgated by the Agriculture, Fisheries and Conservation Department (AFCD) (Information can be viewed from AFCD's internet homepage (www.afcd.gov.hk)). All the cutting arising from physical removal shall not be left on ground but should be packed in bags for proper disposal. The following species in particular shall be dealt with immediately by physical control when discovered:

Scientific name	Guideline and Methods of Clearing
(a) *Mikania micrantha* Kunth.	Use of chemical or biological control agent is not accepted. Clearing with physical means shall be carried out in accordance with the technical guideline and method promulgated, by AFCD, under Nature Conservation Practice Note No. 1 – Clearing Mikania which can be viewed from AFCD's internet homepage.

Containers **25.54** Containers shall be rigid or semi-rigid receptacles with drainage holes at base in which plants are delivered and grown for not less than three months in the growing season before planting. All containerized plants shall not have pot bound roots.

Rootballs **25.55** Rootballs comprise the firmly bound fibrous root and soil of a plant. At all times and in particular during delivery, the rootballs shall be retained intact.

Substitution **25.56** Substitution of specified plant materials shall not be permitted except under special circumstances and with prior approval from the SO.

Slow release fertilizer **25.57** Slow release fertilizer shall be granular NPK chemical fertilizer with a minimum four (4) month release period at 32ºC with the following formula:

14 - 18	parts N	(Nitrogen)
7 - 14	parts P_2O_5	(Available Phosphoric Acid)
12 - 16	parts K_2O	(Soluble Potash)
max. 2	parts MgO	(Magnesium Oxide) plus other trace elements.

Quick release fertilizer **25.58** Quick release fertilizer shall be granular NPK chemical fertilizer with a minimum two (2) week release period at 32ºC with the following formula:

14 - 16	parts N	(Nitrogen)
14 - 16	parts P_2O_5	(Available Phosphoric Acid)
14 - 16	parts K_2O	(Soluble Potash)

Limestone **25.59** Limestone may be used to reduce the acidity of the soil. It shall be ground limestone, containing a minimum of 90% calcium and magnesium carbonates and capable of passing through a 10 mm mesh sieve. Prior to use, take samples and produce a certificate of analysis of the limestone from an approved laboratory within 14 calendar days of taking the sample. An approved laboratory shall mean one of the Employer's laboratories or an Accredited Laboratory. Each certificate to state calcium and magnesium carbonate content and the particle size.

Mulch **25.60** Mulch shall be composed of an organic material such as leaf litter, tree bark, wood shavings, wood bark, decomposed sawdust, chopped tree fern, with a nominal size of 2 – 20 mm or other approved material. It shall have the following characteristics:

(a) In friable and non-gluey texture;

(b) In stable and dry condition;

(c) free from impurities and not made with materials that are known to contain pathogens or other toxic materials injurious to plants, humans, or animals;

(d) Giving off neither toxic nor obnoxious fumes/odour;

(e) Not subject to wind erosion;

(f) No weed growth, other foreign matter or contamination.

Pine bark mulch **25.61** Pine bark mulch shall be very coarse treated pine tree bark, 20 – 150 mm size, free from all kinds of pest, impurities, contamination and other deleterious materials.

Plant labels **25.62** Plant labels shall be:

(a) 100 x 50 x 2 mm white acrylic with 2 no. 5 mm diameter holes, centred 25 mm apart 10 mm from one edge, complete with non-abrasive nylon rope 3 mm diameter for securing to plants, and

(b) The scientific names and Chinese common names of the plant shall be heat embossed onto the label in black lettering. The size of the letters shall not be less than 10 mm and the Chinese characters not less than 13 mm high. Submit a sample for the SO's approval prior to ordering.

Protective fencing for planting works **25.63** Protective fencing for completed planting works shall be proprietary-make bamboo fence comprising the following characteristics:

(a) 600 mm or 900 mm high.

(b) 10 – 20 mm diameter bamboo palings fastened together at each joint with galvanized metal staples and washers, which when erected forms a framework with palings at 150 mm centres.

(c) The fence shall be fixed with rot proof wire to vertical metal stakes comprising 1200 mm long for 600 mm high fence or 1500 mm long for 900 mm high fence, driven 600 mm into the ground at 2000 mm centres.

(d) The metal stakes as detailed above shall be painted black with one primer coat and one finishing coat before installation. All edges of the stakes above ground level shall be smooth.

Wound sealant **25.64** Sealant shall be a proprietary type tree wound dressing that is emulsion formulated and non petroleum based. The dressing shall remain flexible after drying and withstand all weather conditions for arboricultural use in subtropical climate. The sealant shall be approved by the SO prior to application.

Metal stakes **25.65** Metal Stakes shall be 40 x 40 x 4 mm thick GMS angle-iron painted with one coat of approved primer and one coat of approved finishing coat prior to installation. Height of stake shall be 1800 mm or as specified to suit height of plant being supported.

All sharp edges of the metal stakes shall be removed to avoid damage to the plant.

The primer and finishing coat shall be approved by the SO prior to application.

Bamboo stakes **25.66** Bamboo stakes shall be minimum 50 mm diameter bamboo poles and 1500 mm high to suit the height of the plant being supported. All exposed ends shall be properly dressed and finished.

Ties **25.67** Ties shall be either of the following which shall be capable of adjustment after fixing, and shall be fitted with flexible rubber or plastic sleeves to prevent chafing, rubbing or abrasion of the plant. Ties shall be of dark colour.

(a) 5 mm diameter rot-proof and non-abrasive rope with low moisture absorbent rate;

(b) 3 mm diameter plastic coated wire with 20 mm adjustable galvanized steel screw clamp;

(c) 3 mm diameter stainless steel braided wire with 20 mm adjustable stainless steel screw clamp.

Guys **25.68** Guys shall be fitted with a flexible rubber or plastic sleeve to prevent chafing, rubbing or abrasion of the plant, and a 100 mm long stainless steel turnbuckle for adjustment. Guys shall be one of the following:

(a) Multi-strand twisted stainless steel wire of between 4 mm and 6 mm diameter with 20 mm adjustable stainless steel screw clamp.

(b) 8 mm diameter rot-proof rope in dark green, dark brown or black colour;

(c) 4 mm overall diameter plastic coated wire in dark green, dark brown or black colour.

Guying stakes **25.69** Guying stakes shall be 25 x 25 x 5 mm thick galvanized mild steel angle with 5 – 10 mm diameter hole drilled 30 mm from the top prior to galvanizing, painted with one coat of approved primer and one coat of approved finishing coat prior to installation.

Trunk Protection **25.70** 10 mm diameter clear unplasticised polyvinyl chloride (uPVC) hosing shall be used as guy cover and trunk protection hosing; 2 mm thick and 150 mm wide flexible rubber pad long enough to wrap twice round the trunk to be used as trunk protection.

Root barriers **25.71** Root barriers shall be a proprietary type of high-strength, non-toxic, non-woven fabric specifically designed to stop vigorous root penetration of tropical and subtropical trees and shrubs. It shall not be embodied with any chemical substance that is harmful to health of the trees and shrubs or will cause any pollution to the environment.

(a) For application around tree pits, it shall have the following mechanical properties**:**

Mechanical Properties	Test Method	Acceptance Standards (±10%)
Wide width strip tensile	**BS EN ISO 10319**	
- Mean peak strength		3.0 kN/m
- Elongation at peak strength		35 %
- Strength at 5 % strain		1.3 kN/m
CBR puncture resistance	**BS EN ISO 12236**	
- Mean peak strength		525 N

(b) For application on roof top, it shall be of a proprietary type, in a completed assembly, serving multiple functions of tree root barrier, water retention and drainage layer systems, and with cushioning properties to protect the substrate (such as roofing / water-proofing membrane).

Workmanship

Planting season **25.72** Prior approval from the SO shall be obtained for planting in the dry season of December, January and February to minimize potential plant losses.

Landscape Softworks **25.73** Landscape Softworks refer to a series of planting works of a horticultural or arboricultural nature, and shall include the placing, cultivation and preparation of topsoil and subsoil layers, and the supply and planting of trees, shrubs and other plant materials, grassing and arboricultural / tree works (including but not limited to planting, replanting, transplanting, tree surgery work), control of pest and disease, and any work essentially associated with these. Except hydroseeding works (under Clauses 25.133 to 25.141 and 25.161 to 25.167), all Landscape Softworks including the establishment works shall be carried out by a sub-contractor who is a Specialist Contractor listed on the latest "List of Approved Suppliers of Materials and Specialist Contract" under the category of "Landscaping – General Landscape Works (Class I)" if the Contractor is not included in the said list.

Control of pests, fungal infestation and disease **25.74**

(a) At all times during the construction period and Establishment Works period, the Contractor shall take all necessary measures to protect and/or treat the Site (including existing vegetation, preserved trees and all other Landscape Softworks) from pest, fungal and disease attack and all necessary control measures to eradicate pests, fungi and disease from the infected/infested plants and/or areas. The precautionary, preventive and control (inclusive of treatment and eradication) measures shall be carried out, in accordance with Clauses 25.74(b) to (e) and 25.94.

(b) The Contractor shall regularly check for any insect attack or fungus infestation particularly during known periods of activity.

(c) Report immediately to the SO any such occurrence and carry out remedial measures by the use of the appropriate pesticide, insecticide or fungicides and any other necessary chemical treatment and associated arboriculture works to the infected and / or infested areas, as approved by the SO. The Contractor shall comply with the following requirements in applying the pest, fungal and disease control measures:

(i) Environmentally friendly measures shall be adopted, and use of biological control agent shall not be allowed at any time,

(ii) All pesticides, which include insecticides, miticides, herbicides, fungicides and any other chemicals to be used on plants to treat infection, shall be a registered pesticide under the **Pesticides Ordinance (Cap. 133)**, and non-injurious to plant growth,

(iii) Safety precautions as the manufacturer's instruction and statutory requirements shall be strictly followed in storing, handling and applying pesticides, insecticides, fungicides and chemicals so as to prevent unnecessary dispersion to protect the safety of workers and to avoid causing danger or harm to the public and the environment,

(iv) Proposed type and Material Safety Data from the manufacturer shall be submitted for approval before application, and

(v) Plant parts pruned from diseased plants shall not be stockpiled anywhere on the Site and shall be disposed of from the Site.

(d) Upon announcement by the Agriculture, Fisheries and Conservation Department (AFCD) on any quarantine pests or when instructed by the SO, the Contractor shall:

(i) Immediate check for any pest infestation and report to the SO;

(ii) Complete the report within seven days of receiving the announcement by AFCD and/or such instruction by the SO;

(iii) Submit method statements for the control measures to the SO for approval before commencement any work in association with the

control measures.

(e) When discovered within the Site, the following species in particular shall be dealt with immediately in accordance with Clauses 25.74(c) and 25.94.

Scientific Name	English Common Name
Solenopsis invicta Buren	Red Imported Fire Ant (RIFA)
Rhynchophorus ferrugineus Oliv.	Red Palm Weevil
Quadrastichus erythrinae Kim	Erythrina Gall Wasp

Root pruning and undercutting **25.75** Root prune and undercut the root system of rootballed stock to the specified size of root-ball 12 months before lifting from the nursery. Well water plants grown in the open ground prior to lifting and lift carefully to ensure the specified rootball is obtained. At the time of lifting, securely wrap the rootball with hessian, straw or other approved material to prevent loss of soil and moisture and wrap the trunk of standard and heavy standard trees from soil level to the lower branches. Do not remove wrapping material until the plant is required for planting.

Containerized plants **25.76** Container grown and containerized stock shall be well watered before despatch from the nursery and shall remain in the containers until required for planting.

Protection during transit **25.77** Protect all plants from mechanical damage, excessive transpiration and wilting during lifting, transportation and storage. Also protect all plants against excessive sunlight, wind and drought and in case of heavily foliaged plants, i.e. most shrubs and especially evergreens, prevent overheating with its resultant loss of foliage. Replace any damaged plant material rejected by the SO or, with approval, carefully prune and dress wounds with an approved sealant.

Storage of plant material on site **25.78** Stand upright on level ground those trees and shrubs which are not immediately planted in their permanent positions or in an agreed position on site. Protect and maintain in good condition.

If trees and shrubs shall be delivered to the site with shoots and branches bundled, remove all tying materials immediately to prevent heating up and subsequent defoliation.

Before planting **25.79** Cut loose and remove all wrapping materials round roots and containers. Trim any broken roots with clean secateurs or sharp knife. Dress wounds with approved sealant.

Planting **25.80** Plants shall be thoroughly soaked with water for several hours before planting. The soil in the container or rootball shall be moist and cohesive. Containers or rootball wrapping shall not be removed until the time of planting and the rootball shall not be disturbed by loosening or breaking. Each plant shall be placed upright in the pit and set at the same level as planted in the nursery or container.

Backfilling **25.81** Fabricated Soil Mix as Clause 25.6, or Topsoil as Clause 25.5, or Lightweight Soil Mix as Clause 25.10, shall be deposited and compacted in layers around the rootball until level with the surrounding ground in such a manner that the rootball is not disturbed. Plants shall be watered to soak the rootball and the Fabricated Soil Mix or Topsoil or Lightweight Soil Mix, immediately after planting.

Fertilizer **25.82** Apply slow release fertilizer to plants with the Fabricated Soil Mix or Topsoil or Lightweight Soil Mix at the rates as specified in Clause 25.106.

After planting **25.83** All plants shall be planted in their final position within two days of delivery to site to avoid wilting. Immediately after planting and before mulching, thoroughly water all plants to settle the soil around the roots. Continue watering as necessary so as to maintain a moist soil at all times during the construction period and Establishment Works period.

Mulching **25.84** After planting and watering, spread, level and firm mulch 50 mm thick on areas where the gradient is less than 10˚ and within 72 hours after planting. It shall be

placed in accordance with the proper mulching practices. For trees, mulching shall be extended 150 mm beyond the perimeter of the tree pit and/or covered at least the entire root ball zone, and shall always be kept out of contact with tree trunk or root collar.

Notch planting **25.85** When specified, notch plant by forming notches with hand held pick or spade, deep enough to accommodate the roots of the plants. Remove plants from the containers and place upright in the notches taking care to keep the soil and root intact. Firm the plants in the ground with the shoot upright.

Notch planting on slopes **25.86** For notch planting on a slope, form a notch by making two cuts at approximately 90˚ using a hand held pick or spade with the apex pointing up the slope. The notch shall be sufficiently deep to accommodate the root system of the seedling. The notch shall be opened on the second cut to receive the plant, and shall then be pushed firmly back into place. No pits shall be excavated and left open to avoid erosion of the slope, in particular during wet weather.

Pit planting of seedlings, small shrubs, whips, climbers and herbaceous plants **25.87** Pit plant seedlings, small shrubs and whips and herbaceous plants by excavating pits 100 mm larger all round than the root ball and 50 mm deeper than the rootball depth. When planting on a slope, measure the depth from the lowest adjacent ground level on the downward side of the pit. Prepare soil backfill material by adding and mixing in, pre-planting slow-release fertilizer in the quantities as specified in Clause 25.106 and backfill into the pit to a level in order to maintain the original relationship between the root collar of the plant and the soil surface. Remove the plant from its container and set upright in the pit and backfill with fabricated soil mix, or topsoil, firming first with the knuckles and then finally with the feet. Remove surplus and unsuitable material from site.

Pit planting of large shrubs, bamboos, small palms and cycas **25.88** Pit planting of large shrubs, bamboos and palms shall be as Clause 25.87 except that the pits shall be excavated 150 mm larger all round than the rootball and 50 mm deeper than the rootball depth.

Staking for whips **25.89** Secure whips by using one 1500 mm long bamboo stake as Clause 25.66 and one tie as Clause 25.67.

Pit planting of light standard, standard, heavy standard, semi-mature trees, conifers, palms **25.90** Dig tree pits to size as specified below:

Type of Tree/ Palm/ Conifer	Size of Pit
(a) Light standard, standard, small conifers, small palms	750 mm Ø x 600 mm deep
(b) Heavy standard, large palms, large conifers	900 mm Ø x 750 mm deep
(c) Semi-mature trees	1500 mm Ø x 900 mm deep

Soak the rootball of the plant, and fork over the base of the tree pit to a depth of 150 mm. Prepare backfill material by adding and mixing in fertilizer in the quantities as specified in Clause 25.106 with Fabricated Soil Mix or Topsoil or Lightweight Soil Mix. Backfill the base in layers and firm in, adjusting the planting depth so that the soil is level with the root collar of the plant. Remove the rootball covering, place the tree, adjust orientation of the crown and check planting depth, adjusting as necessary. Fix vertical stakes or guying stakes or as specified. Tie tree to stakes or secure trees with guys. Backfill in layers, firming in each layer with heel and water thoroughly. Adjust tree ties or guy wires as necessary. Mulch to a depth of 75 mm, water again and continue to water as required.

Pit safety **25.91** Pits excavated for planting on or adjacent to slopes shall not be left open during wet weather.

Staking **25.92** Stakes as Clause 25.65 or 25.66 shall be securely driven into the ground after the pit has been excavated and before planting in such a manner that the rootball and aerial parts of the plant are not damaged. The stakes shall not be higher than 30% of the overall height of the plant.

Guying **25.93** Guys and sleeves shall be fixed in such a manner that chafing, rubbing and abrasion of the plant is prevented and shall be secured to a well driven steel stake or other anchor. Each plant shall be fitted with three guys secured at a point not higher than 60% of the overall height of the plant. Turnbuckles shall be adjusted as necessary after planting.

Use of chemicals **25.94** Do not use chemicals without prior approval from the SO. Do not use chemicals which are toxic to humans, birds, or animals. Proposed type and Material Safety Data from the manufacturer shall be submitted for approval before application. Store, mix, apply, and dispose of chemicals in accordance with the manufacturer's instructions. Dispose of all product containers in a proper manner after use at the Contractor's expense.

PLANTING - TREES, SEEDLINGS, WHIPS, LIGHT STANDARD, STANDARD, HEAVY STANDARD, SEMI-MATURE, CONIFERS, PALMS, LARGE PALMS, SMALL PALMS AND CYCAS

Materials

Seedling trees **25.95** Seedling trees shall be trees grown from seed and to have all the following characteristics:

(a) Aged between 1 - 2 years old;

(b) A single slender stem;

(c) A well developed vigorous root system;

(d) Total height above soil level of at least 150 mm but not exceeding 900 mm,

(e) Grown and supplied in a container not less than 75 mm in diameter and 150 mm deep, or a tube at least 60 mm in diameter and 150 mm long, and

(f) Free from any kind of pest, fungi, disease and parasitic plants.

Whips **25.96** Whips shall have all the following characteristics:

(a) Aged between 2 - 3 years old;

(b) A single central stem and elementary branch system;

(c) A well developed vigorous root system;

(d) Total height above soil level exceeding 900 mm but not exceeding 2000 mm;

(e) Grown and supplied in a container not less than 125 mm in diameter and 200 mm deep, and

(f) Free from any kind of pest, fungi, disease and parasitic plants.

Light standard trees **25.97** Light standard trees shall have all the following characteristics:

(a) A sturdy straight stem at least 1500 mm high from the root collar to the lowest branch;

(b) Total height above the root collar exceeding 2000 mm but not exceeding 3000 mm;

(c) According to species, either a well balanced branching head or a well defined straight and upright leader with branches growing out from the stem with reasonable symmetry;

(d) A well developed vigorous root system;

(e) Stem diameter of at least 25 mm but not exceeding 45 mm measured at a height of 1300 mm from the root collar;

(f) The diameter of the rootball shall be not less than 300 mm and with a depth not less than 300 mm;

(g) When container grown trees are required, grown in a container at least 350 mm in diameter and 400 mm deep; and

(h) Free from any kind of pest, fungi, disease and parasitic plants.

Standard trees **25.98** Standard trees shall have all the following characteristics:

(a) A sturdy straight stem at least 1800 mm high from the root collar to the lowest branch;

(b) Total height above the root collar exceeding 2750 mm but not exceeding 3500 mm;

(c) Stem diameter exceeding 45 mm but not exceeding 75 mm measured at a height of 1300 mm from the root collar;

(d) According to species, either a well balanced branching head, or a well defined straight and upright leader with branches growing out from the stem with good symmetry, and a minimum length of 600 mm;

(e) A rootball not less than 450 mm in diameter and 300 mm in depth;

(f) When container grown trees are required, grown in a container not less than 500 mm in diameter and 500 mm deep, and

(g) Free from any kind of pest, fungi, disease and parasitic plants.

Heavy standard trees **25.99** Heavy standard trees shall have all the following characteristics:

(a) A sturdy straight stem at least 2000 mm high from the root collar to the lowest branch;

(b) Total height above the root collar exceeding 3500 mm but not exceeding 6000 mm;

(c) Stem diameter exceeding 75 mm but not exceeding 150 mm measured at a height of 1300 mm from the root collar;

(d) According to species, either a well balanced branching head, or a well defined straight and upright leader with branches growing out from the stem with good symmetry, and a minimum length of 800 mm;

(e) A rootball not less than 750 mm in diameter and 400 mm in depth;

(f) When container grown trees are required, grown in a container not less than 750 mm in diameter and 600 mm deep; and

(g) Free from any kind of pest, fungi, disease and parasitic plants.

Semi-mature trees **25.100** Semi-mature trees shall have all the following characteristics:

(a) A sturdy straight stem at least 2200 mm high from the root collar to the lowest branch;

(b) Stem diameter exceeding 150 mm measured at a height of 1300 mm from the root collar;

(c) According to species, either a well balanced branching head, or a well defined straight and upright leader with branches growing out from the stem with good symmetry, and a minimum length of 1500 mm;

(d) A total height above the root collar exceeding 6000 mm;

(e) A rootball not less than 1500 mm in diameter and 600 mm in depth;

(f) A root system previously undercut a minimum of one year prior to lifting, to encourage compact fibrous growth; and

(g) Free from any kind of pest, fungi, disease and parasitic plants.

Conifers **25.101** Conifers shall have all the following characteristics:

(a) A well developed upright stem well furnished with vigorous leaf or needle bearing side shoots with good symmetry;

(b) A well developed vigorous root system;

(c) Minimum dimensions not less than that as specified;

(d) A rootball appropriate in proportion to the size of the plant; and

(e) Free from any kind of pest, fungi, disease and parasitic plants.

Large palms **25.102** Large palms shall have the following characteristics:

(a) A well developed upright habit and multiple fronds with good symmetry, single or multi-stemmed according to species specified;

(b) A well developed, vigorous root system;

(c) A minimum stem height from soil level to the base of the lowest frond as specified, or an overall height of the plant not less than that specified;

(d) A well developed vigorous root system with a root-ball of at least 700 mm diameter and 600 mm depth;

(e) At least 6 months container grown before delivery to site; and

(f) Free from any kind of pest, fungi, disease and parasitic plants.

Small palms and cycas **25.103** Small palms and cycas shall have all the following characteristics:

(a) A well developed upright habit and multiple fronds with good symmetry, single or multi-stemmed according to species specified;

(b) A well developed vigorous root system;

(c) A rootball of at least 300 mm diameter and at least 350 mm deep;

(d) A minimum stem height from soil level to the base of the lowest frond as specified, or an overall height of the plant not less than that specified; and

(e) Free from any kind of pest, fungi, disease and parasitic plants.

Workmanship

Tree pit bases **25.104** Break up the base of each tree pit to a depth of 150 mm. Check all exposed sides of the pit. Any glazed surface caused by digging or excavating shall be rectified manually before backfilling or any soiling operation to avoid the potential of impeded subsoil drainage.

Trees in paved areas **25.105** Where trees are planted in paved areas, carefully lift the tree grills and lay them aside. Excavate tree pit to the full area of the tree grill minimum size 1200 mm x 1200 mm x 1200 mm deep and loosen the soil on all sides and base of the pit. Check the drainage of the subsoil in the pit by filling with water, prior to planting. If water fails to drain away within 30 minutes, inform the SO to ascertain the cause and take remedial action.

Lay clean aggregate 150 mm deep at the bottom of the pit using 20 – 40 mm chip size. When specified place a filter layer over the aggregate layer at the bottom of the pit and tuck down the edges into the soil at the sides. Backfill with fabricated soil mix or topsoil to accommodate the size of rootball specified and carefully firm up soil around the rootball. Allow soil backfill to within 75 mm of the surrounding paving level. Place mulch and re-lay tree grill on top, to match surrounding paving level. Fill the gaps in the grill and between the trunk with mulch or gravel, as specified.

Rate of fertilizer **25.106** Apply slow release fertilizer at max. 20 g/m^2 for general planting areas where trees, palm, shrub, groundcovers etc. are planted together. For the situation of individual specimen planting, the following application rates shall be followed:

(a)	Seedling trees:	25 g for each notch
(b)	Whips:	50 g mix with backfilling soil of each plant
(c)	Small palms, small conifers:	100 g mix with backfilling soil of each plant
(d)	Light standard trees, standard trees, large palms, large conifers and semi-mature trees:	1 kg for each m^3 of backfilling soil

Securing **25.107** Wrap all trees to be staked or guyed above ground with pads of hessian or rubber to prevent ropes or wires chafing the trunk or branches. Position and secure approved ties to prevent any chafing, rubbing or abrasion of trees. The ties shall allow for adjustment but should not restrict growth of tree canopy or root system. Adjustment shall be made as necessary during the construction period and Establishment Works period.

Tripod staking **25.108** When specified, secure stable bamboo tripods to trees by using 3 nos. of bamboo stakes as Clause 25.66. Prevent any chafing, rubbing or abrasion of the tree or restriction of tree growth by using approved ties all in accordance with Clauses 25.92 and 25.107. Any exposed top end of the bamboo stakes shall be appropriately sealed off to prevent mosquito breeding.

PLANTING - GROUND COVER, SHRUBS, BAMBOOS, CLIMBERS & HERBACEOUS PLANTS

Materials

Ground cover **25.109** Ground cover plants shall have all the following characteristics:

(a) Well developed, vigorous multiple shoots;

(b) A well-developed vigorous root system;

(c) Minimum dimensions not less than those specified, with a tolerance which shall not deviate from the specified dimension by more than ± 25 mm;

(d) Grown in a container not less than 125 mm in diameter and 150 mm deep; and

(e) Free from any kind of pest, fungi, disease and parasitic plants.

Small shrubs **25.110** Small shrubs are seedlings or rooted cuttings and shall have all the following characteristics:

(a) A minimum of three vigorous, one-year old shoots with a well balanced shape, and bushy habit;

(b) A well-developed, vigorous root system;

(c) Minimum dimensions not less than those specified, with a tolerance which shall not deviate from the specified dimension by more than ± 100 mm;

(d) Grown and supplied in a container not less than 125 mm in diameter and 150 mm deep; and

(e) Free from any kind of pest, fungi, disease and parasitic plants.

Large shrubs **25.111** Large shrubs are transplanted seedlings or rooted cuttings and shall have all the following characteristics:

(a) A minimum of five vigorous, one-year old shoots with a well balanced shape and bushy habit, to produce a diameter 2/3 of the height;

(b) A well-developed, vigorous root system;

(c) Minimum dimensions above soil level exceeding 600 mm and not less than those specified, with a tolerance which shall not deviate from the specified dimension by more than ± 200 mm;

(d) Grown and supplied in a container not less than 200 mm in diameter and 250 mm deep; and

(e) Free from any kind of pest, fungi, disease and parasitic plants.

Climbers **25.112** Climbers shall have all the following characteristics:

(a) A minimum of four vigorous, one year old shoots not less than 600 mm long except when specified otherwise;

(b) A well developed vigorous root system;

(c) Grown and supplied in a container not less than 125 mm in diameter and 150 mm deep; and

(d) Free from any kind of pest, fungi, disease and parasitic plants.

Bamboos **25.113** Bamboos shall have all the following characteristics:

(a) For multi-stemmed species, a clump of at least four main shoots sprouting from the base at the height specified;

(b) For single stem species, at least one single shoot with total height above soil level not less than the height specified;

(c) A well developed, vigorous root system with a healthy rhizome capable of shooting fresh culm;

(d) Grown and supplied in a container not less than 450 mm in diameter and 450 mm deep; and

(e) Free from any kind of pest, fungi, disease and parasitic plants.

Supports for non-self- clinging climbers **25.114** Supports for non-self-clinging climbing plants to consist of either:

(a) 1 or 2 no. vertical bamboo poles, 15 – 20 mm diameter x 1000 mm minimum height above ground and 250 mm below ground.

(b) 3 no. bamboo poles 15 – 20 mm diameter, 1000 mm minimum height above ground, spaced and tied to 3 or 4 cross bamboo poles 10 – 15 mm diameter to form a triangular shaped support frame. Rot proof ties shall be used to fix bamboo securely together.

Workmanship

Planting ground cover, small shrubs, climbers and herbaceous plants **25.115** Pit plant ground cover, small shrubs, climbers and herbaceous plants in pits shall be 100 mm greater than the diameter of the rootball or root spread and 50 mm deeper than the rootball depth.

Planting large shrubs, and bamboos **25.116** Pit plant large shrubs and bamboos in the pits shall be 150 mm greater than the diameter of the rootball and 50 mm deeper than the depth of the rootball.

Self-clinging climbers against structures **25.117** Plant self-clinging climbers close to the structures and fix main shoots to support using suitable proprietary hooks.

Non-self-clinging climbers against structures **25.118** Plant non-self-clinging climbers 150 mm from the support. Drive the support 600 mm into the ground and fix at the top and middle point to the wall with approved raffia. Carefully turn the climber round the supports with all leading shoots trained upwards.

Non-self-clinging climbers on pergolas **25.119** Plant non-self-clinging climbers 150 mm from the pergola support columns. Carefully turn the plant round the column with all leading shoots trained upwards and tie to the column with approved raffia. Where climbers are placed between columns similarly train up 25 mm diameter bamboo poles; drive the poles 300 mm into the ground, support and tie against the top of the pergola.

Mulching to ground cover **25.120** Apply a 25 mm deep layer of mulch to the surface of all ground cover areas, immediately after watering in.

Mulching to shrubs, climbers bamboos and palms **25.121** Apply a 50 mm deep layer of mulch to the surface of all shrub, climber and bamboo areas, immediately after watering in.

Fertilizing ground cover, large and small shrubs, bamboos and climbers **25.122** Thoroughly mix slow release fertilizer into the backfilling soil mix at the following rates:

(a) 75 g per plant for ground cover plants;

(b) 100 g per plant for all shrubs, bamboos, and climbers.

PLANTING - GRASS

Materials

Seed **25.123** An approved laboratory shall mean one of the Employer's laboratories or an Accredited Laboratory.

All seed shall be true to species and laboratory tested. No seed shall be used unless covered by an appropriately numbered seed analysis report or certificate. The numbered reports or certificates shall always refer to the number on the seed containers. The origin of all seed and the name of the supplier shall be stated on the seed containers.

The quality of grass seed shall be gauged by purity, germination percentage and freedom from weeds. The total weed seed content shall not exceed 0.5% by mass and the total content of other crop seed shall not exceed 1% by mass.

Certificates of seed **25.124** Provide a certificate of testing for each species of seed from an approved laboratory or supplier, stating:

(a) Grass species and variety using scientific names;

(b) Date of testing (should not be more than 6 months before the date of use of the seeds);

(c) Test result on the percentage germination of pure seed in a fixed time under standard laboratory conditions; and

(d) Test result on the percentage composition by weight, including details of purity.

Samples of materials **25.125** Samples of the following proposed materials shall be submitted to the SO at the same time as particulars of the material are submitted:

(a) Each seed mixture;

(b) Turf (according to Clause 25.145 and 25.148); and

(c) Sprigs (according to Clause 25.148).

Germination **25.126** The germination capacity of each constituent of a grass seed mix over a seven-day test period shall be at least 80%.

Purity **25.127** The purity of each constituent of the grass seed mix shall be greater than 90%. Total pernicious weed seed content shall be less than 0.5% and total content of other crop seeds shall be less than 1.0%.

Storage of grass seed **25.128** Store seed in sealed bags off the ground, in a clean, dry, well ventilated place free from vermin. Prolonged storage shall be carried out under controlled conditions of temperature and humidity.

Pre-seeding fertilizer **25.129** Pre-seeding fertilizer shall be a quick release fertilizer.

Mulch for hydroseeding **25.130** Mulch for hydroseeding shall be fine grained organic material such as fine ground tree fibre, paper waste and cellulose.

Dye, soil binding agent **25.131** Dye, and soil binding agent shall be of an approved type, non-injurious to plant growth**.**

Top-dressing **25.132** 65% finely sifted Topsoil or finely sifted Fabricated Soil Mix thoroughly mixed with 35% fine Sand. Marine sand and sand from brackish water shall not be used.

Hydroseeding **25.133** Hydroseeding for Landscape Softworks and the associated Establishment Works shall be carried out by a sub-contractor who is a Specialist Contractor listed on the latest "List of Approved Suppliers of Materials and Specialist Contract" under the

category of "Landscaping – Hydroseeding (Class II)" if the Contractor is not included in the said List.

Hydroseeding is the application by high pressure spraying of the specified mixture of grass seed and/or tree/shrub seeds, fertilizer, mulch and other approved additives in aqueous suspension. Hydroseeding shall include the supply of all materials and equipment necessary for the successful establishment of vegetation by the method described.

Particulars of hydroseeding **25.134** The following particulars of the proposed materials and methods for hydroseeding shall be submitted to the SO.

(a) Species and rate of application of grass seed/tree and shrub seed;

(b) Type and rate of application of fertilizer, mulch and soil binder;

(c) Type and colour of dye;

(d) Type of protective fabric material; and

(e) Details of the company employed to carry out the hydroseeding and the equipment to be used.

Submission before hydroseeding starts **25.135** The particulars in Clauses 25.134 and 25.136 shall be submitted to the SO at least 14 days before hydroseeding starts.

Hydroseeding seed mix **25.136** Hydroseeding seed mix shall be:

	April to August	September to March
Cynodon dactylon (Bermuda grass / Couch grass)	13-15 g/m^2	15 g/m^2
Paspalum notatum (Bahia grass)	8-10 g/m^2	10 g/m^2
Lolium perenne (Perennial Ryegrass)	-	5 g/m^2
Chloris gayana (Rhodes grass)	1- 4 g/m^2 less than 2g/m^2	-
Eragrostis curvula (Weeping Lovegrass) } *Eremochloa ophiuroides* (Common Centipede-grass) } *Cenchrus echinatus* (Buffel grass/ Bur grass) }	5 g/m^2	5 g/m^2
Total	30 g/m^2	35 g/m^2

Note: Tree/shrub mix refer Clause 25.138.

Hydroseeding solution **25.137** Hydroseeding solution to consist of:

Ingredient	Rate
Seed mix Clauses 25.136 or 25.138	35 g/m^2
Mulch in air-dried weight Clause 25.130	200 g/m^2
Fertilizer Clause 25.129	100 g/m^2
Soil binding agent Clause 25.131	25 g/m^2
Non toxic dye Clause 25.164	0.5 – 0.05 g/m^2
Total	Max. 360.5 g/m^2

Tree/shrub species for hydroseeding **25.138** Tree/Shrub species for hydroseeding:

	Scientific Name	English Common Name
	Tree species:	
(a)	*Alangium chinense*	Chinese Alangium
(b)	*Bridelia tomentosa*	Pop-gun Seed
(c)	*Casuarina equisetifolia*	Horsetail Tree
(d)	*Celtis sinensis*	Chinese Hackberry
(e)	*Eucalyptus robusta*	Swamp Mahogany
(f)	*Gordonia axillaries*	Hong Kong Gordonia
(g)	*Ilex rotunda*	Chinese Holly
(h)	*Litsea rotundifoli*	Oblong-leaved Litsea
(i)	*Lophostemon confertus*	Brisbane Box
	Shrub species:	
(a)	*Melastoma sanguineum*	Blood-red Melastoma
(b)	*Melastoma candidum*	Common Melastoma
(c)	*Melastoma dodecandrum*	Twelve-stamened Melastoma
(d)	*Rhaphiolepis indica*	Hong Kong Hawthorn
(e)	*Rhodomyrtus tomentosa*	Rose Myrtle
(f)	*Rhus chinensis*	Sumac
(g)	*Rhus hypoleuca*	Sumac
(h)	*Rhus succedanea*	Wax Tree

Protective layer **25.139** Protective layer shall be non-toxic, biodegradable, porous, translucent, and be 1mm or less thick, cellulose netting. It shall be a proprietary type of degradable fabric with effective certificate issued by the manufacturer and approved by the SO. The fabric shall not degrade within 100 days after application or until the specified grass cover has been established.

Hydroseeding cover **25.140** Hydroseeding shall achieve a cover by grass species of at least 90% of the surface area for each 10 m^2 of the area to be hydroseeded within 28 days after the area has been hydroseeded. The grass cover shall be healthy, vigorous and free from perennial and other weeds.

Samples of hydroseeding materials **25.141** Samples of the following proposed materials shall be submitted to the SO for approval at the same time as particulars of the material are submitted and before confirming orders, and delivery to and use on the Site:

(a) 0.1 kg sample of each type of seeds of grass, trees and/or shrubs used in the mix; and

(b) a piece of protective layer in 300 mm x 300 mm.

Sprigs **25.142** Sprigs shall be stoloniferous grass with blades at least 150 mm long and a vigorous root system at least 100 mm long and free from sticky clay.

Sprigs shall not be used on slopes exceeding 45° to the horizontal.

Sprig species **25.143** Unless otherwise specified, sprig species shall be one or a mixture of the following species:

Scientific Name	English Common Name
Axonopus compressus	Carpet grass
Cynodon dactylon	Bermuda grass / Couch Grass-
Cynodon dactylon 'Tifway T419'	Hilo grass
Paspalum conjugatum	

Turf **25.144** Turves shall possess the following characteristics:

(a) Vigorous grass (in turf plank) of even density with closely-knit sward, with a healthy green colour, true to the species specified and capable of healthy growth;

(b) Each piece of turf should have no more than 10 mm thatch (including dead fibre) on average and be of uniform thickness, with soil thickness below the thatch of not less than 7 mm and not greater 18 mm. The turf shall have with a sufficiently fibrous root system to hold together during handling;

(c) In consistent size, shape and thickness, approximately 500 x 300 x 50 mm thick with an even thickness of both grass sward and growing medium;

(d) Grown in well-drained growing medium suitable for horticultural purpose that shall contain not more than 40% clay sized particle (<0.002 mm in accordance with **BS 3882**) and free from stones over 15 mm in any dimension;

(e) With density of sods sufficient so that no soil is visible when mown to height of 25 mm; and

(f) Free from diseases, impurities, weeds or insect pests or contamination.

Turf sample **25.145** Sample pieces of turf, size 500 x 300 mm shall be submitted to the SO for approval prior to laying. It shall be kept moist and in good condition on site (under Clause 25.148) for comparison with turves brought to site. Turves shall be laid in their final positions within 36 hours of lifting. *Axonopus compressus* shall not be used on slopes exceeding 15º to the horizontal.

Turf species **25.146** Turf species shall be one of the following:

Scientific Name	English Common Name
Axonopus compressus	Carpet grass
Cynodon dactylon	Bermuda grass / Couch Grass
Cynodon dactylon 'Tifway T419'	Common Centipede-grass
Eremochloa ophiuroides	Korean lawngrass
Zoysia japonica	Manila grass
Zoysia matrella	

Handling and storage of sprigs and turves **25.147** Turf and sprigs shall not be lifted when waterlogged or very dry and shall be packed to avoid drying out. Turf and sprigs shall be stored by spreading out and shall not be stacked. Turf and sprigs shall be kept moist and in good condition and shall be delivered and laid within 36 hours after lifting.

Sample for turfing and sprigging **25.148** Provide samples of materials and state the origin of all materials submitted to the SO for approval. An approved turf or sprig sample laid properly in area not less than 900 mm x 900 mm, shall be kept alive and maintained on Site during the turfing/grassing/sprigging operation for reference.

Workmanship - General

Cultivation for turfing and sprigging **25.149** Prior to cultivation, remove all pernicious and/or perennial weeds, by hand, including the complete root system. Cultivate areas with slopes no steeper than 1:2 to a depth of 125 mm and bring to a 25 mm deep fine tilth by hand raking. Areas with slopes of 1:3 or less may be cultivated using approved mechanical means. If necessary, regrade the surface so that finished levels after grassing shall be 25 mm above any adjacent hard surface area. All stones over 25 mm diameter shall be removed. Apply fertilizer at the rate of 40 g/m^2 evenly spread over the area and lightly work into the soil.

Cultivation for hydroseeding **25.150** The surface to be hydroseeded shall be lightly scarified and finished to a coarse open textured surface and shall not be smooth or glazed. Finishing work on slopes by machine shall be carried out across the slope. Vehicle track marks and bucket teeth marks shall not be left parallel to the line of maximum gradient of the slope.

Cultivating on slopes **25.151** Avoid cultivating the existing soil on embankments with slopes of 1:2 or steeper, to ensure that the slope remains stable and to prevent erosion. Areas with slopes of 1:3 or less may be cultivated by hand to a depth of 125 mm and bring to a 25 mm deep fine tilth by hand raking or approved mechanical means. Remove all stones larger than 25 mm in any dimension.

Regrading **25.152** If necessary, carry out regrading of the surface to conform to the prescribed finished levels and create free flowing contours free from humps and water collecting hollows.

Watering **25.153** Water immediately after laying and continue to water by using a fine spray hose attachment to avoid erosion and run off.

Workmanship – Follow up operations on grassing

Rolling **25.154** Immediately prior to the first grass cut, roll the area with a 250 kg flat horticultural roller.

First cut **25.155** Make the first cut when the grass sward is 75 mm high and reduce the sward to 25 mm high.

Subsequent cuts **25.156** Make subsequent cuts as soon as the grass sward is 50 mm high and reduce the sward to 25 mm high or as directed by the SO.

Follow up fertilizer **25.157** Apply a follow up application of fertilizer at a rate of 25 g/m², 28 days after the grassing operation.

Insect and disease control **25.158** Take all precautions necessary to prevent any outbreak of disease or insect attack. When such attacks occur, take necessary action within 3 days after obtaining prior approval from the SO, to eradicate any such disease or insect attacks.

Other requirements **25.159** Undertake any additional follow up maintenance that may be specified or required by the SO within the construction period or Establishment Works period.

Workmanship – Sowing and Hydroseeding

Broadcast sowing **25.160** Broadcast grass seed as by hand, or by mechanical means in two equal sowings at right angles to each other, evenly at rate of not less than 75 g/m^2. The seed shall be covered by lightly working into the surface or by spreading sufficient soil to just cover the seed.

Programming hydroseeding **25.161** Carry out hydroseeding between March and September in damp overcast conditions, but not during rain or periods of strong winds. Obtain approval from the SO for hydroseeding at other times.

Preparation of tree/shrub seed **25.162** Prior to mixing with other ingredients of the hydroseeding mix, all tree/shrub seeds shall be soaked in water at room temperature for 4 to 8 hours before mixing takes place.

Hydroseeding mix **25.163** Thoroughly blend all ingredients defined in Clause 25.137 in water at the rate of 5 L/m^2 to form an aqueous gel solution. Mixing shall be carried out on the Site in the hydroseeding equipment immediately before spraying. Take care to ensure that seeds and other materials are not damaged. Spray the solution by high pressure pump to evenly cover the area at the rates specified, and to avoid loss of sprayed material through watering run-off and erosion of the soil. The hydroseeding mixture shall be constantly agitated during spraying to keep it homogeneous and avoid blockage to pipes. Application works including mixing shall be carried out using a proprietary type of hydroseeding equipment unless otherwise approved by the SO.

Application of soil binders and dye **25.164** Apply and mix in soil binders at the rate recommended by the manufacturer, modified as necessary to suit conditions of Hong Kong and as approved by the SO prior to application. The dye shall be of proprietary type manufactured specifically for hydroseeding purposes and can be chemical or organic in origin but must be non-toxic. The dye shall be in dark green colour and is used to demonstrate that adequate cover has been achieved unless in the opinion of the SO runoff or water courses will be coloured to an unacceptable level. In general, the dye shall be applied at a rate of 0.05 g/m^2. Care shall be taken to avoid runoff from the slope to nearby water courses, carriageway or footpath. Spraying shall take place on days without rainfall.

Patching up **25.165**

(a) When 28 days after hydroseeding, the hydroseeded areas do not show 90% cover over any 10 m^2 area, carry out the following:

(i) Re-spray areas where in the opinion of the SO germination has been unsuccessful; and

(ii) Re-spray areas affected by repairs to washout and gullies and other erosion on slopes.

(b) For areas which in the opinion of the SO are not accessible or are too small for the use of a hydroseeder, patch up by broadcast seeding as follows:

(i) Lightly scarify the area with a rake or similar implement;

(ii) Broadcast the seed and fertilizer over the area at a rate of not less than 75 g/m^2 with a tolerance of + 5%;

(iii) Cover the seed by lightly working into the surface or by spreading sufficient soil to just cover the seed; and

(iv) Carry out broadcast seeding using *Cynodon dactylon* (Bermuda grass), *Lolium perenne* (Perennial ryegrass) or *Axonopus compressus* (Carpet grass).

Protection of hydroseeding **25.166** Immediately following spraying of hydroseeding slurry, protective fabric shall be laid and spiked or stapled to the soil surface using 100 mm long spikes and 150 mm overlap of fabric to prevent soil erosion. On sloping ground the fabric shall be laid along the greatest slope and fully adhere to the hydroseeded surface by sprinkling with water using an approved spray. Care shall be taken not to sprinkle excess water onto the slope causing erosion of the slope. Protective fabric shall also be applied to all areas subsequently re-sprayed. Walking on areas that have been hydroseeded shall be restricted to access for fixing protective material and for patching up, and any other traffic by any means shall be not allowed before full germination as defined in Clause 25.167.

Sowing / hydroseeding acceptance **25.167** Grass areas shall only be accepted as complete when germination has proved satisfactory. Any areas not covered by approved germinated grass within 28 days after sowing shall be re-seeded as Clause 25.165 or Clause 25.169 or as specified.

Workmanship - Sprigging

Laying sprigs **25.168** Thoroughly moisten the cultivated area prior to sprigging. Use a fine spray hose attachment to avoid soil erosion and run off. Lay sprigs at 50 mm centres, lay top-dressing and firm the ground by trampling or use a flat horticultural roller and water in immediately.

Sprigging acceptance **25.169** Sprigging shall only be accepted as complete when growth has started, and an even growth is evident. Any areas covered with less than 90% of the approved grass within 28 days after sprigging shall be re-laid.

Workmanship – Turfing

Laying turves **25.170** Lay turves on the prepared soil bed and firm into position in consecutive rows with 10 mm wide broken joints (as in stretcher bond brickwork) and to the correct levels. Lay turves off planks working over turves previously laid. Where necessary, lightly and evenly firm turves with wooden beaters, the bottom of the beaters being frequently scraped clean of accumulated soil or mud. Adjust any inequalities in finished levels owing to variation in turf thickness or uneven consolidation of soil by topdressing, and raking and/or by packing fine soil under the turves. Do not use rollers. Turf edges and margins shall be laid with whole turves and trimmed to clean straight lines or regular curves.

Top-dressing **25.171** Apply top-dressing as Clause 25.132 immediately after laying turves and as when directed by the SO. Brush well into the turf joints. Top-dressing applications shall be made as many times as necessary to achieve an even and level surface over the whole area.

Turf maintenance **25.172** Water turves as often as is necessary, or as required. Where bare patches still occur 28 days after laying remove the turf which has failed, re-cultivate the soil and re-turf the patches. If shrinkage occurs and the joints open, top-dressing shall be worked into the area and well watered. Maintain turfed areas for the duration of the Contract including all necessary cuts to maintain a grass height of no more than 50 mm.

PLANTING - HERBACEOUS

Materials

Bulbs **25.173** A bulb is a modified shoot consisting of a small fleshy rounded stem, bearing a spherical mass of fleshy leaves, above the developing adventitious root system and free from rot.

Corms **25.174** A corm is a solid, swollen part of the stem at or near ground level and produces a bud at its apex. Corms shall be firm with a strong healthy bud, vigorous root system and free from rot.

Tubers **25.175** A tuber is a swollen underground branch, roundish with buds or ‘eyes’ from which new plants are produced. Tubers shall be firm with a minimum of six ‘eyes’, have a strong root system and free from rot.

Herbaceous plants **25.176** Herbaceous plants shall have the following characteristics:

(a) Well developed, vigorous multiple shoots,

(b) A well developed, vigorous root system,

(c) Total height above soil level or diameter of plant for clumps not less than those specified, with a tolerance which shall not deviate from the specified dimension by more than ± 25 mm,

(d) Healthy well developed bulbs, corms, rhizomes or tubers,

(e) Grown and supplied in a container at least 125 mm in diameter and 150 mm deep, and

(f) Free from any kind of pest, fungi, disease and parasitic plants.

Workmanship

Planting bulbs corms, and tubers **25.177** Place the bulb, corm, or tuber, right way up, in the base of hand dug holes of size appropriate for the species specified and backfill with topsoil or fabricated soil mix.

Planting herbaceous plants **25.178** Plant herbaceous plants as Clause 25.115.

PLANTING - AQUATIC PLANTS

Materials

Pots for aquatic plants **25.179** Pots shall be unglazed fireclay, sound and free from cracks, chips etc. of matching colour and with adequate drainage holes in the base. The ratio of depth to diameter shall be appropriate for the plant species as specified. As a general guide the pot depth shall be greater than its diameter.

Plastic mesh containers **25.180** Plastic mesh containers shall be rectangular, circular or oval in shape, and dark green, dark blue or dark brown, with open mesh bread and laundry basket pattern. The minimum size shall be suitable for containing the species but not less than the following:

(a) 450 mm diameter x 300 mm deep for circular containers; and

(b) 500 x 400 x 300 mm deep for rectangular and oval containers.

Wire mesh cages **25.181** Wire mesh cages shall be galvanized mild steel expanded metal, not more than 2 mm thick with 10 x 10 mm or 5 x 20 mm slot.

Aquatic plants **25.182** Aquatic plants shall have vigorous growth and be grown in pots but not pot bound. They shall be capable of at least twelve months healthy and vigorous growth before requiring re-potting or potting on.

Growing medium **25.183** Plants shall be grown in the appropriate growing medium for the species specified.

Supports **25.184** Supports shall be either upturned fireclay pots or precast concrete blocks of the same diameter as the pot being supported.

Ballast **25.185** Ballast shall be clean rounded stone, evenly graded, 30 – 75 mm diameter.

Workmanship

Planting in pots **25.186** Place pots on supports so that the top lip is 50 mm below water level or as specified.

Ballast in pots **25.187** After placing pots in their final location, and before filling the pool with water, cover the surface of the pot with a 75 mm layer of ballast.

Planting in plastics mesh containers **25.188** Line container with a double layer of hessian, folding the top level with basket lip and overlapping by 75 mm. Place grass sods or sphagnum moss tightly around the base and sides of basket. Place a layer of planting medium over base of container, and position plant centrally in container and backfill with planting medium firmed down around plant. Fill in to a depth 50 mm below basket lip after settlement. Secure with a stake and tie if directed by the SO.

PLANT - INDOOR PLANTS

Materials

Pots **25.189** Pots shall be unglazed fireclay, sound and free from cracks, chips etc. and of matching colour with adequate drainage holes in the base. The depth to diameter ratio shall be appropriate for the plant species as specified (as a general guide, the pot depth shall be greater than the pot's diameter). A base plate shall be provided with each pot.

Dragon pots **25.190** Dragon pots shall be used for individual feature plants and shall be true to type and of matching design and colour as specified, sizes approximately 500 mm high x 450 mm diameter, or as specified. Pots shall be sound and free from cracks, chips etc. with adequate drainage holes in the base. A base plate shall be provided with each pot.

Drainage layer **25.191** The base of each pot shall have a drainage layer comprising either clean pea gravel, broken fireclay or equal and approved material.

Indoor plants **25.192** Indoor plants shall not be pot bound and shall be capable of at least twelve months healthy and vigorous growth before requiring repotting or potting on. Plants shall be grown in the same pot for at least 3 months in the nursery, be in good healthy growing condition. Slow release fertilizer as Clause 25.198 shall be applied to each potted plant prior to delivery to site.

Potting medium **25.193** Indoor plants shall be grown in the appropriate growing medium for the species and shall hold sufficient reserves of nutrients to maintain the plant in satisfactory condition for a reasonable period of time after planting. The potting medium shall normally comprise a fabricated soil mix of the following proportions:

(a) 2 parts manufactured soil conditioner;

(b) 1 part finely sifted sand or decomposed granite; and

(c) 1 part vermiculite pellet or volcanic pellet with a particle size of 5 – 8 mm.

Alternative potting medium constituents may be approved by the SO to suit plant species.

Artificial plants **25.194**

(a) Artificial plants shall be obtained from an approved supplier. Samples of each plant for species and size shall be approved prior to purchase from the supplier.

(b) Artificial plants shall have the following properties:

(i) Man-made, densely leaved with flowers and foliage of colour-fast silk or polyester with realistic appearance in terms of general form, colour, texture and habit resembling the life-like version of the plant species;

(ii) All preserved or dried components of the artificial plants shall be free form rotting, insect and/or fungus infestation; ;

(iii) Multi-stemmed when appropriate to the species;

(iv) With all leaves, flowers, stems, trunks, branches etc. securely fixed;

(v) Set in appropriate size pots entirely filled with dark brown coloured concrete or by an approved method without leaving a protruding lip.

(vi) Leaf to be strongly bonded to plastic backing, single bond between leaf and stem is not acceptable;

(vii) All silk sprays and bushes shall be treated with fire retardant chemicals and accompanied by a test certificate from an Accredited Laboratory;

(viii) No rough silk threads on the edge of leaves;

(ix) All silk sprays and bushes should be firmly secured into styrofoam support base, covered with decorative Sphagnum green moss, decorative stones/pebbles or other approved materials; and

(x) Wire strengtheners in stem must be sufficiently strong to support the bush in its natural shape.

(c) Submittals for the SO's approval prior to ordering:

(i) Detailed layout plans with sections, elevations to demonstrate design proposal.

(ii) Color photographs and job reference shall be submitted for each proposed plant.

(iii) Mock up of full size sample for each type of proposed silk tree or preserved palms, and major group of silk bushes, for approval.

(iv) Sample of all other materials such as container, decorative moss / pebbles, etc. shall be submitted for approval.

(v) Proof or guarantees from manufacturer on fire retardant or preservatives treatment, as detailed above.

Workmanship

Plant boxes **25.195** Lay a 100 mm drainage layer of aggregate at the base of the box and cover the top of the aggregate with a filter layer.

Soiling for indoor plants **25.196** Fill planting boxes with potting medium to 75 mm below the top of the planter box after settlement.

Location **25.197** Place all plants in the planters in their pots except when specified otherwise. Keep the top lip of each pot flush with the soil surface in the planter.

Fertilizing indoor plants **25.198** Apply slow release fertilizer to indoor plants at fifty percent of the rate for the same plant planted outdoors.

Polishing **25.199** Immediately prior to placing in position, thoroughly clean and polish all leaves with an approved leaf polish, in accordance with the manufacturer's recommendations.

Placing artificial plants **25.200** Placing of artificial plants shall be as recommended by the manufacturer and approved by the SO. Shop drawings shall be submitted with samples of each species of artificial plants. Fill to a level 125 mm below the top of the planter with aggregate or treated coarse pine bark mulch or decorative moss or pebbles, and completed with all associated container with support base.

EXISTING VEGETATION TREATMENT INCLUDING PROTECTION AND SURGERY

General

Definitions on trees **25.201** "Tree" means a plant with diameter at breast height measuring 95 mm or more. Plants growing on retaining structures shall also be measured and considered.

Old and Valuable Tree **25.202** "Old and Valuable Tree" (hereinafter referred to as OVT) means any tree included in the Register of Old and Valuable Trees posted at the website maintained by the Leisure and Cultural Services Department and any other OVT designated by the Government (the Agriculture, Fisheries and Conservation Department (AFCD) and the Leisure and Cultural Services Department (LCSD)).

Diameter at Breast Height **25.203** "Diameter at breast height" (DBH) means the diameter of the trunk of the plant measured at a height of 1300 mm above ground level. For trunk with an obviously elliptical cross-section, the diameter at breast height shall be the average of any two diameter measurements taken at right-angle.

Tree crown spread **25.204** "Tree crown spread" means the diameter of the tree crown defined by the outermost branches of the tree.

Tree height **25.205** "Tree height" means the height from ground level to the top of the tree.

Dripline **25.206** "Dripline" of a tree means the imaginary vertical plumb line that extends downward from the tips of the outermost tree branches and intersects the ground.

Tree Protection Zone **25.207** "Tree Protection Zone" (hereinafter referred to as TPZ) is considered as the minimum area around a tree deemed to contain sufficient roots and rooting volume to maintain the tree's viability, and where the protection of the roots and soil structure is treated as a priority. Methods generally used include: (1) the "dripline method", i.e. the tree canopy dripline is used to define the boundary of the of the TPZ and the entire area within the dripline is considered the TPZ; (2) the "tree height method", i.e. the circular area with the radius equal to the height of the tree; and (3) the "trunk diameter method", i.e. multiply the trunk diameter at 1.4m by 6 to 18 to determine the radius of the TPZ. The method and the extent of TPZ shall be agreed by the SO.

For an OVT, the TPZ refers to the zone encompassing the concerned tree along its dripline and extending vertically to 2000 mm upward beyond the top of the tree and 2000 mm downward beyond the ground level at the trunk base of the tree. For an OVT growing on a retaining structure/wall/rock surface, the TPZ should encompass the body of the concerned tree itself and 2000 mm above the tree crown, as well as the vertical and horizontal surfaces of the retaining structure/wall/rock surface covered by the tree roots together with the space up to 2000 mm behind those surfaces.

Preserved tree **25.208** "Preserved tree" means an existing tree, including OVT, not earmarked to be felled, which may be a tree to be retained at its existing location, a tree at its existing location prior to transplanting, or a tree transplanted within the Site.

Arboricultural work **25.209** "Arboricultural work" means any work related to the cultivation and care of trees for any purpose other than timber production, including but not limiting to planting, replanting, transplanting, pruning, tree surgery work and control of pest and disease.

Workmanship

Programming **25.210** The Contractor shall fully allow the effects of preservation and protection of existing trees in his programme, the method of operation and construction, and the vehicular access for the Works.

Site supervisory staff and preservation and protection of existing trees **25.211** The Contractor shall assign a person to oversee the implementation of preservation and protection to existing trees. The person assigned shall be working full-time on the Site but not necessarily working solely for matters related to preservation and protection to existing trees.

The Contractor shall assign a competent member with arboriculture knowledge of the site supervisory staff to oversee and supervise tree works related to arboricultural operations and preservation of trees onsite and any compensatory planting both onsite and offsite including, but without limitation to, planting, transplanting, arboriculture work, and control of pest and disease affecting trees on the Site. The

person assigned shall be working full-time/part-time onsite, but not necessarily working solely on tree works. The assigned person shall have attended relevant training in arboriculture organized by local and/or overseas training institutes (e.g. Construction Industry Council Training Academy, Vocational Training Council) with cumulative training of at least 30 hours in the past 3 years, and have at least two years practical experience in arboriculture. The Contractor shall submit to the SO for approval within 30 days of the date of the Employer's letter of acceptance of the Tender particulars of the assigned person (including his/her name, experience and position) together with a copy of the certificate(s) issued by the training institute(s) confirming "his/her satisfactory completion of the relevant courses" and supporting documents on the required experience.

The Contractor shall also comply with the requirements as stipulated in the following sub-clauses 25.212 to 25.230 (all inclusive), unless otherwise directed or agreed by the SO.

Contractor's responsibility to record existing trees **25.212** The Contractor shall protect and preserve all existing trees and shrubs on Site. No physical disturbance including transplanting / felling / pruning of any existing tree shall be permitted without prior written consent of the SO and the statutory approval.

Temporary fencing, if necessary shall be provided to prevent the encroachment of equipment or materials and contamination of the surrounding ground by oil or other deleterious substances. Do not bank spoil, vegetable soil or other materials within the drip-line zone of individual trees. If it is necessary to trim or cut back trees and shrubs, it must be done under the direction and supervision of the SO in strict compliance with Clauses 2.37 to 2.41 and this Section of the GS. The Contractor shall make allowance in method of operation and vehicular access for tree preservation during the period of Works.

The Contractor shall carry out a tree survey and submit the tree survey record to the SO within 28 days of the date for commencement of the Works.

Tree survey record **25.213** The tree survey record shall cover all existing trees present within the Site or within 2 m of the site boundary and any other trees likely to be affected by the Works. (A plant is considered as a tree if its trunk diameter measure 95 mm or more at a height of 1300 mm above the ground level. (Guidance on measurement of tree diameter is given in the Agriculture, Fisheries and Conservation Department's Nature Conservation Practice Note No.2)). The tree survey record shall be in the form of an A4-sized, bound report which shall bear a report cover indicating the Contract number, Contract title, and date of the report and shall include the following documents, the formats of which shall be agreed by the SO prior to submission of the report.

Tree survey plan **25.214** A tree survey plan showing the locations of all existing trees and identifying the following:

(a) Which trees are earmarked under the Contract for retention at their existing locations,

(b) Which trees are earmarked under the Contract for transplanting,

(c) Which trees are earmarked under the Contract for felling, and

(d) Which trees are not recorded under the Contract and their treatment is yet to be instructed by the SO;

Tree schedule **25.215** A tree schedule comprising the following information:

(a) Scientific name and Chinese common names of the tree species and the identity code / number as shown on the tree survey plan,

(b) Diameter at breast height of the tree,

(c) Trunk diameter (at 1300 mm above the ground level),

(d) Tree crown spread,

(e) Overall tree height,

(f) Condition of tree including form and health (highlighting any structural defects or unhealthy or decaying symptoms which may pose danger to the public if the tree falls), amenity value, survival rate after transplanting and special features, and

(g) Existing ground level at the trunk base.

Photographic record **25.216** Photographic record for each individual tree and tree group complying with the following:

(a) All photographs shall be date-stamped to indicate the dates that the photographs are taken and shall be well-annotated, and

(b) The photograph of each tree shall show clearly the whole tree as far as possible, the identification number of the tree, and the status of the tree as identified by the labeling or marking system on the Site as required in Clause 25.217.

Photographic record and location plan for individual tree together with the tree schedule shall be submitted within 28 days after commencement of the Works or nomination by the SO.

Identity label **25.217** The Contractor shall mark on the Site with labeling or marking systems to identify trees of different status in accordance with the classification in Clause 25.214. The Contractor shall comply with the following in providing the identification labeling or marking systems:

(a) The identification labeling or marking systems for different tree status shall be in different colours and be clearly distinguishable,

(b) The identification labeling or marking system for the preserved trees shall be made of durable materials that are non-injurious to the trees, be placed at a position not easily accessible to the public, and be attached in such a manner that allows for the growth of the trees and does not injure the trees,

(c) The identification labeling or marking systems and the on-site status identification of trees shall be agreed by the SO and installed prior to the commencement of site clearance, demolition, construction of permanent or temporary works, and any other site operations which may affect the trees, and

(d) The Contractor shall reinstate or replace where necessary the identification labeling or marking systems for the preserved trees and shall remove these identification labeling or marking systems from the Site upon completion of the Works, or earlier if so directed by the SO.

Preparation before site clearance commences **25.218** The limits of site clearance shall be agreed by the SO on the Site before site clearance commences. The Contractor shall comply with the following requirements in respect of tree removal, either by felling or by transplanting.

Requirements in respect of tree felling **25.219** In respect of tree felling, the Contractor shall:

(a) Fell only those trees earmarked for such under the Contract and labeled for such on the Site pursuant to Clause 25.217 or those as directed or approved by the SO,

(b) Commence any work related to tree felling on the Site only after the Contractor's compliance with the requirements, such as those related to method statement, stipulated to be completed prior to commencing the tree felling work,

(c) Take all necessary safety precautions, including but not limited to those stipulated in Clause 25.339, to protect the people engaged in the tree felling work as well as the people and property in the vicinity throughout the whole process of tree felling,

(d) Tree trunks and branches shall be removed in sections for reasons of safety and in such a manner that any potential damage to the public and adjacent utilities, services or pipes, structure, slopes or stream course vegetation is avoided,

(e) Fell the trees by cutting them near the ground, with their stumps ground rather than pulled so that the roots of the nearby plants to be retained are not injured,

(f) Remove the stumps and rootballs of the felled trees carefully to avoid causing damage to the roots of the nearby plants to be retained, where it is necessary to have such removal as directed by the SO,

(g) Do not use a preserved tree as anchor when winching out a stump,

(h) Remove all debris, wood, and roots where necessary pursuant to Clause 25.219 (d) to (g), from the trees felled from the Site as soon as possible. Burning of vegetation or any other construction debris is not permitted, and

(i) All voids formed as a result of the above works shall be backfilled with clean material as appropriate.

Requirements in respect of tree transplanting **25.220** In respect of tree transplanting, either within or off the Site, the Contractor shall:

(a) Transplant only those trees earmarked for such under the Contract and labeled for such on the Site pursuant to Clause 25.217 or those as directed or approved by the SO,

(b) Commence any work related to tree transplanting on the Site only after the Contractor's compliance with the requirements, such as those related to method statement, stipulated to be completed prior to commencing the tree transplanting work, and

(c) Take all necessary safety precautions, including but not limited to those stipulated in Clause 25.339, to protect the people engaged in the tree transplanting work as well as the people and property in the vicinity throughout the whole process of tree transplanting.

Prior approval **25.221** Where it is found necessary for the completion of the Works to remove, either by felling or by transplanting, any trees other than those earmarked for such under the Contract or those directed or approved for such during the progress of the Works by the SO, the Contractor shall:

(a) Report to the SO the necessity of such tree removal,

(b) Provide all reasonable assistance as required by the SO in the tree survey

and the justification for the proposed tree removal with substantiation and the necessary details such as site formation plan and architectural or engineering drawings, for the SO's preparation of the tree felling or transplanting application for the tree removal, and

(c) Fell or transplant the trees only after the SO's approval to the tree removal which shall normally be given only after the tree felling or transplanting application has been approved by the government approving authority (the Lands Department (LandsD) / LCSD / AFCD).

Restriction on site uses

Exercise care **25.222** For the preserved trees, the Contractor shall exercise the greatest care to avoid any damage to them and shall comply with the following:

Restrictive uses **25.223** Take all necessary precautions to ensure that:

(a) No nails or other fixings shall be driven into the trees, including the exposed tree roots,

(b) No fencing, services, or signs other than the identification labels or markings required under Clause 25.217 shall be attached to any part of the trees,

(c) No trees shall be used as anchorages for ropes or chains used in guying or pulling or for equipment used for removing stumps, roots or other trees, or for any other purposes,

(d) No soil, materials, equipment or machinery shall be stockpiled or stored within the TPZ(s),

(e) No site offices, workshops, canteens, containers or similar structures shall be installed within the TPZ(s),

(f) Petrol, oil, bitumen, creosote, cement and other materials likely to be injurious to the trees shall be kept away from the TPZ(s), and any accidental spills of these materials shall be cleaned up immediately,

(g) Excessive water shall be drained away from the TPZ(s) to prevent damage to tree roots by asphyxiation,

(h) The surface on slopes shall be shaped so that water will not drain to the tree trunks but bypass them,

(i) No passage or parking of vehicles and no operation of equipment or machinery shall take place within the TPZ(s) unless otherwise agreed by the SO,

(j) No stripping of surface vegetation or top layer of soil shall be carried out within the TPZ(s) unless otherwise agreed by the SO,

(k) No fires shall be lit within the TPZ(s) or in a position where the flames will likely extend to within 5 m of foliage, branches or trunks of the trees, bearing in mind the size of the fire and the wind direction,

(l) No concrete mixing, gas tank filling, paintbrush and tool cleaning, or equipment maintenance shall be carried out within the TPZ(s),

(m) Any necessary scarification or cultivation within the TPZ(s) shall be carried out carefully by hand so as not to cause damage to the trees, in particular the bark and the roots,

(n) Any equipment, in particular delivery vehicles, overhead cranes, mechanical excavations, drilling rigs and piling rigs, shall be carefully operated so as not to cause striking of the trunks, branches, foliage or root collars of the trees,

(o) The trees to be felled that are adjacent to, or that lie within a continuous canopy of, the preserved trees, shall be carefully removed, and if necessary in sections but not using bulldozers in any circumstances, so as not to cause damage to the preserved trees such as scraping bark off trunks or breaking branches of trees,

(p) Where it is necessary to use herbicides to kill any vegetation, herbicides that can leach through the soil, such as the products containing sodium chlorate, and any other herbicides that are injurious to the trees shall not be used,

(q) Allowance shall be made for the slope of the ground so that damaging materials such as concrete washings, mortar or diesel oil cannot run towards the trees,

(r) Alkaline clays or limestone shall not be used for filling or paving, concrete shall be mixed on a thick plastic tarpaulin or outside the Site, and mixing trucks shall not be rinsed out on the Site, so as not to cause changes, in particular increases, in soil pH, and

(s) All building debris and chemical wastes shall be hauled away for proper disposal, and in any circumstances shall not be burned or buried on the Site or be disposed of by pouring them on the soil within the Site.

Repair for damage **25.224** Repair any damage to the trees in accordance with the requirements stipulated in Clauses 25.249 to 25.255,

Restricted access within Tree Protection Zone **25.225** Where the passage or parking of vehicles or the operation of equipment or machinery within the TPZ(s) as referred to in Clause 25.223(i) is considered necessary and is agreed by the SO, carry out the following measures to reduce soil compaction:

(a) Minimize the traffic of the vehicles, equipment or machinery, and

(b) Confine the passage or parking of vehicles or operation of equipment or machinery to the areas laid with temporary protective mulching as stipulated in Clause 25.237 and with double, overlapping, thick metal sheet coverings, or other materials of equivalent strength as agreed by the SO, placed on top,

Undergrowth within Tree Protection Zone **25.226** Where it is necessary to clear the existing undergrowth within the TPZ(s) to allow access and visibility for, and operation of any construction work,

(a) Shrubs shall be pruned and grass or other herbaceous plants shall be cut to a height of not less than 50 mm above the ground level but not pulled out by equipment in any circumstances, and

(b) The agreement of the SO shall be obtained prior to commencing the vegetation clearance,

Protection from increased exposure **25.227** Protect the preserved trees, where necessary, from increased exposure to sun and wind due to removal of adjacent trees,

Routing **25.228** Align all routes of the overhead services within the Site and all access routes to the Site or within the Site away from the preserved trees as far as possible and seek the SO's approval to the alignment,

Report on tree problems **25.229** Observe and report to the SO of any preserved tree having structural defects or unhealthy or decaying symptoms which may pose danger to the public if the tree falls,

Bimonthly report **25.230** Update the photographic record taken in accordance with Clause 25.216 and submit a report on the updated photographic record to the SO at bimonthly intervals or at intervals agreed by the SO, complying with the following:

(a) Each of the reports shall comprise all preserved trees,

(b) Each of the reports shall be in the form of an A4-sized, bound document which shall bear a report cover indicating the Contract number, Contract title, and date of the report,

(c) The format of the reports shall be agreed by the SO prior to submission of the first report,

(d) All photographs shall be date-stamped to indicate the dates that the photographs are taken and shall be well-annotated,

(e) The photograph of each tree shall show clearly the whole tree as far as possible, the identification number of the tree, and the status of the tree as identified by the labeling or marking system on the Site as required in Clause 25.217, and

(f) Each of the reports shall include details of any damage caused to the trees and any signs of health deterioration of the trees in the reporting period, accompanied with photographic record of the damage and the tree deterioration.

Protection from construction activities

Protection from physical damage and soil compaction by construction activities **25.231** The Contractor shall erect, secure and maintain in good condition temporary protective fencing to protect the preserved trees. Details of the temporary protective fencing shall be in accordance with British Standards listed in Clause 25.257. The Contractor shall submit method statements including construction details to the SO for approval and obtain such approval before commencing the erection of the protective fencing.

Temporary protective fencing **25.232** The temporary protective fencing shall be erected along or beyond the perimeter of the tree protection zone of each individual tree. Where the TPZ(s) of two or more trees overlap with each other, the temporary protective fencing shall be erected along or beyond the perimeter of the aggregate tree protection zone of the trees or as directed by the SO.

Sequence of work **25.233** The Contractor shall complete erection of the temporary protective fencing prior to the commencement of site clearance, demolition, construction of permanent or other temporary works, and any other site operations which may affect the preserved or protected trees.

Removal of temporary protective fencing **25.234** The Contractor shall remove the temporary protective fencing from the Site upon completion of all related tree works (Clauses 25.231 to 25.313 all inclusive), or earlier if so directed by the SO. The Contractor shall not remove or relocate the temporary protective fencing or enter the area enclosed by the temporary protective fencing without the prior agreement of the SO.

Alternative protective measures **25.235** Should erection of temporary protective fencing is not practicable or the preserved tree grows on a retaining structure, the Contractor shall adopt the following requirements in Clauses 25.236 to 25.239 and with prior approval from the SO.

Temporary protective hessian armouring **25.236** The Contractor shall provide temporary protective hessian armouring around tree trunks to protect the preserved trees. When instructed by the SO, the Contractor shall provide temporary protective hessian and plank armouring as an alternative to

the same trees for enhanced protection. Details of the temporary protective hessian armouring and hessian and plank armouring shall be in accordance with British Standards listed in Clause 25.257, or to the approval of the SO.

Temporary protective mulching **25.237** Unless otherwise agreed by the, the ground of the TPZ(s) of the trees referred to in the Clause 25.236 shall be protected from damage by construction activities through the use of temporary protective mulching. When instructed by the SO, double, overlapping, thick metal sheet coverings, or other materials of equivalent strength as agreed by the SO, shall be laid on top of the temporary protective mulching to provide additional protection from soil compaction due to passage or parking of vehicles or operation of equipment or machinery. Details of the temporary protective mulching shall be in accordance with British Standards listed in Clause 25.257, or to the approval of the SO.

Complete tree protection before any site activity start **25.238** The Contractor shall complete erection of the temporary protective armouring and application of the temporary protective mulching prior to the commencement of site clearance, demolition, construction of permanent or other temporary works, and any other site operations which may affect the trees.

Removal of protective measures **25.239** The Contractor shall remove the temporary protective armouring and the temporary protective mulching from the Site upon completion, or earlier if so directed by the SO. The Contractor shall not remove or relocate the temporary protective armouring or the temporary protective mulching without the prior agreement of the SO.

Protection from changes in ground levels **25.240**

(a) Without the prior approval of the SO, the Contractor shall not change the existing ground levels within the TPZ(s) of the preserved trees unless the Contract explicitly requires such changes.

(b) Where it is necessary for the completion of the Works to reduce the existing ground level around a preserved tree which will result in a lowering of the existing ground level within the tree protection zone, the Contractor shall comply with the following requirements:

(i) Construct a retaining wall to accommodate the reduction in the existing ground level around the tree,

(ii) Before commencing the construction of the measures to accommodate reduction in the ground level pursuant to Clause 25.240(b)(i), submit method statements, including construction details, for the measures for the SO's approval,

(iii) Commence the construction of the measures only after the SO's approval to the method statements,

(iv) Follow the requirements stipulated in Clause 25.241 regarding excavation and cutting of tree roots, and

(v) Maintain balanced moisture content in the tree and in the soil after construction of the measures, by carrying out necessary precautionary measures such as crown thinning, watering and mulching.

(c) Where it is necessary for the completion of the Works to raise the existing ground level around a preserved tree which will result in a rise in the existing ground level within the tree protection zone, the Contractor shall comply with the following requirements:

(i) Construct a dry well and soil aeration system to accommodate minor to moderate rise of up to 300 mm in the existing ground level around the tree,

(ii) Construct a dry well and soil aeration system to accommodate major rise of more than 300 mm in the existing ground level around the tree,

(iii) Before commencing the construction of the measures to accommodate rise in the ground level pursuant to Clauses 25.240(c)(i) and/or 25.240(c)(ii), submit method statements, including construction details, for the measures for the SO's approval, and

(iv) Commence the construction of the measures only after the SO's approval to the method statements.

Protection from excavation including trenching **25.241** Without the prior approval of the SO, the Contractor shall not carry out excavation within the TPZ(s) of the preserved trees unless the Contract explicitly requires such excavation work. For the approved excavation work within the TPZ(s), the Contractor shall comply with the following requirements:

(a) Obtain agreement from the SO to the detailed locations and extent of the excavations before commencing any excavation work,

(b) Carry out the following before commencing any cutting work to the aerial roots or underground roots of the preserved trees:

(i) Determine the locations of the major roots and the bulk of the their absorbing roots so as to keep the cutting of tree roots to a minimum and to preserve the tap roots, sinker roots and support roots of the trees in any circumstances,

(ii) Obtain agreement from the SO to the extent of root cutting on the Site, and

(iii) Where the stability of the trees is likely to be jeopardized, comply with the requirements stipulated in Clauses 25.245 (a) to (c),

(c) Submit to the SO photographic records showing the condition of the affected trees and the agreed extent of excavations and root cuttings as marked on the Site prior to commencement of the excavation work and root cutting work and thereafter submit photographic records showing the condition of the affected trees and the progress of the excavation work and root cutting work at weekly intervals until backfilling of the excavations is complete,

(d) Excavate the trench on the paved side of the tree if one exists, or tunnel the service in the manner and as shown in **BS 5837** close to the tree trunk on one side:

(i) Excavate a trench as narrow as possible directly towards the tree along a radius to not closer than 1.0 m from the trunk or where roots larger than 25 mm in diameter are encountered, whichever distance is farther away from the trunk,

(ii) Tunnel straight beneath the tree at a depth of not less than 750 mm and in a way to avoid damaging any tap root, sinker roots or support roots,

(iii) Exit on the opposite side along another radius, and

(iv) Sleeve the service where it passes beneath the tree to reduce the risk of damage to the service and facilitate future servicing and repair,

(e) Pile the excavated materials outside the TPZ(s) to reduce soil compaction,

(f) Carry out the excavations carefully so as not to damage the bark and root collars of the preserved trees,

(g) Maintain balanced moisture content in the trees and in the soil after backfilling of the excavations, by carrying out necessary precautionary measures such as crown thinning, watering and mulching, and

(h) Move the temporary protection fencing stipulated in Clauses 25.231 to 25.239 to the edge of the intended excavation area, between the excavation area and the rest of the tree protection zone, during the duration of excavation work, and move back the same to its original location after backfilling.

Precautions in carrying out excavation

25.242 The Contractor shall take the following precautions when carrying out excavation that involves cutting of the roots of the preserved trees:

(a) Excavation shall be carried out using only hand-held tools such as hoe and spade, but not mechanical diggers or bulldozers in any circumstances,

(b) Whenever roots are encountered and before root cutting is carried out, soil shall be carefully forked away from the roots using hand-held tools up to the edge along which root cutting is required,

(c) Root cutting shall be carried out carefully using clean and sterilized hand-held pruning tools, and roots greater than 25 mm in diameter shall be pruned carefully so as not to result in shattered and frayed roots,

(d) Any roots damaged during excavation shall be cut back cleanly with sharp tools to undamaged tissue and treated with an approved fungicidal dressing prior to backfilling,

(e) All cut and exposed roots shall be prevented from drying out during excavation by adopting the following measures until backfilling, unless otherwise agreed by the SO:

(i) Wrap the tap roots, sinker roots, support roots, and roots with diameter exceeding 50 mm, which shall not be cut, with hessian, straw or other porous, absorbent fabric once they are exposed,

(ii) Hang thick hessian or other porous, absorbent fabric from top of the cut surface over the exposed roots and soil immediately after root cutting, and

(iii) Mist the hessian or fabric in a frequency that keeps the roots and the soil at the cut surface moist all the time,

(f) The hessian, straw or other porous, absorbent fabric stipulated in Clause 25.242(e)(i) and the hessian or fabric stipulated in Clause 25.242(e)(ii) shall be removed immediately before backfilling, and

(g) Excavations shall be backfilled with soil mix incorporated with slow release fertilizer at a rate of 500 g/m^3 or at a rate as directed by the SO to a level not higher than the original soil level at the root collar.

Protection from drilling

25.243 Without the prior approval of the SO, the Contractor shall not carry out drilling, such as soil nailing and drilling for bore holes, rock bolts or dowels, within the TPZ(s) of the preserved trees unless the Contract explicitly requires such drilling work within the TPZ(s). For the approved drilling work within the TPZ(s), the Contractor shall comply with the following requirements:

(a) Obtain agreement from the SO to the detailed locations and extent of the drill holes before commencing any drilling work, bearing in mind that the drill holes shall be located in such a way that the structures to be placed into

the drill holes, including the surface elements of the structures such as soil nail heads, are at a minimum distance of 500 mm from the trunks of the preserved trees unless otherwise agreed by the SO in exceptional circumstances, and

(b) Carry out the following before commencing any cutting work to the aerial roots or underground roots of the preserved trees:

(i) Determine the locations of their major roots and the bulk of the their absorbing roots so as to keep the cutting of tree roots to a minimum and to preserve the tap roots, sinker roots and support roots of the trees in any circumstances,

(ii) Obtain agreement from the SO to the extent of root cutting on the Site,

(iii) Where the stability of the trees is likely to be jeopardized, comply with the requirements stipulated in Clauses 25.245 (a) to (c),

(c) Carry out the drilling work carefully so as not to damage the branches, foliage, trunk, bark and root collars of the preserved trees when gaining access for, supporting, mobilizing, positioning and operating the drilling rig, and

(d) Maintain balanced moisture content in the trees and in the soil after the drilling work, by carrying out necessary precautionary measures such as crown thinning, watering and mulching.

Precautions to avoid root damage **25.244** The Contractor shall take the following precautions when carrying out drilling work that involves cutting of the roots of the preserved trees:

(a) Drilling work and root cutting work shall be carried out carefully,

(b) Roots greater than 25 mm in diameter shall be pruned carefully in order to prevent shattered and frayed roots, and

(c) Any roots damaged during drilling shall be cut back cleanly with sharp tools to undamaged tissue and treated with an approved fungicidal dressing.

Protection from instability **25.245** (a) Where the Works involve cutting of any major roots or other major parts of the preserved trees or any other works that may jeopardize the stability of the preserved trees, the Contractor shall install all necessary physical support for the preserved trees to ensure their stability. The Contractor shall pay particular attention to the preserved trees growing on retaining structures in order to prevent the trees from being dislodged from its position as a result of inadequate support.

(b) The physical support for the preserved trees shall be installed securely prior to commencement of the root cutting, tree pruning or any other works that may affect the stability of the trees. Before commencing the installation of the physical support measures, the Contractor shall submit method statements for the support measures to the SO for approval. The Contractor shall commence the installation of the support measures only after the SO's approval to the method statements.

(c) The physical support for the preserved trees shall be securely founded in footings independent of existing walls or building structures or in other supporting systems as appropriate, without interfering with other works, other existing features, and the preserved trees. Where the affected tree is growing on a retaining structure, the Contractor shall make a detailed assessment to estimate the weight of the tree and identify the best position of supporting the tree in relation to its overall spread and centre of gravity. The method statements for the support measures in respect of the trees growing

on retaining structures shall include the following information:

(i) Details of the form of construction and where requested by the SO structural design calculation for the support measures, demonstrating the bearing capacity of each element,

(ii) Details of the foundation of the support measures, demonstrating that the support measures shall not interfere with other works, other existing features, and the preserved trees and shall not affect the stability of the retaining structure,

(iii) Means of securing the tree to the supporting measures, including how cups and ties are adjusted to the form of the tree, and

(iv) Method of fabrication and erection on the Site.

(d) The Contractor shall remove the physical support for the preserved trees from the Site upon completion, or earlier if so directed by the SO. The Contractor shall not remove or relocate the physical support for the trees without the prior agreement of the SO.

Restrictions on pruning preserved trees

Pruning of preserved trees **25.246**

Without the prior approval from the SO, the Contractor shall not carry out pruning to the preserved trees unless the pruning work is required under the Contract or is directed by the SO. Where it is found necessary for the completion of the Works or for safety or other justifiable reasons to carry out any tree pruning work other than those approved ones, the Contractor shall notify the SO of such requirement and seek the SO's approval before carrying out the tree pruning work. The Contractor shall carry out the approved pruning work according to the timing stipulated in Clause 25.305 or other programme instructed or agreed by the SO.

The Contractor shall follow the requirements in Clause 25.309 regarding the submission of method statement on tree pruning.

The Contractor shall follow the requirements in Clause 25.339 regarding the safety precautions to be taken in tree pruning work.

Standards of pruning **25.247**

The Contractor shall follow the requirements in Clauses 25.303, 25.304, 25.306 and 25.307 regarding the standards of tree pruning work.

Tree care

Control of pest and disease for preserved trees **25.248**

(a) The Contractor shall take all necessary precautionary measures to protect the preserved trees from pest and disease attack and all necessary control measures to eradicate pest and disease from the infected trees.

(b) Before commencing the application of the pest and disease control measures, the Contractor shall submit method statements for the control measures to the SO for approval. The Contractor shall commence the application of the control measures only after obtaining the SO's approval to the method statements.

(c) The method statements for the pest and disease control measures shall cover, amongst other aspects as required by the SO, the pesticide or fungicide to be used and any other necessary associated arboricultural work to the infected areas.

(d) The Contractor shall comply with the following requirements in applying the pest and disease control measures:

(i) Environmentally friendly measures shall be adopted, and

(ii) Safety precautions as the manufacturer's instruction shall be strictly followed in using pesticide or fungicide so as to avoid causing danger or harm to the public and the environment.

Repair of damage to and replacement of preserved trees and other affected plants **25.249** The Contractor shall carry out all necessary work of repair of any damage to the preserved trees and any other plants affected.

Repair works **25.250** The work of repair of damage as referred to in Clause 25.249 shall include the following:

(a) All necessary arboricultural work to the preserved trees and any other plants damaged, which may include:

(i) Tree surgery work to remove dead, damaged, diseased or hazardous parts, to repair wounds, or to provide cables or braces for additional support,

(ii) Watering and/or mulching in case of water deficiency, and

(iii) Applying appropriate fertilizers in case of nutrient deficiency,

(b) The replacement planting pursuant to Clause 25.255 for the trees and any other plants damaged to an extent as described in Clause 25.254 and the subsequent Establishment Works for the new plants for 1 year, when instructed by the SO, and

(c) Any other reinstatement work necessary to bring the damaged plants to their original condition prior to the occurrence of the damage, as directed by the SO.

Report on occurrence of damage to preserved trees **25.251** The Contractor shall notify the SO of any damage to the preserved trees and other affected plants within the same day of the occurrence of damage and shall submit to the SO within 7 days of the occurrence of damage, a report comprising the following information in a format agreed by SO:

(a) The timing of the damage,

(b) The nature and extent of the damage,

(c) Photographic records of the damage,

(d) The proposed work of repair of the damage, and

(e) The proposed protection measures to avoid recurrence of similar incident.

Firming, securing and wound treatment **25.252** When directed by the SO, the Contractor shall firm up and secure all dislodged trees and any other dislodged plants and shall treat all wounds of the damaged trees/plants within 3 days of the occurrence of the damage.

Sequence of work **25.253** Save as stated in Clause 25.252, the Contractor shall not carry out any work of repair of the damage prior to the SO's acceptance of the report as required in Clause 25.251.

Replacement planting of damaged trees/plants **25.254** The Contractor shall provide replacement planting of the damaged trees and any other affected plants under the following circumstances:

(a) In the opinion of the SO the damaged trees/plants are dead,

(b) In the opinion of the SO, the trees/plants have been substantially damaged, resulting in one or more of the following conditions:

(i) That imminent death of the trees/plants within the coming growing season is predicted,

(ii) That the structural integrity of the damaged trees/plants is permanently compromised and consequently the trees/plants become an irreparable public hazard,

(iii) That any major parts of the damaged trees/plants have been lost and consequently their form, habit and balance have been grossly altered so that their function cannot be reasonably recovered or the trees/plants are causing harm to other preserved trees.

Requirements on removal of the damaged trees/plants **25.255** When instructed by the SO, the Contractor shall carry out the following:

(a) Removal of the damaged trees/plants for which replacement planting as Clause 25.254 is required, in accordance with the following requirements:

(i) For the removal of the damaged trees, the Contractor shall prepare a tree felling application document to the SO's satisfaction and provide any other assistance or information as required by the SO, for the SO's application for approval to the felling of the damaged trees from the government approving authority (LandsD/LCSD/AFCD),

(ii) The Contractor shall fell the damaged trees only after the SO's approval to the tree felling, which shall normally be given only after the tree felling application has been approved by the government approving authority (LandsD/LCSD/AFCD), and

(iii) The Contractor shall remove the damaged plants from the Site.

Replacement **25.256** Replacement planting of new plants in accordance with the following requirements:

(a) The Contractor shall complete the replacement planting within 28 days from the SO's instruction or other time duration as agreed by the SO, and

(b) For replacement planting, the Contractor shall plant new plants of the same species and of similar size and form as the damaged plants prior to the damage or provide other alternative replacement planting as agreed by the SO.

Other references on arboricultural / tree work **25.257** The Contractor's attention is also drawn to the latest editions of the Technical Circular, practice notes and guidelines promulgated by the Development Bureau and the following British Standards and British Standard Code of Practice for general reference:

BS 3998 Tree work – Recommendations

BS 4428 Code of Practice for General Landscape Operations (Excluding Hard Surfaces)

BS 5837 Trees in relation to Construction – Recommendations

EXISTING VEGETATION TREATMENT INCLUDING FELLING, TRANSPLANT AND SURGERY

Tree felling

Identification **25.258** At the commencement of works, and concurrent with the tree protection works, Contractor shall identify and clearly mark all trees that are indicated on Contract drawing as trees to be felled in accordance with Clauses 25.213 to 25.217. Any tree which for any reason is required to be felled during the progress of the work shall be immediately drawn to the SO's attention and permission sought from relevant authority prior to any felling being carried out.

Workmanship – tree felling

Workmanship on tree felling **25.259** During the tree felling operations, all works shall be in accordance with Clause 25.219.

Method statement **25.260** Unless under emergency situation agreed by the SO, the Contractor shall submit method statement on tree felling for the SO's approval and shall commence any work related to tree felling only after the method statement has been approved in writing by the SO.

Transplanting trees

Transplanting trees, palms and conifers **25.261** For the purpose of this Clause, palms and conifers are also considered as trees.

Programme and method statement for transplanting trees **25.262** The Contractor shall submit and obtain approval from the SO, prior to any works to the trees on the Site, a detailed method statement and programme for transplanting the existing trees, outlining the method, sequencing, timing of operations, and the location and type of machinery to be used for the following operations:

(a) Protection before lifting and transplanting,

(b) Root pruning, including the root ball size, and the number of stages, the operations involved in each stage, and the period between each stage of root pruning,

(c) Crown thinning,

(d) Excavating trenches for root ball preparation,

(e) Design and construction of supporting measures,

(f) Attaching lifting gear to the trees,

(g) Protection during transit,

(h) Temporary holding nursery, if required,

(i) Lifting,

(j) Transportation to new location, including routing,

(k) Preparation of receptor site,

(l) Placement, backfilling, mulching and securing at receptor site,

(m) Backfilling and making good the donor site, schedule of establishment works during the establishment period.

Planning for transplanting **25.263** Conifers and palms shall be transplanted while dormant, and deciduous trees shall be transplanted in early spring or fall, unless otherwise permitted by the SO.

Record on transplanting **25.264** The Contractor shall keep a complete photographic record with date-imprinted, for each existing tree to be transplanted, at the various stages of the transplant process as detailed under Clause 25.262. Contractor shall agree with the SO on the submission details prior to commencement of the root pruning works.

Standards of transplanting **25.265** All works and materials shall be with good arboricultural practice and in accordance with British Standards listed in Clause 25.257.

Replacement **25.266** Any tree transplanted or to be transplanted that dies or is damaged to an extent that, in the opinion of the SO, replacement planting is necessary, shall be replaced by the Contractor. The Contractor shall provide replacement planting of new trees of

the same species and of similar size and form as the dead or damaged ones prior to the death or damage or provide other alternative replacement planting as agreed by the SO. The Contractor shall complete the replacement planting within 28 days from the SO's instruction or other time duration as agreed by the SO.

Workmanship - Transplanting trees

Pre-transplant preparation **25.267** The pre-transplanted tree shall be preserved and protected in accordance with Clause 25.223, prior to the commencement of the crown and root pruning works.

Crown pruning

Restrictions on crown pruning **25.268** Limited crown pruning to remove dead, diseased, broken or damaged branches and facilitate transit operation shall only be carried out with prior approval from the SO. The spacing, balance and attachment of the limbs should be evaluated at time of crown pruning. Reduction of the original crown spread shall limit to the maximum of 25% to produce a well-shaped, balanced head. The central leader shall not be removed.

Root pruning

Programme **25.269** The Contractor shall allow the tree transplanting works in his programme of Works in such a way that the root pruning to the approved size of root ball shall commence as early as possible so as to ensure maximum fibrous root growth prior to transplanting operations.

Root pruning period **25.270** Root pruning should normally take place with a minimum of 1 month allowed for root regeneration between cuts. The period shall be approved by the SO.

Root pruning period may be adjusted to suit specific tree species and/or imposed project constraints.

Anchoring **25.271** Where the stability of the tree is likely to be jeopardized, the Contractor shall subject to approval on submitted method statement, install all necessary physical support for the pre-transplanted tree to ensure its stability.

During the whole period of root pruning stages, make regular inspection of the stability of the trees and adjust the physical support as necessary. Ensure that chafing of the trunk or branches does not occur.

Root ball preparation **25.272** The dimensions for the root ball shall be determined by the Contractor, approved by the SO, based on tree species/size and site specific conditions to ensure the pre-transplanted tree's maximum potential of survival during and after transplant.

After determining the size of the root ball and after obtaining approval from the SO, the proposed circumference of the root ball shall be marked on the ground for inspection and approval by the SO.

Root pruning in stages **25.273**

(a) The circle shall be divided into 6 equal segments and the work shall take place in four stages.

(b) Each root pruning stage shall be performed at least one month after the previous stage unless otherwise directed by the SO. The four stages are:

(i) 1st stage - Dig a trench on the outside of the marked circumference, in only two opposing segments,

(ii) 2nd stage - After a period of not less than 1 month since the 1st root pruning (or a longer period as specified or as directed by the SO), dig a trench on the outside of the marked circumference, in the next two opposing segments,

(iii) 3rd stage - After another period of not less than 1 month since the 2nd root pruning (or a longer period as specified or as

directed by the SO), dig a trench on the outside of the marked circumference, in the last remaining two opposing segments,

(iv) 4th stage - After a further period of not less than 1 month since the 3rd root pruning (or a longer period as specified or as directed by the SO), prepare the root ball as specified and cut the underside of the root ball, followed by uplifting and transplanting.

(c) All cuts shall be made with sharp spade, or other implements in accordance with all other relevant British Standards listed in Clause 25.257. Cuts must be clean to avoid tearing or breaking the roots.

(d) The trench shall be 200 - 300 mm wide and 750 mm deep, or as directed by the SO. The excavated trench shall be backfilled with fabricated soil mix or peat moss to encourage new growth of root tips.

Maintenance during root pruning period **25.274** The Contractor shall inspect the tree every 28 days to check its health. Any sign of deterioration shall be reported immediately to the SO and remedial action taken to rectify the situation.

The root ball zone shall not be subjected to undue compaction. The Contractor shall erect temporary protective fencing in accordance to Clauses 25.231 to 25.239 from the 1st stage of root pruning until tree lift.

The Contractor shall water regularly, remove weed growth, carry out insecticide treatment and any other horticultural work as necessary and as approved by the SO.

The application of root activator, where necessary, shall be carried out according to the manufacturer's instruction.

Tree lifting and protection

Timing **25.275** Tree lifting operations will be timed so as to enable transplanting of material direct to areas of proposed planting. No transplanting operations shall commence until either the receptor site or the holding nursery is fully prepared as specified. Any plant uplifted must be transplanted and watered the same day.

Watering **25.276** Lifting and transplanting operations shall be carried out only following a period of consistent rainfall which has thoroughly watered the trees to the satisfaction of the SO or following a thorough watering of the trees by the Contractor at a rate agreed by the SO.

Wrapping of root ball **25.277** Before uplifting, the outer edge of the previously dug trenches shall be loosened from the surrounding soil, and ball can be shaped with taper on the sides, slanting inward toward the base.

Damp hessian is placed on the sides and across the top of the ball and pinned. The Hessian should cover the full circumference of the root ball with bottom skirt hanging out. This skirt is pinned to the ball later after the tree is taken out of the hole. This Hessian shall be kept moist throughout the time of uplifting until the uplifted tree is transplanted in its new location.

Uplifting **25.278** Plants shall be lifted carefully to avoid damage to root ball. Roots shall be cut free from ground, not pulled, using a suitable implement to give a clean cut. All roots greater than 50 mm diameter shall be treated with an approved sealant.

Protection **25.279** All trees to be transplanted shall be wrapped and protected to prevent mechanical damage during lifting and transport, and protected against excessive sunlight, wind, and drought.

Extra care must be taken to avoid damage to the bark. If limbs are to be tied, they must not be tied so tightly to create sharp bend that could compress the tissues or cause breakage.

The Contractor shall provide all necessary plant, machineries of appropriate capacity, and exercise all precautionary measures to protect the people engaged in the transplant operations as well as the people and property in the vicinity during the entire uplift and transplant operations.

Containerized root ball **25.280**

Trees transplanted to the holding nursery are to be containerized, using containers of appropriate material and size to suit the approved root ball size. They shall be planted in an upright position, allowing adequate space for growth, and tied and staked securely to avoid damage to the tree stems. Immediately following planting the trees shall be watered thoroughly to ensure a thorough soaking of the roots.

The tree root ball container shall vary in accordance with the tree root ball dimensions. Allow for a minimum of 150 mm clearance between the root ball edges to the sides and at least 300 mm to the bottom of the root ball container. This space shall be filled with moist peat moss or other materials as agreed by the SO.

Protection during transit **25.281**

Crown of the tree should be loosely wrapped to minimize drying and wind damage. Anti-transpirants may be applied with the approval from the SO in accordance with manufacturer's instruction.

Trucks should be well padded to protect the trees from injury. The buds of the palms shall be well supported throughout the transit period. Care shall also be taken in packing of the trees to prevent over-heating, cooking the foliage and crushing of the foliage and branches.

Planting and maintenance

Preparation of planting pit at receptor site **25.282**

(a) During planting pit preparation, the existing topsoil ploughed from digging shall be stripped and put aside for reuse as much as possible and to avoid a distinct interface between the pit and the surrounding soil.

(b) The planting pit shall be:

(i) with drainage to allow effective percolation of water;

(ii) prepared to prevent settling;

(iii) dug to the depth not exceeding the depth of the root ball and the sides of the pit shall be scarified;

(iv) in terms of the width, at a minimum of 1.5 times the diameter of the root ball or as approved by the SO.

Direct planting in receptor site **25.283**

Tree transplanted directly to the final receptor site is to be planted and secured, if required, in accordance with the Clauses 25.80 to 25.93, unless otherwise proposed by the Contractor and approved by the SO.

Synthetic or treated hessian around the root ball must be removed upon planting in the receptor site. Natural hessian should also be removed, if practicable, or to fold back, to ensure roots can grow out of the root ball. All pins and twines shall also be removed to avoid girdling the tree.

Replanting from holding nursery to receptor site **25.284**

Trees with root ball containerized shall be transported from holding nursery to the permanent receptor site with container intact.

The sides and bottom of the container shall be removed carefully by hand held tools without damage to the root ball.

Planting procedure shall be in accordance with Clauses 25.80 to 25.93, unless otherwise proposed by the Contractor and approved by the SO.

Immediate maintenance **25.285** Plant materials shall be maintained immediately after transplanting works, from existing location for period as specified under the Contract.

Such maintenance shall include all measures necessary to establish and maintain all plants in an acceptable vigorous and healthy growing condition. The establishment works shall be carried out in accordance with requirements under Clauses 25.314 to 25.334 and 25.336, unless otherwise proposed by the Contractor and approved by the SO.

Watering upon transplanting **25.286** Immediately after transplanting, the base of all plants shall be well watered to thoroughly soak the root ball. Trees shall be well watered in evenings and early morning only.

Dry season watering **25.287** Watering shall be carried out daily during the dry season, generally September to April, and as required during the wet season.

Mulch **25.288** A consolidated layer of 50 mm thick of mulch shall be placed around the tree, extending 150 mm beyond the perimeter of the tree pit and covering at least the entire root ball zone. Mulch shall not be placed immediately around the tree trunk or root collar.

Weeding to rootball **25.289** Rootball shall be kept free of weeds at all times and in accordance with Clauses 25.322.

Crown cleaning **25.290** At the instruction of the SO, trees shall be pruned selectively to remove dead, damaged or dangerous branches. The pruning method of crown cleaning shall follow the requirements in Clauses 25.303 to 25.309.

Transplanting shrubs, climbers, groundcovers and bamboos

Transplanting shrubs, climbers, groundcovers and bamboos **25.291** For the purpose of this Clause, climbers, groundcovers and bamboos are also considered as shrubs.

Programme for transplanting shrubs **25.292** The Contractor shall submit and obtain approval from the SO, prior to any works to the shrubs on the Site, a detailed method statement and programme for transplanting the existing shrubs, outlining the method, timing of operations for the following operations:

(a) Root pruning, including the root ball size, and the number of stages, the operations involved in each stage, and the period between each stage of root pruning,

(b) Crown pruning,

(c) Temporary holding nursery, if required,

(d) Placement, backfilling, mulching and securing at receptor site,

(e) Schedule of establishment works during the period for establishment works.

Standards of transplanting shrubs **25.293** All works and materials shall be with good arboricultural practice and in accordance with British Standards listed in Clause 25.257.

Replacement Any shrub transplanted or to be transplanted that dies or is damaged to an extent that, in the opinion of the SO, replacement planting is necessary, shall be replaced by the Contractor. The Contractor shall provide replacement planting of new shrubs of the same species and of similar size and form as the dead or damaged ones prior

to the death or damage or provide other alternative replacement planting as agreed by the SO. The Contractor shall complete the replacement planting within 28 days from the SO's instruction or other time duration as agreed by the SO.

Workmanship - transplanting shrubs

Workmanship on transplanting shrubs **25.294** Size of root ball shall be determined by the Contractor and approved by the SO, dependent on the species / size of the shrub.

Agreed size of root ball shall be marked on ground, and roots shall be cut free from ground, not pulled, using a suitable implement to give a clean cut.

Transplanting operations shall be carried out only after thorough watering of the shrubs to the satisfaction of the SO.

Uplifted root ball shall be wrapped with damp hessian, placed in a suitable size basket and keep moist at all times until re-plant to receptor site, in accordance with Clauses 25.80 to 25.91.

Wrap the foliage of the shrub to protect against excessive sunlight, wind and drought if shrub is to be transported to a distant site. Care shall be taken in packing to prevent over-heating with its resultant loss of foliage.

Immediately after transplanting, the base of all plants shall be well watered to thoroughly soak the root ball.

Plant materials shall be maintained immediately after transplanting works, from existing location for period as specified under Contract, in accordance with Clause 25.314 to 25.332.

TRANSPLANTING TREES OF SEMI-MATURE SIZE AND ABOVE

Materials

Transplanting semi-mature trees and above **25.295** Semi-mature trees and trees of size above shall be all as described in Clause 25.100 or as specified.

Programme for transplanting semi-mature trees and above **25.296** Clauses 25.262 to 266 shall apply.

Workmanship – transplanting trees of semi-mature size and above

Pre-transplant preparation for trees of semi-mature size and above **25.297** Clauses 25.267 to 25.272 and 25.274 shall apply with the exception of Clause 25.270 shall be replaced by "2 months" instead of "1 month".

Root pruning in stages **25.298**

(a) After determining the size of the root ball and after obtaining approval from the SO, the proposed circumference of the root ball shall be marked on the ground around the tree. This circle shall be divided into 6 equal portions and the work shall take place in three stages:

(i) 1st stage - Dig a trench on the inside edge of the marked circumference, in only the first three alternate portions, leaving the remaining portions uncut.

(ii) 2nd stage - After a period of not less than 2 months since the first root pruning (or a longer period as specified or as directed by the SO), proceed to dig a trench on the inside edge of the marked circumference in the

remaining three uncut portions.

(iii) 3rd stage - After a further period of not less than 2 months since the 2nd root pruning (or a longer period as specified or as directed by the SO), prepare the root ball as specified and cut the underside of the root ball, followed by uplifting and transplanting.

(b) All cuts shall be made with sharp spade, or other implements in accordance with all relevant British Standards listed in Clause 25.257. Cuts must be clean to avoid tearing or breaking the roots.

(c) The trench shall be 200 - 300 mm wide and 1000 mm deep, or as directed by the SO. The excavated trench shall be backfilled with fabricated soil mix or pear moss to encourage new growth of root tips.

Tree lifting and protection **25.299** Clauses 25.275 to 25.281 shall apply

Large trees must be removed from the hole with crane or other mechanical device, of appropriate capacity. Trees should not be lifted by the trunk.

Planting and maintenance of transplanted semi-mature trees **25.300** Clauses 25.282 to 25.290 shall apply.

TREE SURGERY WORK

Generally

Scope of work **25.301** Tree surgery work shall cover tree pruning, treatment of wounds and injuries, and treatment of cavities and water pockets to the trees;

"Tree pruning" means the removal of unwanted branches such as those shown in Fig. (1) in Annex A, either for reducing risk and inconvenience to the public, maintaining or improving tree health and structure, or improving appearance of the tree;

"Treatment of wounds and injuries" means any work to the tree for reducing the risk of colonization of wound pathogen to tree wounds and enhancing the natural regeneration of tissues on the exposed surfaces;

"Treatment of cavities and wet pockets" means any work to the tree for deterring further wood decay at the cavities and wet pockets and/or achieving other management objectives such as strengthening the tree structure and deterring human access.

Safety precautions in tree surgery work **25.302** The Contractor shall take all necessary safety precautions, including but not limited to those stipulated in Clause 25.339, to protect the people engaged in the tree surgery work as well as the people and property in the vicinity.

Workmanship – Tree surgery work

Workmanship of tree surgery work **25.303** The workmanship of tree surgery work shall generally follow the requirements in **BS 3998**, Tree work – Recommendations. Where there are inconsistencies between this BS and other provisions in the contract, other provisions in the contract shall prevail over this BS.

Types of pruning **25.304** "Formative pruning" means selective pruning of the lateral branches of a tree so as to develop a desirable tree form with a strong and straight trunk, a well-balanced crown with properly spaced scaffolding branches and a clear central ladder;

"Crown lifting / Crown Raising" mean selective pruning to remove lower branches to increase vertical clearance from ground level;

"Crown reduction" mean selective pruning to reduce the overall height and spread of the crown, while maintaining a well-balanced and natural form and shape;

"Crown thinning" means selective pruning to remove weak, thin, crossing and live branches to reduce the density of foliage, but without affecting the overall height and spread of the tree; and

"Crown cleaning" means selective pruning to remove dead, dying, withered, broken, damaged, hanging, detached, decayed, cankered, insect burrowed, cracked or diseased branches, branch stubs, the relatively weaker or poorly structured member of a crossed branch pair, or excessive water sprouts.

"Restorative Pruning" means selective pruning to remove damaged, crossing and dead branches to restore tree health and structure to a better and more natural condition.

Timing of pruning **25.305**

(a) For maintaining the vitality of the tree, the following requirements shall be observed where practicable when planning the timing of pruning work:

(i) Avoid pruning at times when the disease- and decay- resistance of the tree is likely to be impaired by physiological stress induced by previous tree work, construction damage, or seasonal or weather-related factors such as during or soon after a drought or when starch reserves have been depleted by spring flushing and flowering.

(ii) Avoid pruning prior to flowering season of the tree.

(iii) Avoid pruning at the timing that will result in exposure of tissues to severe conditions, such as those due to season, weather or known seasonal presence of pathogens, taking into account the tolerance of the species concerned to such conditions.

(iv) Depending on the species concerned, avoid pruning at certain times of the year when pruning will result in bleeding of sap and hence losing sugars.

(v) Avoid pruning during spring and early summer active growing period.

(vi) Pruning of evergreen trees just before spring, for faster healing in the coming growing season.

(vii) Pruning of deciduous trees after shedding leaves in winter when trees are dormant, for minimizing the risk of pest problem associated with wounding and allowing the trees to take advantage of the full growing season to close and compartmentalize wounds.

(viii) Suitable structural pruning of young trees for facilitating the development of a straight trunk.

(ix) Allow sufficient time for a tree to recover following any damage or adverse management that might have increased its vulnerability to physiological dysfunction, before carrying out any further pruning.

(x) Pruning of tree species whose defences against various wound-related diseases depend partly on the production of gum or resin, when these processes are at their most active.

(b) For improving health of trees or reducing risk and inconvenience to the public, pruning shall be conducted as and when required.

(c) For accommodating the following types of conflicts between construction and trees, pruning shall be carried out prior to the erection of the temporary protective fencing and the initiation of construction activities where practicable:

(i) Conflicts incurring permanent occupation of the space by building structure and, hence permanent loss of subaerial growth space of the tree.

(ii) Conflicts temporarily demanded by the need to provide sufficient working space to conduct construction activities adjoining the tree.

(d) For crown cleaning, pruning shall be carried out prior to the erection of the temporary protective fencing and the initiation of construction activities where practicable.

(e) Extensive crown lifting shall be phased over a number of years where practicable, with a view to providing some opportunity for physiological and biomechanical adaptation to the resulting wounding and branch removal.

Extent of pruning **25.306**

(a) The amount of leaf-bearing twig structure removed and the size of pruning cuts, both individually and collectively, shall be kept to the minimum required to achieve the objectives, observing the following requirements where practicable:

(i) Each final cut shall be kept as small as possible by cutting at an optimum angle.

(ii) The diameter of the final cut shall generally not exceed one-third of that of the parent stem or branch but shall even be smaller for old and declining tree to allow for the relatively small proportion of sapwood and the slow rate of wound occlusion.

(iii) The number and size of cuts shall generally be limited so that their total cross-sectional area does not exceed one-third of that of the stem, when measured at 1.5 m above ground level.

(b) The pruning work shall be done in phases to allow refoliation if the minimum pruning required to achieve the objectives in a one-off operation cannot retain enough leaf area for satisfactory physiological function, taking into account the species tolerances, the tree's age and condition and any implications for the safety of other trees.

(c) To avoid over-pruning which will affect the healthy growth of the trees, the removal of tree crown shall be limited to not more than one quarter of the original coverage in each pruning operation and the tree crown shall be kept in a well-balanced and natural form and shape after pruning.

(d) For species that are relatively susceptible to wound-induced decay, pruning shall be restricted to healthy, small-diameter parts of the tree, and shall be carried out as sparingly as possible and without exposing heartwood or ripewood.

(e) For species that have relatively strong defences against decay but produce non-durable heartwood or ripewood, at least two-thirds of the diameter of any cut shall consist of wood that, according to characteristics of the species concerned, is assessed as still containing living tissue.

(f) For branches which are close together on a parent stem or branch, the following requirements shall be observed where practicable:

(i) Removal of such branches shall be avoided, unless the tree is young tree or the cuts are so small as to be capable of being fully occluded,

and therefore resistant to decay, within a few years.

(ii) If removal of such branches cannot be avoided, the branches selected for removal shall not be closely aligned within the tree's vascular system, that is in a vertical line.

(iii) If the precaution in sub-clause (f)(ii) of this Clause is not practicable, the pruning work shall be phased over several seasons with a view to lessening its damaging effects.

(g) For crown lifting, the clearance to be achieved shall be as that stipulated in the contract and the following requirements shall be observed where practicable:

(i) Excessive removal of lower branches from a parent stem which might lead to increased swaying shall be avoided.

(ii) Pruning shall not result in the removal of more than 15% of the live crown height where practicable.

(iii) The remaining live crown shall make up at least two-thirds of the height of the tree.

(h) For crown reduction, the tree height and crown spread which are to remain or the average equivalent in branch length shall be as those stipulated in the contract and the following requirements shall be followed where practicable:

(i) The remaining live crown shall maintain a strong framework of healthy small-diameter branches and twigs, that is a leaf-bearing structure, capable of producing dense leaf cover during the following growing season.

(ii) The crown shall be reduced in proportion to its original shape, so as to avoid altering the balance of the tree as a whole. The shape of the crown shall not be altered unless there is a specific need to do so, such as for biomechanical integrity.

(iii) Crown reduction shall not be carried out in addition to other crown pruning operations, which will add to the amount of wounding and leaf loss.

(i) For crown thinning, the following requirements shall be followed:

(i) An even density of foliage shall be retained throughout a well-spaced and balanced branch structure after pruning.

(ii) Excessive removal of lower branches from a parent branch which leads to lion-tailing and increased swaying shall be avoided.

(j) For crown cleaning, the following requirements shall be followed:

(i) Remove only the plant parts referred to in Clause 25.304 and do not remove live and healthy branches.

(ii) Do not reduce crown size.

(iii) Do not reshape the crown.

(iv) Do not thin the crown.

(k) For restorative pruning, the following requirements shall be followed:

(i) Tree parts with imminent failure risks should be removed as soon as possible.

(ii) Structural restoration should be conducted by progressive reduction of lever of arms and lion-tailing to achieve a balanced tree crown.

(iii) Some live branches can be removed to redistribute the loadings and relocate the center of gravity in tree crown. Heading cuts should be avoided as a large proportion of lateral branches would be removed that results in large pruning wounds and severely disfigured tree form.

(iv) The ultimate goal of sprout management is to relocate energy reserves, develop new branch leader and encourage wound closure. The most vigorous sprouts which would develop side branches should be left for lateral branch development, and sprouts located near the selected sprouts should be removed to provide sufficient growing space.

Pruning techniques **25.307**

(a) Pruning shall be carried out with the cut just above and sloping away from an outward facing healthy bud.

(b) Dead branches shall be cut back to live tissue or growing point as shown on Fig. (2) in Annex A, without causing injury to living bark or sapwood.

(c) All cuts shall be made to avoid splintering or tearing of bark that would catch water and encourage rot.

(d) Loose, dead or damaged bark shall be cleanly cut back to firm healthy bark without leaving any jagged edges.

(e) Ragged, rough edges of bark or wood shall be trimmed cleanly from around wounds with a sharp knife to the minimum extent that is necessary so as to hasten wound closure, and twigs less than 15 mm diameter at the point of attachment shall be cut with sharp secateurs.

(f) Long and heavy branches shall be cut in sequence of section by section, with each section in no more than 400 mm in length, to remove the main weight of the branch from the perimeter of the crown in towards the trunk.

(g) For a live branch with a diameter larger than 50 mm at the point of attachment, or in general a thinner but long branch that cannot be held by one hand to prevent bark tearing as it falls near the end of the cutting, the drop cut method (also known as the three-cut or three-step method) as follows and as shown in Fig. (4) of Annex A and in Annex B shall be adopted to prevent bark tearing of the parent stem below the wound of the cut branch:

(i) Make the first cut from the underside at a distance of approximately 300 mm from the parent branch or trunk,

(ii) Make the second cut from above at a point 25 mm further away from the first cut,

(iii) Make the final (third) cut just outside the branch collar to remove remaining branch segment.

(h) Care shall be taken to avoid tearing or compressing retained wood and bark when a cut is made, and to prevent falling branches from harming other parts of the tree including its roots.

(i) For branch shortening, which should be the main cutting mode, the following requirements shall also be observed where practicable:

(i) Pruning shall be conducted using the proper reduction cut down to the next lower node, as illustrated in Fig. (1) and Fig. (2) of Annex C.

(ii) The final cut shall be made distal to a union or group of unions where one or more healthy lateral branches bear enough foliage to sustain the parent stem or branch, and be made just beyond and parallel to the distal end of the bark ridge, if apparent, of the lateral branch chosen for retention as shown in Figure 2 of **BS 3998**.

(iii) If there is only one such union near the intended cut, the lateral branch shall have a diameter of at least one-third and preferably more than half that of the removed portion.

(iv) The final cut shall not exceed 100 mm in diameter except on very large trees.

(j) For branch removal, which shall be minimized, the following requirements shall also be observed where practicable:

(i) Pruning shall be conducted using the proper removal cut down to the fork of the parent stem, as illustrated in Annex B and Annex D.

(ii) The branch removal shall not result in leaving a stub or cutting flush to the main trunk as shown on Fig. (5) and Fig. (6) of Annex A respectively. The final cut shall be made close to the trunk or parent limb without cutting into the branch bark ridge and branch collar following the guidelines in Clause 25.307(j)(iii), so that no part of the stem is damaged or torn, and no snags or stumps are left.

(iii) The position and angle of the final cut shall follow the pruning guidelines as follows:

(1) If a branch collar is visible, the final cut shall be made just outside the branch collar, as shown in Figure 2 of **BS 3998**, in Fig. (7) of Annex A, and in Annex D.

(2) If there is a branch bark ridge but no visible branch collar, the final cut shall be made with its top edge just outside the branch bark ridge and at an angle as shown in Figure 2 of **BS 3998**, in Fig. (8) of Annex A, and in Annex D or at more acute angles where a co-dominant stem or branch is removed or where there is an acute union with included bark as shown in Annex D.

(3) If neither a branch collar nor a branch bark ridge is obvious, such as on a tree with very fissured bark, the final cut shall be made with its top edge just outside the basal flare of the branch and at right angles to the branch being removed, as shown in Figure 2 of **BS 3998**.

(4) If the species has whorled branches, the final cut shall be made just distal to a whorl.

(k) For crown cleaning, use reduction cut as far as possible to minimize live wood removal and use removal cut only as the last resort.

(l) The following malpractices of pruning shall not be allowed:

(i) Topping of trees, meaning cutting of the trunk and branches between nodes leaving stubs, as shown in Fig. (9) of Annex A, which will damage the tree form and structure and initiate decay in trunk and branches.

(ii) Leaving stubs which can die back and inhibit wound occlusion or give rise to undesirable proliferation of new shoots, as shown in Fig. (5) of Annex A.

(iii) Bark tearing of parent stem, as shown in Fig. (3) of Annex A.

(iv) Flush cut, meaning branch cutting that gets too close to the parent stem, as shown in Fig. (6) of Annex A.

(m) Other types of damage to the tree shall be avoided during pruning, including but not be limited to the following -

(i) All foreign and undesirable objects found on the tree during pruning, such as wires, cables, strings, ropes, clamps, and nails, shall be removed very carefully so as not to inflict harm on the tree in the process of removal. The Contractor shall not attempt to extract foreign objects that have been embedded firmly in wood.

(ii) No climbing spur or other means of climbing that may damage the bark or the cambium of the tree shall be permitted.

(iii) In using ropes to climb the tree, rope injury of the tree shall be consciously avoided.

(n) For the tools and equipment used in pruning work, the following requirements shall be observed:

(i) Clean and sharp tools shall be used in pruning to produce smooth and clean cuts of a single flat, sloping face to facilitate healing and reduce the risks of attack by insects and fungi.

(ii) For branches smaller than 12 mm in diameter at the point of attachment, pruning shear could be used; and for branches greater than 12 mm in diameter, pruning saw shall be used.

(iii) After cutting one tree, the pruning tools shall be wiped clean of all wood particles and disinfected before using them on another tree.

(o) Pruning wounds shall be treated according to Clause 25.310.

(p) All pruning debris shall be removed from the Site as soon as possible and at the end of every working day.

(q) Any adjacent areas affected by the pruning work shall be reinstated.

Personnel involved in pruning **25.308** The personnel who directly participate in pruning work shall have received formal training in pruning and have demonstrable practical experience in carrying out pruning work.

Method statement on pruning **25.309**

(a) Unless under emergency situation agreed by the SO, the Contractor shall submit method statement on tree pruning for the SO's approval and shall commence any work related to tree pruning only after the method statement has been approved in writing by the SO and the actual amount and locations of pruning have been agreed by the SO on the site.

(b) The information to be included in the method statement shall include but not be limited to the following:

(i) The proposed plant parts to be pruned and the approximate diameter and length of these plant parts.

(ii) The proposed types of pruning cut to be adopted.

(iii) The proposed pruning locations.

(iv) The proposed sequence and procedures of pruning.

(v) The tools and equipment to be used.

(vi) The name(s), qualifications and experience of the personnel who will participate directly in the tree pruning work.

(vii) Highlight of the branch to be pruned being –

(1) Larger than 50 mm in diameter at the point of attachment to the stem,
(2) First order live branch
(3) Second order live branch
(4) Third order live branch.

(viii) The vertical clearance where crown lifting is to be achieved.

(ix) The tree height and crown spread which are to remain where crown reduction is to be achieved.

(x) Time frame for pruning work and pruning interval;

(xi) Photographic record in colour to illustrate the whole view of the tree, and the concerned tree parts.

Treatment of wounds and other injuries **25.310** Any dead, damaged and decayed tissue at or surrounding a wound or an injury shall be removed using a clean, sharp implement without damaging the living tissue.

Unless otherwise instructed by the SO, any wounds or injuries shall be left uncovered instead of being painted with wound dressing or coating to avoid water retention and disease development.

If there is a high risk of a wound or an injury being colonized by a pathogen such as a canker fungus, an approved wound protectant, where available and proven to be effective for the tree species and type of pathogen, shall be applied to the fresh wound as soon as practicable, when instructed or agreed by the SO, to provide short-term protection.

If a large area of bark has become detached very recently, it shall be held in place or replaced by a moisture-retentive wrapping, when instructed or agreed by the SO, in order enhance the possibility of tissues regenerating naturally on the exposed surface(s). The Contractor shall keep monitoring the condition of the wound or injury and shall remove the wrapping when the bark has reunited, callus has developed on the exposed wood, or the treatment has been successful.

The Contractor shall submit method statement on treatment of wounds and other injuries for the SO's approval and shall commence any work related to treatment of wounds and other injuries only after the method statement has been approved in writing by the SO.

Treatment of cavities and wet pockets **25.311** Where it is necessary to clear the dry cavities of loose rubbish and rotten wood in order to assess its extent and the need for any further work, no attempt shall be made to cut into or exposed sound wood as the resulting wounds are likely to breach the tree's natural defences against wood-rotting fungi.

Where it is necessary to clear the wet cavities of water, no attempt shall be made to apply any drainage measures that will breach the tree's defensive barriers. If the walls of a wet cavity are to be strengthened by the insertion of bolts, it shall be done above the level at which water accumulates.

If a water pocket is free from decay, no action shall be taken.

If installation of some form of barrier is necessary to deter human access, such barrier shall be inserted so that it cannot easily be removed and will not have any adverse effects on the tree or on wildlife that might be using the cavity. If a filling is the only effective deterrent, it shall be composed of non-toxic material.

The Contractor shall submit method statement on treatment of cavities and wet pockets for the SO's approval and shall commence any work related to treatment of cavities and wet pockets only after the method statement has been approved in writing by the SO.

Additional damage **25.312** Repair any damage to existing plants caused by tree surgery operations or any other cause during the construction period as instructed by the SO.

Tools and equipment **25.313** Use the type of tools and equipment recommended by and in accordance with **BS 3998**.

ESTABLISHMENT WORKS

General – Establishment Works

Establishment works **25.314** Maintain the works after the completion date for a period of twelve months or as specified. Carry out all measures necessary to ensure that all plants shall thrive and become established within this period. Keep works neat and tidy and free from litter at all times.

Replacement planting **25.315** Replace all plants during the Establishment Works period which are dead, dying or not conforming to the original specification within two weeks of identification. Agree a schedule of replacement planting with the SO. Planting of the replacement plants shall be to the satisfaction of the SO, and take the same form as the original planting details contained in the Contract. Notch planting of replacement plants in any form shall not be accepted. Ensure soil conditions are satisfactory before replacement planting.

Damaged plants due to vandalism or typhoon **25.316** The Contractor shall not be responsible for replacing dead or damaged stock caused by vandalism or typhoon. The responsibility shall be with the Contractor to prove that death or damage was caused by circumstances beyond his control. A written report with clear photographic record (in colour and date imprinted) shall be submitted to the SO within 14 days of such an occurrence.

Water **25.317** The Contractor shall import fresh water to water plants. Attempts shall be made by the SO to arrange for the supply of mains water, the supply, however, is not guaranteed. If the supply is made available, the Contractor shall pay all necessary water charges.

Maintenance operations **25.318** The number of operations as specified is based on an assessment of the work required. The Contractor shall submit a schedule of maintenance operations for the SO's approval at least 3 months prior to the completion of the landscape work.

During Establishment Works period, the Contractor shall submit record of maintenance operations with dates and type of work carried out on site and photographic records, every 3 months during the Establishment Works period starting from the date of completion in accordance with the Contract. All operations shall be verified by the SO. Additional operations may only be implemented after authorization by the SO. Seek authorization from the SO at least three weeks prior to any additional operations being required.

Replacement planting due to parasitic plants **25.319** Replace those plants affected by parasitic plants during the Establishment Works period.

Workmanship – Establishment Works

Watering **25.320**

Water all trees, shrubs, grass and other plants so as to maintain a moist soil adequate to ensure satisfactory establishment. In dry weather when rainfall is less than 5 mm per day, watering shall be carried out every day during the Establishment Works period. Thoroughly water areas as instructed by the SO. Complete watering within 24 hours of receiving such instruction.

Watering Time **25.321**

Carry out watering either early morning or late afternoon or both as the case may be.

Weeding **25.322**

All grassed and planted areas shall be kept free from weeds throughout the period for establishment works. Any unwanted plants including *Mikania micrantha* Kunth found within the Site is considered as noxious weeds and shall be removed by the Contractor once it is identified upon discovery within the Site, or when instructed by the SO throughout the period for establishment works.

Weeding shall be carried out by hand or by mechanical methods agreed by the SO in such a manner that damage to the grass and planted areas will not be caused. Any chemicals for weeding operation shall not be used unless otherwise instructed or approved by the SO. Weed removal by fire shall not be allowed at any time. All weeds, litter and other rubbish resulting from the weeding operation shall be disposed of from the Site. Any ground cover plants, herbaceous plants, climbers, mulch or soil disturbed or removed during the weeding operation shall be replaced and replenished.

Planted areas in bare ground shall be weeded to remove all unwanted vegetative growth including aerial parts and roots, over the complete area. Planted areas other than in bare ground shall be weeded to remove all competing and overhanging vegetative growth by cutting the growth down to not more than 50 mm above soil level.

Remove weeds by approved mechanical or manual means so as not to cause any damage. Remove from all planted areas all weeds and rubbish resulting from this operation. Replace any mulch disturbed or removed during weeding. Inspect weeding requirements monthly. Maintain a circle of bare soil, 200 mm diameter greater than that of the tree trunk or palm stem, around all plant bases in grassed/turfed areas. Weed areas as necessary or instructed by the SO. Complete weeding within seven days of receiving such instructions.

Parasitic plants and noxious weeds shall be removed in accordance with Clauses 25.52 and 25.53 accordingly. Replace those plants affected by parasites during the construction period.

Firming up **25.323**

Plants which become loose as a result of wind rock or other causes shall be firmed up. The Contractor shall carry out an inspection of the plants each month and after heavy rain or wind for this purpose.

Securing stakes and ties **25.324**

Re-secure stakes and ties throughout the Establishment Works period. Inspect at least once per month and replace all broken, damaged or otherwise unsatisfactory stakes and ties. Adjust any ties which are causing chafing or abrasion. Remove all trees staking, ties or guys when the trees or palms are full established at the end of the Establishment Works period, or as instructed by the SO.

Pruning during Establishment Works period **25.325**

Prune all trees, shrubs and climbers to encourage bushy growth, improve flowering and remove dead damaged or crossing branches and dead flower heads or as instructed by the SO. An inspection of pruning requirements shall be made monthly.

Pruning method **25.326**

Prune and remove branches at the appropriate time of the year depending on species using sharp, clean tools. Prune with the cut just above, and sloping away from, an outward facing healthy bud. Remove branches by cutting flush with the adjoining stem and in such a way that no part of the stem is damaged or torn. Trim ragged

edges of bark with a clean sharp knife. Retain the individual habit and shape of the plant, unless otherwise directed or if it is the intention of the design to form a clipped hedge. Comply with the requirements in Clause 25.310 in the application of wound dressing or coating.

Grass cutting **25.327** Grassed areas shall be cut by manual or mechanical methods agreed by the SO and in a manner that does not cause pulling of roots or damage to planting in or near the grassed area. All cuttings shall be raked off and disposed of within 24 hours after cutting. Cutting to height according to the following categories:

(a) Category 1 grass shall be reduced by cutting to a height of 50 mm when it reaches 100 mm high.

(b) Category 2 grass shall be reduced by cutting to a height of 100 mm when it reaches 300 mm high.

(c) Category 3 grass cutting shall be cutting of areas of hydroseeding which are stated in the Contract to be subsequently maintained as mown grass.

Thinning **25.328** Where instructed by the SO, reduce the number of plants due to overcrowding. Dig up shrubs, and replant in agreed positions, fertilize and water, all in accordance with the specification or as instructed by the SO.

Fertilizing **25.329** Carry out two applications of slow release fertilizer, one during early spring and one during late summer or as directed by the SO, at the following rates:

(a) 250 gm per semi-mature tree;

(b) 200 gm per heavy standard tree, large palm and large conifer;

(c) 125 gm per standard tree, medium size palm, and medium size conifer;

(d) 75 gm per seedling tree, whip, small palm, small conifer, shrub, climbing plant and bamboo; and

(e) 40 gm/m^2 for grass areas, ground cover planted areas, and herbaceous plants.

Aeration **25.330** During the Establishment Period, immediately after fertilizing and prior to the application of mulch, cultivate all shrub areas by hand, using a horticultural fork to a depth of 100 mm to aerate the soil**.**

Mulching **25.331** During the last 14 days of the Establishment Period immediately after weeding, top up all shrub areas with a minimum depth of 50 mm of mulch.

Regular control of pests, fungal infestation and disease **25.332** During the Establishment Period, the Contractor shall regularly, at an interval not check for any pest, fungal and disease attack insect take all necessary measures to protect and/or treat the Site (including existing vegetation, preserved trees and all planting works) from and all necessary control measures to eradicate pests, fungi and disease from the infected and/or infested plants. The precautionary, preventive and control (inclusive of treatment and eradication) measures shall be carried out in accordance with Clauses 25.74(b) to 25.74(e).

Indoor plants cleaning **25.333** Clean the leaves of all indoor plants at least once a month, and apply fertilizer.

Artificial plants upkeep **25.334** Maintain artificial plants as follows:

(a) Clean, dust and keep all leaves and other components of the artificial plants in a tidy condition;

(b) Replace plant components when they are found to be loose or missing;

(c) If plants are damaged or broken replace the plants with plants which are as originally specified;

(d) Cleaning routine shall be at least once a month for silk trees and bushes, and once every four months for preserved palms, or whenever as necessary to keep all plants in clean, tidy condition; and

(e) Maintenance schedule as well as method statement on the cleaning of silk trees, bushes and preserved palms shall be submitted for approval prior to commencement of Establishment Works period.

Protective fencing **25.335** Regularly check protective fencing and immediately carry out all necessary repairs to ensure that the fence is maintained in good condition at all times. Remove, when instructed by the SO, protective fencing at the end of the Establishment Period.

Completion of Establishment Works except grass cover **25.336** Immediately before the end of the Establishment Works period, check that the following actions are complete and advise the SO where all these operations have been carried out:

(a) All tree and shrub planting shall be free from weeds;

(b) All planted and grassed areas shall be free from litter;

(c) Top up all mulched areas to give a minimum depth of 50 mm;

(d) All replacement planting and patching up of grass shall be completed;

(e) All stakes and ties shall be adjusted and secured; and

(f) All grassed areas shall be cut and the edges trimmed.

Compliance criteria of grass cover before the end of Establishment Works period **25.337** Tests shall be carried out to determine the grass cover for turfing, or sprigging, or hydroseeding. The tests shall be carried out 100 days after grassing, and within 30 days before the end of Establishment Works period. The grass shall be cut to a height of 300 mm if necessary over the parts of the area to be tested. At least one test shall be carried out for every 1,000 m^2 of the grassed areas. Tests shall be carried out at locations which in the opinion of the SO are representative of the grassed area as a whole. At each test location an approximately square area of 10 m^2 shall be marked. The percentage of bare ground other than rock and other hard material in each 10 m^2 test area shall be measured. At least 90% of each test area shall be covered with grass. If the result of any test for grass cover does not comply with the specified requirements for grass cover, the defective area shall be re-hydroseeded, re-sprigged, or re-turfed, or re-seeded, all in accordance with Clauses 25.123 to 25.172, and to the satisfaction of the SO.

SAFETY IN TREE WORK

Hazards in tree work **25.338** In undertaking tree work, the Contractor shall take all necessary precautions to protect the people engaged in the work as well as the people and property in the vicinity, against the associated hazards including but not limited to the following:

(a) safety of access to the tree site, in particular that on slope or uneven terrain, in relation to:

(i) Lack of roadside footpath serving as a buffer zone and work station,

(ii) Adjacent to vehicular access,

(iii) Obstruction due to railing or fence,

(iv) Obstruction due to retaining wall,

(v) Obstruction due to pipe or open drain,

(vi) Obstruction due to catch pit,

(vii) Obstruction due to soil nail or beam,

(viii) Obstruction due to boulders,

(ix) Obstruction due to large buttress or surface roots,

(x) Obstruction due to tree stumps,

(xi) Obstruction due to overhead wire,

(xii) Obstruction concealed or obscured by groundcover vegetation,

(xiii) Steep gradient,

(xiv) Loose or slippery slope surface,

(xv) Uneven slope surface,

(xvi) Wet slope surface

,

(xvii) Dense undergrowth, and

(xviii) Exposure to strong wind;

(b) Hazards in the course of tree work operation:

(i) Unstable or uneven ground surface to stabilize ladder or hydraulic platform,

(ii) Cramped space interfering with safe operation of chain saw and other tools,

(iii) Poor visibility due to dense branches and foliage,

(iv) Tool or body in touch with overhead wire,

(v) Low light level due to shielding by dense tree crown,

(vi) Treating trees with leaning or curved trunks and limbs,

(vii) Treating branches that hang above the carriageway,

(viii) Treating branches that are interlocked with those of neighbor trees,

(ix) Impact injury due to falling branch or trunk, including deadwood hanger,

(x) Worker's head or limbs hitting branches,

(xi) Worker falling from height,

(xii) Lightning strike and inclement weather,

(xiii) Risk of flash flood and overflowing open drain,

(xiv) Skin contact with inhalation of harmful or allergenic substances,

(xv) Skin contact with harmful or allergenic plants or organisms or their products,

(xvi) Disturbing the nests of biting or stinging insects (especially bees, hornets, wasps),

(xvii) Insect bite or sting (especially bees, hornets, wasps, mosquitoes and fire ants); and

(c) Personal health condition:

(i) Heat cramp,

(ii) Heat exhaustion,

(iii) Heat stroke,

(iv) Personal health situation that may impair physical fitness and judgment, and

(v) Allergic reactions.

Safety precautions in tree work **25.339** The safety precautions referred to in Clause 25.338 shall include but not be limited to the following:

(a) Development of a structured and comprehensive programme of accident prevention;

(b) Inclusion of site-specific risk assessments, method statements, safety rules and safety procedures on tree work in the Safety Plan and continuous updating of them to include tailor-made stipulations to suit the site-specific potential hazards;

(c) Inclusion of the following in risk assessment and method statements:

(i) Site and tree conditions,

(ii) Safe access on slope or uneven terrain,

(iii) Relevant means of safe access and safe working platform for working on slope, uneven terrain or at height,

(iv) Safety precautions in the planning and adjustments to the mode of operations to abate the potential hazards to the workers and site personnel as well as people who may get near the work site and the property in the vicinity,

(v) Safety precautions in the use of tools and equipment, such as chain saw and cutting tools with sharp cutters,

(vi) Hazards of falling objects, in particular falling tree trunks or branches,

(vii) Biological hazards, such as insect bites or stings (e.g. bees, hornets, wasps and fire ants), and exposure to harmful or allergenic fungi, etc.,

(viii) Use of lifting appliances for intended lifting activities,

(ix) Hazards associated with weather, such as hot weather, thunderstorm, persisting heavy rain, strong wind, etc.,

(d) Before commencement of any tree work every day,

(i) Check that all safety provisions are in place and in line with the recommendations included in the updated risk assessments and the approved method statements,

(ii) Check that the tools and equipment needed for all aspects of the tree work are safe for use as well as serviceable and fit for purpose,

(iii) Conduct safety briefing by the Safety Supervisor to all workers and site personnel, which shall include but not be limited to the following aspects related to the tree work:

(1) Work plan,

(2) The whole range of relevant safety rules and procedures and potential hazards,

(3) The roles of all workers in the safe system of work,

(4) Hazards on different strands of works for different groups of responsible works for contracts with Site Safety Cycle requirements,

(5) Main characteristics of the trees that will be worked on with a bearing on safety,

(6) Requirement of the tree workers to report to the Safety Supervisor of their health conditions that may have a bearing on their physical fitness to impair their judgement and compromise safety standards;

(e) An ongoing commitment to safety at all levels;

(f) Teamwork and clear communication amongst all members of the crew;

(g) Keen awareness of one's own capabilities and limitations as well as the capabilities and limitations of tools and equipment;

(h) Engagement of tree workers who have received suitable training and have adequate experience for carrying out the tree work;

(i) Engagement of tree workers who have received suitable training and have adequate experience in aerial rescue, for carrying out work aloft in the trees;

(j) Engagement of tree workers who have received adequate training for:

(i) Safe use of tools and equipment,

(ii) Inspecting or testing the tools and equipment carefully before every task to ensure that they are in good working order and to ascertain that they are in a state that is safe to use;

(k) Documentation and verification of the training and experience of the tree workers by the Safety Supervisor;

(l) Adequate training and continual updating in relevant knowledge and skills;

(m) Understanding of the relevant and up-to-date safety regulations and standards;

(n) Inclusion of tree work as mandatory item in the safety checklist and thus safety inspections conducted by the Safety Supervisor;

(o) Inclusion of tree works as mandatory agenda items in the Site Safety and Environmental Committee meetings for discussion and reporting;

(p) Clear assignment of duties to every member of the crew;

(q) Mandatory use of personal protection equipment such as goggles, chainsaw trousers, safety boot, gloves and helmets;

(r) Proper choice, use and maintenance of tools and equipment;

(s) Provision of suitable lifting appliances for intended lifting activities;

(t) Provision of an effective means of communication to promptly alert outdoor workers to take shelter in case of inclement weather;

(u) Unequivocal demarcation and enforcement of safety zones, into which access shall be restricted;

(v) Vigilant of what every team member is doing at all times;

(w) Vigilant and conscious recognition of potential risks at all times;

(x) Avoiding tree pruning on humid, windy and rainy days;

(y) Removing objects attached to the trees which may hinder the tree work;

(z) Incorporation of safety precautions in every aspect of tree works;

(aa) Seamless coordination between workers on ground and aloft;

(ab) Deploying adequate manpower to maintain traffic flow;

(ac) Placing directional/warning signs to divert traffic/pedestrian, with approval from the authority, if necessary;

(ad) Adoption of the command and response (acknowledgement) system of communication;

(ae) Clear and direct transmission of warning signals;

(af) Effective plan for safe positioning of partners on the ground and a safe and fast escape route;

(ag) Stopping the tree work in the event of a tree defect that will comprise the safety of the worker(s) or the tree being found during the tree work, and reporting the discovery to the SO immediately;

(ah) Carrying out the tree work at appropriate time where there are specific seasonal problems of certain species so that people and property are adequately protected;

(ai) Using hand tools where practicable when working on trees infected with pathogens that are likely to be transmitted through physical contact, to allow disinfection to be carried out effectively;

(aj) Following strictly the manufacturer’s guidance when disinfecting personal protective equipment and climbing or rigging equipment of pathogens;

(ak) Conducting tree work in a manner that avoids or minimizes the creation of new hazards, including but not be limited to the following:

(i) Avoid creating top-heavy crown in crown lifting;

(ii) Adopt a system that controls the safe transfer of branches and large pieces of wood to the ground when pruning or felling trees and minimize damage from falling branches or large pieces of wood by removing or shortening the branches in a controlled manner and not

allowing the cut sections to fall freely unless an assessment has shown that there is no significant risk of damage or injury occurring;

(iii) Avoid using any part of a preserved tree to redirect a load or as an anchor.

SECTION 26

GEOTECHNICAL WORKS ON SOIL AND ROCK SLOPES

PREPARATION WORKS

Inspection scaffolding **26.1**

(a) Install means of access consisting of scaffolding constructed of sound bamboo, metal or other materials agreed by the SO to enable the SO and the staff of the SO to examine slope treatment works. The Contractor shall not use the scaffolding for carrying his own site operations without the permission of the SO. The scaffolding shall allow access to within 0.8 m of the slope face. Scaffolding members shall provide hand and foot holds for climbing at centres not exceeding 0.5 m vertically and 0.8 m horizontally.

(b) Install a system of safety ropes on the scaffolding. Safety ropes shall be 12 mm diameter and shall have a breaking force of at least 18 kN. The system of safety ropes shall consist of:

(i) Vertical ropes at not more than 3 m centres horizontally securely anchored to the crest of the slope, and

(ii) Horizontal ropes at not more than 3 m centres vertically.

Construct the system of safety ropes in such a manner that the ropes are tied at not more than 3 m spacings in both directions to form a net.

(c) The scaffolding shall conform to the relevant safety requirements in the **Code of Practice for Bamboo Scaffolding Safety** and the **Code of Practice for Metal Scaffolding Safety** issued by the Labour Department. The scaffolding structure at every grid shall be sufficiently strong for safely supporting at least a person and equipment weighing 120 kg. Construct the scaffolding in such a way that makes it possible for a person to climb on the outside face of the grid without having to climb across any over-hanging portion or member.

(d) Provide a suitable fall-arresting system approved by the SO at every area where the slope inspection process may be involved. The fall-arresting system shall normally be vertical independent lifelines securely tied to stout steel pegs, tree trunks or other suitable anchorages (except the scaffolding members) at a horizontal interval of maximum 4 m. Each lifeline shall be a fibre rope with a minimum diameter of 15.9 mm complying with the American National Standard, **ANSI/ASSP Z359.1**, or other relevant international safety standards.

(e) Make available to the SO two sets of full body safety harnesses with suitable fall arresters for attaching to the lifelines. All the provided fall-arresting systems and equipment shall meet the relevant requirements in the **Guidance Notes on Classification and Use of Safety Belts and their Anchorage System** issued by the Labour Department. In addition, appoint a Competent Person according to the **Guidance Notes** to check the provided safety equipment and anchorage system prior to their being used each time. Appoint a Competent Person to provide necessary training to every concerned person to ensure the proper use of the safety equipment.

(f) Allow in the programme sufficient time for the SO to inspect the rock slope in details, to check the stability, to design rock slope stabilisation work, and to determine the extent of the works required. The Contractor shall not be entitled for any claim in respect of the time required by the SO to inspect design and instruct the rock slope stabilisation works.

(g) Where the slope stabilisation works include the removal of rock or other material, the SO may wish to carry out a reinspection of the area of the slope from which rock or other material has been removed. If required, re-erect or repair the inspection scaffolding to allow the reinspection to take place. As a result of this inspection, the SO may order to carry out further stabilisation works. Make due allowance in the programme for the time required to re-erect or repair the inspection scaffolding and to carry out further works directed by SO. The Contractor shall not be entitled for any claim in respect of the time required by the SO to carry out such re-inspection, design and ordering of such further rock slope stabilisation works.

(h) Obtain the permission of the SO before inspection scaffolding is dismantled.

Particular of access **26.2** Submit particulars of the proposed means of access for slope treatment works, including access structures and reinstatement, to the SO for approval at least 14 days before the slope treatment works start.

Protection fences and barriers **26.3**

(a) Construct protection fences and barriers for slope treatment works as stated in the Contract before slope treatment work starts.

(b) Repair damage to protection fences and barriers immediately. Obtain the permission of the SO before protection fences and barriers are dismantled.

Preparation for slope treatment works **26.4**

(a) Clear vegetation and remove existing impermeable surfaces and topsoil from existing soil slopes before slope treatment works start.

(b) Trim and scarify surface of slopes before slope treatment works start. On completion of trimming and scarifying, remove all loose materials from the surface of slopes by means of water jet coupled to compressed air for rock slopes and air jet for soil slopes.

(c) Clean rock faces and joints, and the surface and joints of retaining walls of moss, vegetation and loose material, immediately before slope treatment works start, and remove surplus water by an air jet. Divert water flowing from or across the rock face by relief drains or by other methods agreed by the SO before the application of impermeable surfaces.

(d) Where rock slope works are included in the Contract, allow sufficient time in the programme for the SO to inspect the rock slope, to check the stability, to design slope treatment works and to determine the extent of the works required, taking into account of any specified time stated in the Contract that the SO may require for the inspection and design of slope treatment works.

Preliminary stripping of slope **26.5** Where ordered by the SO, carry out preliminary stripping of topsoil and existing chunam, sprayed concrete and other impermeable surfaces as a separate operation for inspection by the SO prior to any further slope treatment works which may be required. Provide effective temporary measures to guard against rainfall and surface water damaging exposed surfaces until the permanent surface protective works are completed.

ROCK SLOPE TREATMENT WORKS

Scaling and trimming of rock slopes **26.6**

(a) Carry out scaling and trimming of rock slopes in such a manner that soil and rock is removed from the slope face without affecting the stability and integrity of the slope. Take measures to prevent uncontrolled falls of debris arising from scaling and trimming works. Remove all material removed or excavated by scaling and trimming and loose fragments of soil and rock from the slope. Clean rock faces using a water jet coupled to compressed air after scaling and trimming is complete.

(b) Carry out rock scaling only on areas as directed by the SO. Rock scaling shall include the removal of all loose blocks of any size using hand tools, or boulders not exceeding 0.2 m^3 in volume using powered mechanical equipment.

Rock splitting **26.7** Carry out rock splitting using percussive hammers, drills, hydraulic splitters, chemical expanding agents, hand-tools or other methods agreed by the SO.

Removal of boulders **26.8** Take down boulders which are to be removed from slopes by means of line drilling, expansive grouts, rock breakers or other methods agreed by the SO. For the purpose of this Clause, a boulder to be removed on rock slopes shall qualify as "boulder" only if it exceeds 0.2 m^3 in volume before excavation and it cannot be removed without the use of powered mechanical equipment.

Sealing and infilling of rock joints **26.9**

(a) Seal joints in rock faces with Grade 20/20 concrete, cement mortar or masonry as stated in the Contract. Rock for masonry infilling shall be bedded in cement mortar. Install relief drains instructed by the SO before rock joints are sealed or infilled.

(b) The extent of rock joints and depth of materials in rock joints to be excavated prior to sealing and infilling shall be as directed by the SO.

Concrete buttresses **26.10**

(a) Concrete for buttresses shall be Grade 20/20 unless otherwise stated in the Contract.

(b) Drainage which is required behind buttresses shall consist of relief drains connected to 50 mm diameter uPVC outlet pipes laid at a gradient of at least 1 in 50. Fix the uPVC pipes securely to the formwork before concreting starts.

Fixing protective mesh for slopes **26.11** Orient, lace, suspend down and fix protective mesh for slopes onto the slope face with dowels at intervals not exceeding 3 m in accordance with the details as shown on the Standard Drawing in **Appendix 1**. Position the last column or row of dowels fixing the edges and base of the protective mesh not more than 300 mm from the respective edges/base of the mesh. Avoid laps in vertical mesh sheets as far as possible. Where necessary, laps between vertical sheets shall be at least 300 mm minimum and the lapping sheets shall be laced in the same way as adjacent vertical sheets as shown on the Standard Drawing in **Appendix 1**.

Protective mesh for slopes shall be PVC coated galvanized steel wire woven into a double twist hexagonal mesh comply with **BS 4102**. Each hexagon shall be 80 mm × 60 mm. The steel wire shall be at least 2.2 mm diameter and the PVC coating shall be at least 0.4 mm thick. PVC coating on steel wire shall comply with **BS 1722-16** or equivalent. The colour of PVC coating is to be approved by the SO. Wire for protective mesh shall comply with **BS 1052**. Galvanized coating on wires shall comply with **BS EN 10244-2**. The tolerance on the opening of mesh shall comply with **BS EN 10223-2**. Tying wire for protective mesh shall be 2.2 mm diameter PVC coated galvanized soft annealed steel wire. Bolts for fastening protective mesh to rock or structure shall be galvanized mild steel hooks. Anchor bolts and accessories for fastening protective mesh to soil nail head shall be of stainless steel Grade A4 to **BS EN ISO 3506-1** and **BS EN ISO 3506-2**. Hooks, fixing pins, steel plates and washers for fixing the protective mesh to slope face shall be galvanized to **BS EN ISO 1461**.

SPRAYED CONCRETE

Glossary of terms **26.12** The term "sprayed concrete" refers to the concrete produced by the projection of a wetted aggregate/cement mixture onto an area by means of air pressure applied through a continuously feeding pressure vessel. The following definitions cover the meaning of certain words and terms commonly used in this type of work:

(a) Blow pipe: air jet operated by nozzleman's helper in sprayed concrete gunning to keep rebound or other loose material out of the work.

(b) Ground wire: small gauge high-strength steel wire used to establish line and grade for sprayed concrete.

(c) Nozzle: attachment at end of sprayed concrete material hose from which material is jetted at high velocity.

(d) Nozzleman: workman on sprayed concrete crew who manipulates the nozzle, controls consistency and makes final disposition of the material.

(e) Overspray: the aggregate and cement or wet sprayed concrete carried by the escaping air perpendicular to the nozzle stream and parallel to the surface of application, 360° around the point of application. The material is deposited not at the point of application.

(f) Rebound: aggregate and cement or wet sprayed concrete which bounces away from a surface against which sprayed concrete is being projected.

(g) Sand pocket: a porous area low in cement content.

Preparation of slope surface **26.13**

(a) Remove weak material along joints or seams in slope surfaces to which sprayed concrete will be applied to a depth equal to the width of the weak zone. Construct tree rings for all existing trees within the slope surfaces to which sprayed concrete will be applied in accordance with Standard Drawing in **Appendix 2**. The space between tree ring and tree trunk at ground level shall be at least 200 mm. Before sprayed concrete is applied, protect all tree trunks, railings, utilities, pipes, structures, street furniture and other facilities etc. adjacent to or within the sprayed concrete area with approved means to prevent from being contaminated by sprayed concrete particles. The Contractor shall be responsible for cleaning and making good all contaminated surfaces to the satisfaction of the SO.

(b) When the soil surface temperature exceeds 25°C or the moisture content is less than 10%, water the surface with sprays before commencing sprayed concrete unless otherwise instructed by the SO. Do not use hoses without sprays. Carry out spraying of water onto the slope surface not more than 1 hr before spraying of concrete starts.

Nozzlemen and equipment for spraying concrete **26.14**

(a) Apply sprayed concrete using the dry process in which water and admixtures are added at the nozzle. Alternatively, apply sprayed concrete using the wet process in which wet ready-mixed concrete is supplied to the nozzle.

(b) Equipment for the dry-mix process shall be capable of projecting a mixture of cement, fine and coarse aggregate and water at high velocity on to the surface of the slope to produce a dense homogenous cover. The equipment shall be fitted with weight-batching facilities.

(c) Equipment for the wet-mix process shall be capable of projecting a mixture of wet ready-mixed concrete at high velocity onto the surface of the slope to produce a dense homogenous cover.

(d) Only employ skilled operators experienced in the use of sprayed concrete. The nozzlemen must have adequate experience of work of a similar nature to that required in the Contract. Submit details of the experience of the proposed nozzlemen to the SO for approval at least 14 days prior to the commencement of spraying.

Trial panel **26.15**

(a) Construct a trial panel at least 50 mm thick and at least 3 m × 3 m for sprayed concrete on the surface to be treated. Estimate the average percentage rebound for each trial panel and use it in the calculations of the cement content of the applied concrete.

(b) Where required by the SO, construct trial panels for different type of spraying equipment and different nozzlemen. Make test panel to establish the suitability of the sprayed concrete mix, spraying equipment and nozzlemen and test it as stated in Clauses 26.24 to 26.28 in connection with every trial panel.

Fixing reinforcement **26.16**

Fix securely fabric reinforcement for sprayed concrete to the slope by steel nails or anchor bolts and lay it without sharp bends or creases. Place the fabric reinforcement centrally in the sprayed concrete and support it clear of the ground and away from all surface irregularities with adequate number of cover blocks in

accordance with the specified concrete cover. Fix cover blocks on top of the fabric reinforcement immediately above the cover blocks on the lower side to assist nozzlemen to ascertain the thickness of sprayed concrete and cover on top of the fabric reinforcement during spraying. The minimum cover shall be 30 mm. Laps between adjacent sheets of fabric reinforcement shall be at least 150 mm or 40 times the diameter of the lapping wires whichever is greater.

Weepholes and expansion joints in sprayed concrete **26.17**

(a) Construct 50 mm diameter weepholes in accordance with the following:

(i) On soil surfaces, at 1.5 m staggered centres in each direction, and

(ii) On rock faces, on rock joints and at locations / spacings as directed by the SO.

(b) Extend and construct all weepholes to the full thickness of the sprayed concrete with an outward inclination of 1 in 10.

(c) Construct expansion joints on soil slopes in sprayed concrete in line with the expansion joints of adjacent U-channels, berm slabs and concrete structures etc. or at 15 m intervals maximum where there is no adjacent U-channels, berm slabs and concrete structures. The lines of joints between panels shall be straight and continuous and shall form a regular pattern approved by the SO.

(d) Construction joints in sprayed concrete shall comply with the requirements specified in Clause 6.51.

Spraying concrete **26.18**

(a) Measure the surface temperature and moisture content of the soil, and submit the results to the SO, immediately before sprayed concrete is applied.

(b) For the dry-mix process, the aggregates for sprayed concrete shall be kept dry before mixing. Natural sand shall not be used unless with the prior agreement of the SO. The water shall be added at the nozzle at the instant of application. The air and water supply, the rate of application and all other factors affecting the quality of the work shall be adjusted to produce dense concrete with no sloughing.

For the wet-mix process, the ready-mixed concrete shall comply with Clause 6.44 unless otherwise approved by the SO.

For both the dry-mix process and the wet-mix process, rebound material shall not be reused and shall be removed within 8 hr after spraying.

(c) Apply sprayed concrete in layers not exceeding 50 mm thick to the total thickness stated in the Contract. The maximum panel dimension shall not exceed 15 m^2.

(d) Apply sprayed concrete perpendicular to the surface to be sprayed, and do not position the nozzle farther than 1.5 m from the surface during spraying.

Colour pigment in sprayed concrete **26.19**

(a) Where ordered, mix colour pigment approved by the SO thoroughly with the sprayed concrete mix, and apply a layer of 25 mm thick of the coloured sprayed concrete to form the total thickness stated in the Contract.

(b) Submit details of the colour pigments (e.g. specification and colour samples etc.) and the method statement for the approval of the SO prior to application. The pigment shall comply with **ASTM C979/C979M** and shall have the characterization of light fast, lime proof, weather resistance and durability like concrete. Colour to be employed shall be directed by the SO.

Curing sprayed concrete **26.20**

Cure sprayed concrete for at least 4 days after application by one of the methods as stated in Clause 6.52.

Inspection of sprayed concrete **26.21**

Test the completed areas of sprayed concrete by tapping with a wooden mallet for hollows and other defects. Cores of 75 mm diameter shall be taken from the completed area of sprayed concrete at the rate of 1 no. per every 150 m^2 of sprayed

surface or part thereof at locations determined by the SO for checking the quality and thickness of the sprayed concrete as well as cover to reinforcement. Whenever any defect is found, carry out further investigation to locate the extent of the defect. Areas which in the opinion of the SO are substandard or hollow shall be removed and resprayed at the Contractor's own expense. The Contractor shall be responsible to patch up the core holes with cement mortar of colour matched with the adjacent surfaces.

Submission of particulars **26.22**

(a) Submit the following particulars of the proposed materials and methods of construction to the SO:

(i) Type and performance of mixing and spraying plant,

(ii) Details of water sprays and associated pumps for surface spraying,

(iii) Method of curing,

(iv) Details of trial panels and test panels,

(v) Methods of measuring surface temperature and moisture content of the soil,

(vi) Methods of achieving the specified thickness of sprayed concrete and the specified cover to reinforcement and methods of measuring the thickness and cover after spraying,

(vii) Method of fixing of reinforcement,

(viii) Details of materials and mix design,

(ix) Details of dry mix process and/or wet mix process for applying sprayed concrete,

(x) Name and details of the experience of the nozzlemen who will be employed on the Works,

(xi) Details of working platform,

(xii) Method of forming expansion joints, and

(xiii) Sequence of spraying on sloping surfaces.

(b) Submit the particulars to the SO for approval at least 14 days before sprayed concrete is used.

Records of sprayed concrete **26.23**

Keep records of sprayed concrete operations on the Site, and submit them daily to the SO. The records shall contain details of the quantities of all materials used at each location. The records could be either a hard copy or soft copy as agreed by the SO. The hard copy report shall use recycled papers. The soft copy shall be in read-only format and the hard copy shall be double side printed as agreed by the SO.

Test panels **26.24**

(a) Determine the strength of sprayed concrete from concrete cores cut from a test panel constructed at the same time as sprayed concrete is applied.

(b) Construct one test panel for each application in a day or as directed by the SO.

(c) The test panel shall be 250 mm thick and shall be at least 1 m × 1 m. The mould shall be securely fixed in position at the same height and inclination as the surface being sprayed. Construct the panel by spraying concrete into the mould at the same time as the concrete to be tested is applied. Cure the test panel by the same method as the sprayed concrete.

Concrete cores from test panels **26.25**

(a) Provide three concrete cores from each test panel. Do not take cores within 125 mm from the edges of the panel.

(b) Concrete cores shall be 100 mm diameter and shall be the full depth of the test panel.

(c) The method of taking concrete cores shall be in accordance with **CS1**.

Testing of concrete cores **26.26**

(a) Test each concrete cores to determine the compressive strength.

(b) The method of preparing and testing the cores to determine the compressive strength shall be in accordance with **CS1**. Test three concrete cores at 28 days.

Compliance criteria **26.27** The results of tests for compressive strength of concrete cores shall be interpreted in accordance with **CS1**. Adjustment to the measured strength in respect of the age of the core when tested shall not be made unless permitted by the SO. The minimum compressive strength of concrete cores, converted to estimated in-situ cube strength in accordance with **CS1**, shall be the specified grade strength at 28 days.

Non-compliance **26.28** If the result of any test for compressive strength of concrete cores from sprayed concrete does not comply with the specified requirements for the property, submit particulars of proposed changes to the materials, mix design, methods of production or methods of construction to the SO. Further trial mixes shall be made, and further trial panels shall be constructed unless otherwise permitted by the SO.

ROCK DOWELS

Rock dowels **26.29** Rock dowels shall comply with **CS2** and shall be cut in accordance with **BS 8666** to the specified shapes and dimensions. Rock dowels shall be properly handled and stored as stated in Clauses 26.35 and 26.36, and the surface conditions shall be as stated in Clause 26.38. Rock dowels shall be galvanized to **BS EN ISO 1461** and if damaged, shall be repaired as stated in Clause 26.39. The name and location of the galvanizing factory shall be submitted to the SO for approval. Provide the approved galvanizing factory's certificate showing that the galvanized coatings comply with the requirements including the test results carried out for thickness of coating. Rock dowels shall have non-corrodible centralizers capable of ensuring an even annulus of grout around the steel bar to the approval of the SO. A typical layout of rock dowels is as shown in **Appendix 3**.

Grout for rock dowels **26.30** Grout for rock dowels shall be as stated in Clauses 26.52 to 26.62.

Drilling and preparation of rock dowel holes **26.31**

(a) The drilling of rock dowels shall be as stated in Clause 26.63.

(b) The diameter of the hole shall be at least:

(i) 20 mm larger than the diameter of the rock dowel bar, or

(ii) 20 mm larger than the outer diameter of the connectors, if used, or

(iii) 50 mm,

whichever is the largest.

(c) Prior to installation of rock dowels, flush the hole with clear water until the return water runs clear. On completion of flushing, use compressed air to blow out any standing water from the hole.

Grouting for rock dowels **26.32**

(a) Grouting for rock dowels shall be as stated in Clauses 26.52 to 26.62, except as in (b) and (c) of this Clause.

(b) Rock dowels shall be grouted over the complete length of the drillhole in which the dowel is installed. Centralizers shall be fitted to rock dowels before grouting to ensure an even annulus of grout. No jacking or hammering of the dowels shall be carried out during the whole process of insertion of dowels into drillholes. Rock dowels shall be grouted immediately after insertion into the drillholes, and shall be over their whole

length in one single operation. Grout shall be introduced at the lower end of drillholes with downward inclinations, and displace all air and water through the top of the drillhole.

(c) If considered necessary by the SO, the drillhole shall be grouted as in (b) above, but with the rock dowels to be pushed into the hole only after it has been completely filled with the grout and also when no grout leakage can be observed.

Records of rock dowels **26.33** Keep records of installation of rock dowels on the Site, and submit a copy to the SO within 7 days after each installation operation. The records shall contain details of the location, length, inclination and level of each rock dowel installed.

SOIL NAILS

Materials **26.34**

(a) Soil nail bars shall be of Grade 500B ribbed steel reinforcing bars to **CS2**. Dimensions, mass per metre and permissible deviation of soil nail bars shall refer to **CS2** Clause 1.4. Chemical composition and mechanical properties of soil nail bars shall refer to **CS2** Clauses 1.5 and 1.6 respectively. All steel components for soil nails shall be galvanized to **BS EN ISO 1461** and materials for repair to galvanized coating shall comply with **BS EN ISO 1461**. The name and location of the galvanizing factory shall be submitted to the SO for approval. Provide the approved galvanizing factory's certificate showing that the galvanized coatings comply with the requirements including the test results carried out for thickness of coating.

(b) Steel reinforcement for soil nail heads shall be Grade 500B ribbed steel reinforcing bars to **CS2**.

(c) Nuts shall be of Grade 4 steel and comply with **BS 4190**.

(d) Reinforcement connectors shall be of a proprietary type approved by the SO and shall be of type 1 mechanical couplers conforming to the **Code of Practice for Structural Use of Concrete**. The connectors shall be capable of developing the full tensile strength of the parent bars.

(e) Bearing plates shall be of Grade S275 steel plate and comply with **BS EN 10025-1** and **BS EN 10025-3**. Steel plates for pull-out and performance tests shall be square with length not less than 300 mm and ratio of length to thickness not larger than 10. Holes in steel plates for soil nail heads shall be drilled perpendicular to the face of the steel plate and centre of the hole shall be at a position of within 2 mm from the centroid of the plate. The clearance between the steel bar and the hole of the steel plate shall not be more than 2 mm.

(f) Concrete for soil nail heads shall be grade 30/20 or 30 MPa sprayed concrete and shall comply with Clauses 26.12 to 26.28.

(g) Soil nails shall have non-corrodible centralizers capable of ensuring an even annulus of grout around the steel bar. The nominal diameter of the centralizers shall not differ from the specified diameter of the drillhole by more than 10 mm. Wires and ties for fixing and anchoring packers, centralizers and grout pipes etc. shall be made of non-corrodible materials. Determine the spacing of the centralizers and the suitability of the method of fixing the centralizers, grout pipes and corrugated sheathing where required by carrying out trials on site until no damage, deformation and displacement of the centralizers, grout pipes and corrugated sheathing are observed on completion of assembling all components, during inserting and withdrawing the soil nails. Once approval is given, no change to the type, method and arrangement of fixing of the centralizers, grout pipe and corrugated sheathing shall be made without the prior approval of the SO.

(h) For soil nails using threaded type reinforcement connectors but without galvanized coating on either the threads inside the connectors or the threads at the ends of reinforcement bars, use heat-shrinkable sleeve of a proprietary

type as approved by the SO as an alternative to galvanization as a corrosion protection measure to the connections. Clean thoroughly any rust on the threads of reinforcement bars and connectors before being connected together.

(i) A typical layout and design of soil nails is as shown in **Appendix 4**.

Handling of soil nail bars **26.35**

(a) Soil nail bars shall not be subjected to rough handling, shock loading or dropping from a height.

(b) Nylon, rope or padded slings shall be used for lifting galvanized soil nail bars. Bundles shall be lifted with a strong back or with multiple supports to prevent abrasion.

Storage of soil nail bars **26.36**

(a) Soil nail bars shall be stored off a levelled, well drained and maintained hard-standing ground on level supports and in a manner, which will not result in damage or deformation to the soil nail bars, or in contamination of the soil nail bars. Measures to protect the soil nail bars from wetting and rusting caused by weather shall be proposed for SO's approval. Soil nail bars shall be stored horizontally.

(b) Different types and sizes of soil nail bars shall be stored separately.

(c) Soil nail bars shall not be stored on or adjacent to concrete surfaces that form part of the permanent works.

(d) Galvanized soil nail bars shall be stored on wooden or padded cribbing.

Cutting soil nail bars **26.37**

Soil nail bars shall be cut in accordance with **BS 8666** to the specified shapes and dimensions.

Surface condition of soil nail bars **26.38**

(a) Soil nail bars shall be clean at the time of assembling and shall be free of loose mill scale, loose rust or any substance that, in the opinion of the SO, is likely to reduce the bond or affect the bars or grout chemically. The soil nail bars shall be maintained in this condition until insertion into drillholes.

(b) If the surface condition of the soil nail bars deteriorates such that it does not comply with the requirements stated in Clause 26.38(a), the soil nail bars shall be cleaned or dealt with by other methods agreed by the SO.

Repairs to galvanized coating **26.39**

(a) The part of the soil nail bars shall not be used in the permanent works if the coating to galvanized soil nail bars is damaged,

(i) At any point by an amount exceeding 25 mm^2 in area or 50 mm in length, or

(ii) At more than three points in a 1m length by amounts of each less than 25 mm^2 in area or 50 mm in length, or

(iii) At more than six points in the cut length of a bar by amounts of each less than 25 mm^2 in area or 50 mm in length.

(b) Except as stated in Clause 26.39(a), all damaged areas and cut ends of galvanized soil nail bars shall be repaired by materials to be approved by the SO. Sufficient material shall be applied to provide a coating of at least the same thickness as the galvanized coating. The Contractor shall refer to Section 6.3 and Annex C of **BS EN ISO 1461** for advice on repair of damaged areas.

(c) Repairs to galvanized coatings shall be carried out within 8 hr of cutting or identifying damage. Traces of rust shall be removed from the surface of the soil nail bars before the repair is carried out.

Tolerances: soil nail bars **26.40**

Tolerances on cutting soil nail bars shall comply with **BS 8666** Table 5.

Grout for soil nails **26.41** Grout for soil nails shall comply with Clauses 26.52 to 26.62 except that the water cement ratio shall not exceed 0.45 and PFA shall not be used unless agreed by the SO.

Drilling and preparation of soil nail holes **26.42**

(a) The drilling and preparation of soil nail holes shall be as stated in Clause 26.63.

(b) The minimum hole diameter shall be 100 mm.

(c) For installation of soil nails on masonry walls, ensure that the masonry wall is not to be damaged during the whole process of soil nail installation operation, and submit the proposal to the SO for approval before carrying out such work.

(d) Clear drillholes of all debris and standing water immediately before grouting. Before the soil nails are installed, furnish the SO with all necessary equipment and assistance to check the inclination, bearing, cleanliness and length of all drillholes.

Submission on soil nails **26.43**

(a) Submit the following particulars of materials and methods of construction for soil nails to the SO for approval at least 28 days before start of pull-out test:

(i) Details and samples of soil nail bars, coupling sleeves, nuts, washers, plates, connectors, centralizers, grout pipes, corrugated sheathing, and packers for isolating the bond length,

(ii) Details of galvanizer to be employed for galvanizing the steel components,

(iii) Details of working platform,

(iv) Method of drilling and details of drilling equipment,

(v) Method of grouting and details of grouting equipment,

(vi) Details of equipment for testing soil nails, including test and calibration certificates,

(vii) Details of testing assembly including details of datum for deformation measurement and bearing pad,

(viii) Details of heat-shrinkable sleeve for protecting the connections between reinforcement bars if galvanized coating to either the threads inside connectors or at the ends of reinforcement bars is not applied, together with details of the heat application equipment for shrinking the sleeves, and

(ix) Method of repairing damaged heat shrinkable sleeves during heat application or other installation process of soil nails.

(b) Test and calibrate all equipment for testing soil nails by approved laboratories not more than 3 months prior to the date of carrying out the tests. Submit test and calibration certificates to the SO at least 7 days before the test.

Pull-out test **26.44** Install and test soil nails for pull-out tests prior to the installation of permanent soil nails. The number of pull-out tests shall be as shown on the drawings or as instructed by the SO. Soil nails subjected to pull-out tests shall not form part of the permanent works, and their locations shall be indicated on site. The testing arrangement shall be as shown in Sheet 2 of **Appendix 5**, and further details of the testing arrangement including the set-up and support for the testing apparatus shall be submitted for the SO's approval. The apparatus for measuring loads and deformations shall have an accuracy of 2 kN and 0.05 mm respectively. The apparatus for measuring deformation shall be capable of measuring a displacement of up to 50 mm. The apparatus shall be tested and calibrated by approved

laboratories not more than 6 months prior to the date of carrying out the tests. Submit test and calibration certificates to the SO at least one week before the test. Set up the loading apparatus in such a way that no loading, other than the pull-out load, acts on the steel bar at the nail head. The reaction of the pull-out load from the loading apparatus shall act on a sufficiently sized rigid bearing plate placed against a temporary cut face at normal to the alignment of the steel bar to ensure adequate load spreading and to avoid eccentric loading. Position monitoring instruments carefully, and support them independently to record the extension of the soil nail steel bar and any movement of the steel bearing plate. The following procedure shall be adopted:

(a) Soil nail shall be grouted over the length as specified in the drawings or as directed by the SO. Isolate the length to be grouted by means of an approved packer that can prevent grout from leaking through to the free-length section during grouting and that can ensure that the proposed bonded section is effectively grouted to the required length as shown in the drawings. The size of the packer shall be compatible with the diameter of the drillhole. The entire free length of the steel bar shall be properly debonded or capped to ensure that the test load can be directly transferred to the bonded zone in case of grout leak through the packer. Do not carry out the pull-out test until the grout has reached a cube strength of 21 MPa.

(b) The maximum test load shall be either 90% of the yield load of the steel bar of the test soil nail (T_p) or the ultimate soil/grout bond load (T_{ult}), whichever smaller, unless directed otherwise by the SO.

(c) Load the test nail in stages: from the initial load (T_a) via two intermediate test loads (T_{DL1} and T_{DL2}) to the maximum test load. T_{DL1} and T_{DL2} are the loads that result in the bonded zone tested to the design working bond strength and 2 times the working bond strength respectively. An initial load (T_a) equal to 5% of T_p or T_{DL1}, whichever is smaller shall be applied. All loadings including T_a, T_{DL1}, T_{DL2} and T_p shall be specified in the drawings or as directed by the SO.

(d) During the first two loading cycles, maintain the intermediate loads, T_{DL1} and T_{DL2} for 60 min for deformation measurement. After the measurement has been completed, the load shall be reduced to T_a and the residual deformation shall be recorded. In the last cycle, the test load shall be increased gradually from T_a straight to maximum test load and then maintained for deformation measurement. The measurement at each of the cycles shall be taken at time intervals of 1, 3, 6, 10, 20, 30, 40, 50 and 60 min. The test nail shall be considered to be able to sustain the test load if the difference of nail movements at 6 and 60 min does not exceed 2 mm or 0.1% of the grouted length of the test nail. In this case, the test shall proceed to the next loading cycle or be terminated if the test nail is subjected to T_p. If the deformation in the last 10 min is larger than 0.05 mm, the load shall be held longer as directed by the SO.

(e) If the nail fails to sustain the test load T_{DL1}, T_{DL2} or T_p, terminate the test and record the nail movement against residual load with time. The measurements shall be taken at time intervals of 1, 3, 6, 10 and every 10 min thereafter over a period for at least two hours. Where required the measurements shall be continued and at intervals as directed by the SO.

(f) Throughout the test, the soil nail movement as well as the movement of the bearing plate versus the applied load shall be measured, recorded and plotted on a graph along with all other relevant information in the format as shown respectively in Sheet 2 and 3 of **Appendix 5**, unless otherwise approved by the SO.

(g) Where required, pull out the whole soil nail from the drillhole for the SO's inspection. The drillhole so left shall then be filled by grouting. Where the steel bar remains in-situ after the pull-out test, the bar shall be cut-off flush with the finished ground and the remaining part of the drillhole grouted.

Submission on pull-out test record **26.45**

(a) Provide drilling records of holes selected for pull-out tests to the SO within 24 hr after drilling.

(b) Submit results of pull-out tests to the SO within 3 days of completion of the test.

Permanent soil nail installation and grouting **26.46**

(a) During the whole process of soil nail installation, do not carry out jacking or hammering of the soil nail bars. Soil nails shall be grouted immediately over their whole length in one single operation after insertion into the drillholes. Soil nails which are not immediately grouted after insertion and are left overnight in the drillhole shall be withdrawn from the drillhole and the drillhole shall be checked for cleanliness before re-insertion.

(b) Secure soil nails in position by non-corrodible centralizers to ensure an even annulus of grouting to be applied around the steel bar.

(c) Wires and ties for fixing and anchoring packers, centralizers and grout pipes etc. shall be made of non-corrodible materials. The method of fixing and spacing of the centralizers shall be determined by carrying out trials on site until no deformation of the centralizers is observed on completion of assembling all components forming the soil nails. Once approval is given, no change to the type, method of fixing and spacing of the centralizers shall be made without the prior consent of the SO.

(d) Grouting for soil nail holes shall be as stated in Clauses 26.52 to 26.62, except as stated in (a), (b) and (c) above.

Performance test **26.47**

Carry out performance tests on selected permanent soil nails as directed by the SO. Each group of soil nails of the same type and those grouted in one day shall be tested. The number of performance tests to be carried out shall be 6% of the total number of permanent soil nails (in any case at least one) in the group. The apparatus for measuring loads and deformation shall have an accuracy of $\pm$ 2 kN and $\pm$ 0.05 mm respectively. Test and calibrate the apparatus by approved laboratories not more than 3 months prior to the date of carrying out of the tests. The following procedure for performance tests shall be adopted:

(a) Do not carry out the performance test until the grout has reached a cube strength of 21 MPa.

(b) The test load (T_p) shall be (1.0 + designed minimum factor of safety against pullout failure at soil-grout interface)/2 times the working load required, which shall not be greater than 80% of the yield stress of the steel bar forming the soil nail.

(c) Apply an initial load (T_a) equal to 20% of T_p.

(d) Then load the soil nail up to T_p as specified in Clause 26.47(b) and maintain the loading for 20 min. Take measurements of the deformation with the load held constant at time interval of 1, 2, 3, 5, 6, 10, and 20 min. If the nail deformation between 1 min and 10 min exceeds 1 mm or the deformation in the last 10 min exceeds 0.05 mm, hold the maximum test load T_p for an additional 40 min and record deformations at 30, 40, 50, and 60 min. If the deformation in the last 10 min exceeds 0.05 mm, the load shall be held longer as directed by the SO.

(e) Reduce the load to T_a and the extension recorded. Then unload the soil nail as well as that of the bearing plate.

(f) Throughout the test, the deformation of the soil nail as well as that of the bearing plate versus the applied load shall be measured and recorded in a format as shown on Sheet 4 of **Appendix 5**, unless otherwise approved by the SO. Submit the results to the SO within 3 days after completion of the test.

(g) A soil nail shall be considered as failed if,

(i) It is pulled out before or after the maximum allowable test load T_p as specified in Clause 26.47(b) is reached, or

(ii) The nail deformation between 6 min and 60 min at the maximum allowable test load T_p exceeds 2 mm, or

(iii) The soil nail head movement has exceeded e_f in which

$$e_f = T_p L/(EA) + 5\ mm$$

where

T_p = Test load in performance test as specified in Clause 26.47(b)

L = Total length of soil nail

A = Cross sectional area of steel bar

E = Young's modulus of steel bar

Report the failure to the SO immediately.

(h) For any one failure of performance test, select two additional soil nails from the group and carry out further performance tests. If either one of these 2 additional soil nails also fails to reach the test load specified in Clause 26.47(b) above, the particular group of soil nails shall be considered as not complying with the specified requirements.

Submission on performance test record **26.48** Submit results of performance tests to the SO within 3 days of completion of the test.

Non-compliance **26.49** Submit remedial proposal for replacement soil nail installation for those group of soil nails which have failed the performance test.

Soil nail heads **26.50**

(a) Construct soil nail heads in accordance with the details as shown on the Standard Drawings in **Appendix 4** as specified. Method statement for the construction of soil nail heads shall be submitted to the SO for agreement.

(b) Concreting of soil nail heads shall be carried out in a manner which ensures that the placed concrete is adequately compacted. Unless agreed otherwise by the SO, concreting of soil nail heads using sprayed concrete shall be applied in two stages, allowing the bearing plate to be positioned firmly against the first stage concrete. The method statement as referred to in Clause 26.50(a) shall include proposal for the construction sequence of 2-stage sprayed concrete soil nail heads. Trial runs shall also be conducted to demonstrate to the SO that the proposed method statement will produce satisfactory results and the rebound of sprayed concrete material is minimal.

Records of soil nails **26.51** Keep records of installation of soil nails, and submit a copy to the SO within 7 days after each installation operation. The general soil nail data, drilling and grouting records, pull out test record tests and plottings and performance test records shall be recorded and presented in a format as shown in Sheets 1 to 4 of **Appendix 5**, unless otherwise approved by the SO.

GROUTING FOR GEOTECHNICAL WORKS

Grout material **26.52**

(a) Cement grout for the drillholes shall consist of cement, sand and water. Obtain prior approval from the SO if admixtures are to be used.

(b) Sand for grout shall be natural sand or crushed natural stone complying with **BS 1200: 2019**, and shall have a particle size distribution such that 100% passes a 2 mm BS test sieve and not more than 30% passes a 0.2 mm BS test sieve.

(c) Water for grout shall be clean fresh water having a temperature not exceeding 30°C or less than 5°C.

(d) Cement grout shall have a minimum cube strength of 30 MPa at 28 days. The water cement ratio shall not exceed 0.45.

(e) The amount of bleeding of grout shall not exceed 0.5% by volume 3 hr after mixing or 1.0% maximum when measured at 23 $\pm$ 1.7°C in a covered glass or metal cylinder of 100 mm internal diameter and with a grout depth of approximately 100 mm. In addition, the water shall be reabsorbed by the grout within 24 hr.

(f) The flow cone efflux time of grout shall not be less than 15 s.

Mixing grout **26.53**

(a) Mix grout material by weight batching. The mix proportions may be adjusted if approved by the SO depending on the results of the trial grouting, water tests in the hole or the results of previously grouted holes.

(b) The time during which the grout is mixed in high speed mixers shall be suitable for the type of mixer used. Grout shall be continuously agitated in a holding tank after mixing and shall be screened before being circulated in the grout lines. Circulate mixed grout continuously in such a manner that grout which is not taken in a hole can be returned to the holding tank.

(c) Grout to which a retarding agent has not been added, and which is not used within 30 min after mixing, shall not be used for grouting.

Pressure grouting **26.54**

(a) Unless otherwise permitted by the SO, holes in rock should be grouted in grouting stages not exceeding 3 m. Grouting may be carried out in either an upstage or a downstage sequence.

(b) Ground other than rock shall be grouted in such a manner that grout can be injected at various points along the grout hole in a multi-stage operation. The grouting method shall employ perforated pipes with rubber sleeve valves unless otherwise permitted by the SO.

(c) Grouting pressures shall initially be 100 kPa per 4 m depth of hole and shall not exceed the overburden pressure unless permitted by the SO.

(d) Holes shall be grouted in a continuous operation at the grouting stages and pressures as approved. Unless otherwise permitted by the SO, grouting shall be carried out by injecting the grout under pressure into each grouting stage of the hole until the grouting stage refuses to take further grout.

(e) If in the opinion of the SO grouting of any hole or grouting stage has not been completed due to excessive grout take, low pressures, excessive leakage or other causes, the hole shall be redrilled or flushed out with water and re-injected with grout.

Loss or leakage of grout **26.55**

(a) If during the grouting of any drill hole, grout is found to flow from adjacent grout holes in quantities which in the opinion of the SO are sufficient to interfere seriously with the grouting operation or to cause appreciable loss of grout, cap the holes temporarily. If in the opinion of the SO capping is not essential, leave ungrouted holes open to allow air and water to escape.

(b) If during the grouting of any hole grout is found to flow from joints in the geological formation at the Site or any other location, the leaks shall be plugged or caulked in a manner agreed by the SO.

(c) Inform the SO immediately, if during the grouting of any hole the grout take increases suddenly by a significant amount.

Standpipes and capping **26.56**

(a) Unless otherwise permitted by the SO, grout holes shall be capped after drilling and before grouting. Capping shall be by a suitably sealed grout connection, standpipe, packer or other methods agreed by the SO. The cap

shall seal the hole to prevent contamination or clogging of the hole until grouting operations start.

(b) Install standpipes, where required, in holes after drilling. Seal the pipe into the hole using cement grout consisting of OPC and water in the proportions 1:1 by volume.

(c) Standpipes for grouting shall be standard black metal pipe complying with **BS EN 10255 or BS 1387**.

(d) With permission from the SO, non-metallic grout pipe may be used for grouting rock dowels and soil nails when pressure grouting is not normally required.

Submission on record of grouting **26.57** Submit a record of grouting for each hole to the SO within 24 hr after completion of grouting of the hole. The record shall contain the following details:

(a) Hole location and reference number,

(b) Depth of hole,

(c) Collar level and hole inclination,

(d) Type of grout and grout mix proportions,

(e) Volume of grout injected,

(f) Grouting stage numbers and lengths,

(g) Grouting pressures,

(h) Details of grout injections,

(i) Times and details of any interruptions, leakages, equipment malfunctions and ground movement.

Requirement for tests **26.58** Carry out the following tests for each batch of grout upon instruction from the SO:

(a) Flow cone efflux time of grout,

(b) Crushing strength of grout cubes,

(c) Bleeding of grout.

A batch of grout for geotechnical works is any quantity of grout used for grouting geotechnical works in one continuous operation in one day.

Grout - flow cone efflux time **26.59** Provide one sample of grout from each batch of grout to determine the flow cone efflux time of the grout. The method of testing shall be in accordance with **ASTM C939/C939M-16a**.

Crushing strength of grout **26.60** (a) Provide one sample of grout from each batch of grout to determine the crushing strength of the grout. Provide samples not more than 1 hr after the grout has been mixed, and protect them from moisture content changes before test cubes are made.

(b) Make nine 100 mm test cubes from each sample of grout taken as stated in Clause 26.60(a). Three test cubes shall be tested to determine the crushing strength at 3 days, three test cubes shall be tested to determine the crushing strength at 7 days, and three test cubes shall be tested to determine the crushing strength at 28 days. For permanent soil nails and rock dowels, the test cubes for determining the crushing strength at 3 days and 7 days can be omitted.

(c) The method of making, curing and testing the test cubes shall be as stated in **CS1**.

Bleeding of grout **26.61**

(a) Complete bleeding test immediately prior to each application of grout for geotechnical works in a day or as directed by the SO. One sample of grout shall be provided from each batch of grout to determine the amount of bleeding of the grout.

(b) Test grout for geotechnical works for bleeding in accordance with **ASTM C940-16.**

(c) Provide samples not more than 30 min after the grout has been mixed, and protect them from moisture content changes before the tests for amount of bleeding are carried out.

(d) Each sample of grout taken as stated in (a) and (b) above shall be divided into three specimens. Each specimen shall be tested to determine the amount of bleeding according to Clause 26.52(e).

Non-compliance **26.62**

If the result of any test for grout does not comply with the specified requirements as stipulated in Clause 26.52, submit particulars of proposed changes to the materials, grout mix or methods of production to the SO. Further grouting trials shall be carried out unless otherwise permitted by the SO.

DRILLING OF HOLES FOR GEOTECHNICAL WORKS

Drilling and casings **26.63**

(a) Carry out drilling for holes using rotary or percussive-rotary drill with air or water as the flushing medium. Water flush shall not be allowed in case of soil nail holes unless otherwise permitted by the SO. The set-up of drilling plant and ancillary equipment shall be in such a manner that water, dust, fumes and noise generated in the course of drilling and grouting operation shall be sufficiently diverted, controlled, suppressed and muffled.

(b) Use casings to prevent collapsing of the drillhole and to permit unobstructed insertion of the bar or grout pipe, unless otherwise permitted by the SO. Remove these casings immediately before or simultaneously with the grouting in such a manner that the grout hole will not collapse and the injection of grout will not be hindered.

(c) Soil nails shall be grouted on the day when the soil nail bars are inserted into drillholes. Soil nails which are not grouted after insertion and are left in drillholes overnight shall be withdrawn from the drillholes and the drillholes shall be reflushed with compressed air prior to re-insertion.

(d) The permitted deviation of drillholes shall be $\pm 2°$ to the vertical and horizontal alignment as specified by the SO. The cover to the lower end of the bar shall be at least 50 mm.

(e) Do not carry out drilling within a 15 m radius zone of any fresh grouted soil nail or rock dowel completed within the last 24 hr.

DRAINAGE AND EROSION CONTROL

Relief drains **26.64**

(a) Relief drains shall be drain mats with multi-layer porous fabric wrapped in filter fabric and covered with an impermeable fabric or products having equivalent functions or performance as approved by the SO. PVC flanges for connecting relief drains to outlet pipes shall be as shown on the Standard Drawing in **Appendix 6**.

(b) Submit the following particulars of the proposed materials and methods of construction for relief drains to the SO:

(i) Details of relief drains and outlets, and

(ii) Method of fixing relief drains to the slope face.

(c) Submit the particulars to the SO for approval at least 14 days before fixing of relief drains starts.

(d) Submit samples of the relief drain together with the particulars of the material to the SO for approval.

(e) Construct a trial length of relief drains of at least 2 m.

(f) Fix relief drains in position before surface protection or remedial measures are applied. Carry out fixing in a manner which will not affect the serviceability of the relief drains or outlets. Discharge water collected in relief drains to outlets agreed by the SO.

Granular filter **26.65**

(a) Granular filter shall consist of durable, inert, natural material free of clay, organic material and other impurities. Design granular filter materials in accordance with the design criteria stated in **GEO Publication 1/93 "Review of Granular and Geotextile Filters"** and current amendments.

(b) Submit the following particulars of the proposed materials and methods of construction for granular filters to the SO:

(i) Whether granular filter material is to be supplied ready mixed or is to be mixed on the Site,

(ii) Source of supply, including name of supplier of ready mixed material,

(iii) Quantity of each constituent if the material is to be mixed on the Site,

(iv) Constructional plant and methods of mixing for material mixed on the Site,

(v) Method of storage and location of storage areas on the Site,

(vi) Methods of deposition and compaction of material,

(vii) Results of three tests for particle size distribution of the fill material against which the granular filter is to be placed, and

(viii) Details of filter design including calculations and grading envelopes.

(c) Submit the particulars to the SO for approval at least 14 days before deposition of granular filter material starts.

(d) Submit samples to the SO for approval of the source and type of each material at the same time as particulars of the material are submitted.

(e) Do not handle or store granular filter material in a manner which will result in mixing of the different types and sizes or in segregation, contamination, deterioration or erosion of the material.

(f) Place stockpiles of granular filter material on well-drained, prepared areas, and separate them by dividing walls of sufficient height to keep the different materials separate.

(g) Mix thoroughly granular filter material by the method approved by the SO, and remix material which has been stockpiled before deposition.

(h) Compact granular filter materials in accordance with the requirements for rock fill materials as stated in Clause 3.20.

(i) Deposit granular filter material in a manner which will not result in segregation or contamination of the material.

(j) Deposit granular filter material in such a manner that a continuous free draining zone is formed. Clean and scarify the surface of each layer before the next layer is deposited unless otherwise permitted by the SO.

(k) A batch of granular filter material is any quantity of granular filter material of the same type and grading delivered to the Site at any one time.

(l) (i) Provide one sample of granular filter material from each 500 m^3 or part thereof of the material delivered to the Site.

(ii) Unless otherwise permitted by the SO, provide one sample of granular material from each 500 m^3 or part thereof of granular filter material which has been deposited and compacted.

(iii) The size of each sample taken as stated in Clause 26.65(l)(i) shall be 10 kg. The method of sampling shall be in accordance with **CS3**.

(iv) Samples taken as stated in Clause 26.65(l)(ii) shall consist of material excavated from the compacted layer to form a flat bottomed, steep sided hole of approximately 0.13 m^2 to the complete depth of the compacted layer. A template shall be used to fix the edges of the hole if necessary. The sides and bottom of the hole shall be at least 50 mm from other types of fill material.

(m) (i) Test each sample of granular filter material to determine the particle size distribution.

(ii) The method of testing shall be in accordance with the wet sieving method stated in **Geospec 3**, Test Method 8.2.

(n) (i) If the result of any test for particle size distribution on a sample of granular filter material taken as stated in Clause 26.65(l)(i) does not comply with the specified requirements for particle size distribution, provide additional samples from the same batch and carry out additional tests for particle size distribution.

(ii) The batch shall be considered as not complying with the specified requirements for particle size distribution if the result of any additional test for particle size distribution does not comply with the specified requirements for particle size distribution.

(iii) If the result of any test for particle size distribution on a sample of granular filter material taken as stated in Clause 26.65(l)(ii) does not comply with the specified requirements for particle size distribution, provide additional samples from the same batch and carry out additional tests for particle size distribution. The number of additional samples shall be as stated in Clause 26.65(l)(ii).

(iv) The batch shall be considered as not complying with the specified requirements for particle size distribution if the result of any additional test for particle size distribution does not comply with the specified requirements for particle size distribution

(o) Typical details of filter blanket for fill slope are as shown in the Standard Drawing in **Appendix 7**.

Geotextile filter **26.66**

(a) Geotextile filter shall be a proprietary type approved by the SO and shall have the properties stated in the Contract.

(b) Submit the following particulars of the proposed materials and methods of construction for geotextile filter to the SO:

(i) Manufacturer's name and source of supply,

(ii) Details of geotextile filter including manufacturer's literature,

(iii) A certificate for the geotextile filter showing manufacturer's name, the date and place of manufacture and showing that the geotextile filter complies with requirements stated in the Contract, and including results of tests stated in the Contract,

(iv) Calculations showing that the geotextile filter complies with the filtration characteristics stated in the Contract,

(v) Details of previous uses of the geotextile filter,

(vi) Details of quantities to be supplied in each delivery,

(vii) Method of storage,

(viii) Methods of cutting and jointing geotextile filter,

(ix) Method of repairing small batches, and

(x) Methods of laying and holding in position.

(c) Submit the particulars, including certificates, to the SO for approval at least 28 days before the first delivery of the geotextile filter to the Site. Certificates shall be submitted for each batch of geotextile filter delivered to the Site.

(d) Submit geotextile filter sample together with the particulars of the material and two pieces of geotextile filter joined samples in accordance with the manufacturer's recommendations for each type of joint to the SO for approval.

(e) Deliver geotextile filter in secure wrappings to ensure that the geotextile filter is dry and protected from damage, contamination and exposure to conditions which may adversely affect it.

(f) Store geotextile filter on a level surface, and keep it in a secure and dry condition, which will not result in damage to the fabric or in contamination of the fabric.

(g) (i) The total period for which geotextile filter is exposed to daylight or other sources of ultra-violet radiation during handling, delivery, storage and installation shall not exceed 7 days.

(ii) Do not use geotextile filter which has been damaged or exposed to daylight or other sources of ultra-violet radiation for longer than the period stated in Clause 26.66(g)(i) in the permanent work unless permitted by the SO.

(iii) Carry out repairs to geotextile filter which has been torn or damaged during installation using a patch of the same material extending at least 300 mm beyond the edge of the damaged area. Do not carry out repairs on geotextile filter which has been damaged during storage or storage before installation.

(h) (i) Install geotextile filter in such a manner that the individual yarns, webs or layers of the fabric retain their intended orientation and relative positions with respect to each another.

(ii) Install, cut and join geotextile filter in accordance with the manufacturer's recommendations.

(iii) Laps in sheets of fabric reinforcement which are not stated in the Contract to be joined shall be at least 300 mm.

(i) Do not operate constructional plant and other vehicles on installed geotextile filter, unless in opinion of the SO it is adequately protected by a cover of fill material or other means agreed by the SO.

(j) Keep records of installation of geotextile filter on the Site, and submit a copy to the SO each day. Records shall contain the following details:

(i) Identification of structures and sections of work where geotextile filter is installed,

(ii) Type of geotextile filter, including identification of batch,

(iii) Date of first exposure of geotextile filter to ultra-violet radiation before installation,

(iv) Type of joint, amount of overlap, method of holding in place and any repairs to geotextile filter carried out during installation,

(v) Date of installation of geotextile filter, and

(vi) Date of final covering of geotextile filter.

Filter drainage pipe **26.67**

(a) (i) Filter pipes shall comply with the following:

Precast concrete pipes :	**BS 5911-1 & BS EN 1916**
Vitrified clay pipes :	**BS EN 295**
DI pipes :	**BS EN 545**
Steel pipes :	**BS EN 10224**
Perforated concrete pipes :	**BS 5911-1 & BS EN 1916**
uPVC pipes :	**BS EN 1401-1 or BS 3506**
Corrugated polyethylene tubing :	**AASHTO M252-18**

(ii) Do not use Class O uPVC pipes.

(iii) Cut the perforations in perforated pipes clearly, and uniformly space them along the length and circumstance of the pipe.

(iv) Join uPVC plastic pipes using couplers.

(b) (i) Submit the following particulars of the proposed materials and methods of construction for filter pipes to the SO:

(1) Details of type of pipes, including manufacturer's literature,
(2) A certificate showing the manufacturer's name, the date and place of manufacture and showing that the pipes comply with the requirements stated in the Contract,
(3) Details of previous installations using similar pipes, and
(4) Method of installation.

(ii) Submit the particulars to the SO for approval at least 28 days before installation of the filter pipes starts.

(c) Submit samples to the SO for approval of the source and type of each material at the same time as particulars of the material are submitted.

(d) Store coils of plastic tubing for filter pipes flat.

Erosion control mats **26.68**

(a) (i) Non-biodegradable mats for erosion control shall be woven and ultraviolet stabilized mats. The colour of the mats shall be black or dark green or other colour as directed or approved by the SO.

(ii) Biodegradable mats for erosion control shall be woven coir mesh mats or woven jute mats.

(iii) The mats shall have the material properties as stated in the Contract.

(iv) The mats must be produced by proprietary manufacturers and specifically designed for the erosion control of sloping ground.

(b) Submit the following particulars of materials and methods of construction for mats for erosion control to the SO for approval at least 14 days prior to installation.

(i) Details of materials,

(ii) Manufacture's literature including recommended sequence of mats installation and hydroseeding,

(iii) Method of lapping, fixing and anchorage,

(iv) Method of placing and tamping of soft soil into the mats, if required,

(v) Details of equipment, and

(vi) A certificate from the manufacturer on the compliance of the materials, as and where appropriate.

(c) Submit samples of the erosion control mat together with the particulars of the material to the SO for approval.

(d) Clear areas to be applied with mats of all roots, rubbish, debris and loose soils. All local irregular spots and areas shall be either trimmed or filled with compacted fill material or compacted soil cement to provide smooth surfaces. The finished slope surfaces shall be inspected by the SO prior to installation of mats.

(e) Lay and fix mats for erosion control onto sloping ground in accordance with the manufacturers recommended procedures and in compliance with the following requirements:

(i) Anchor the mats except biodegradable types along the slope crest and each berm level with at least 200 mm of mat length embedded into the ground or underneath the concrete berm slabs. The mats shall also be embedded at least 200 mm into any adjacent structures to be constructed. The mats shall be rolled out from top down the slope surfaces. Provide sufficient anchorage pins at a maximum spacing of 1 m centre to centre to ensure the mats are in complete and total contact with the ground at every place. In areas of irregularities due to exposed rocks or existing structures, provide additional anchorage pins to prevent any gap or void forming underneath the mats. Lapping between mats shall be at least 150 mm and shall be formed with the upslope mat over the downslope mat. Do not form lapping within 1 m of any intersection of two slope surfaces which have a sharp difference in slope gradient or strike direction.

(ii) The biodegradable erosion control mats shall be anchored along the crest of slope and each berm with at least 2 rows of bamboo sticks or wooden pegs at a maximum horizontal spacing of 550 mm on 300 mm length mat lapping. The mats shall be rolled out from top down the slope surfaces. Sufficient bamboo sticks or wooden pegs at a maximum spacing of 1 m centre to centre shall be provided to ensure the mats are in complete and total contact with the ground at every place.

(iii) In areas of irregularities due to exposed rocks or existing structures, additional anchorage pins shall be provided to prevent any gap or void forming underneath the mats. Lapping between mats shall be at least 150 mm and shall be formed with the upslope mat over the downslope mat. No lapping shall be formed within 1 m of any intersection of two slope surfaces which have a sharp difference in slope gradient or strike direction.

(iv) Where recommended by the manufacturer, place and tamp soft soil into the mats and completely fill all void within the mats to form an integral composite structure on completion of laying and anchoring of the mats.

(v) The sequence of hydroseeding and laying of mats shall be in accordance with the manufacturer's recommended sequence. Lay

the protective materials for hydroseeding on top of the erosion control mat, if specified.

Raking drains **26.69**

(a) Type 0 raking drains shall be unlined raking drains. Drain holes shall be at least 40 mm diameter.

(b) Type 1 raking drains shall be single pipe raking drains consisting of a single perforated pipe with a non-perforated invert.

(c) Type 2 raking drains shall be single pipe raking drains consisting of a single perforated pipe with a non-perforated invert and enclosed within a geotextile filter sheath.

(d) Type 3 raking drains shall be double pipe raking drains consisting of an outer permanent pipe and an inner removable pipe enclosed within a geotextile filter sheath. The outer and inner pipes shall be perforated pipes with a non-perforated invert.

(e) Pipes for raking drains shall be perforated pipes with non-perforated invert as approved by the SO. A typical layout of raking drain is as shown in **Appendix 8**. The portion of openings in the perforated pipe shall cover between approximately two-thirds 50% and 70% of the circumference of the pipe. The percentage of opening areas to overall surface area of the pipe shall not be less than 14% for 40 mm diameter pipe, nor less than 8% for 65 mm or above diameter pipe. The pipe material shall have the following physical properties or having equivalent functions:

(i) Material: non-metallic

(ii) Minimum tensile strength: 21,300 kN/m^2

(iii) Minimum compressive strength: 22,000 kN/m^2

(iv) Minimum flexural strength: 6,800 kN/m^2

Couplers for filter pipes shall also have non-perforated invert and shall be of similar strength and durability of the pipe materials. The lapped length of coupler and each end of the filter pipes shall be at least 100 mm. The elongation at the pipe connection shall be less than 5 mm under a 45 kg pulling force.

(f) Geotextile filter sheaths for raking drains shall be formed of non-woven geotextile filter robust enough to prevent tearing, and shall have the following physical properties or materials having equivalent functions or performance as approved by the SO:

(i) Material: non-metallic

(ii) Minimum tensile strength: 17 kN/m

(iii) Apparent opening size: 140 μm

(iv) Coefficient of permeability under 2 kN/m^2: 5 x 10^{-3} m/s

(v) Flow rate at 100 mm head under 2 kN/m^2: 195 L/m^2s

Tying wires for jointing pipes and stitching filter sheath shall be non-metallic wires of minimum breaking load of 400 N or similar approved.

(g) Installation of raking drains.

(i) The length of raking drains assembled before installation shall not exceed 12.5 m. Secure connections between consecutive pipes in such a manner that the cumulative longitudinal extension of a 12.5 m

assembled length of pipe does not exceed 5 mm when pulled by hand.

(ii) Wrap pipes for Type 2 and Type 3 raking drains in geotextile filter sheath in the following manner prior to installation to ensure that the overlap and stitching be located against the non-perforated invert of the pipe. Place the pipe onto and along the centre of a strip of geotextile filter with the non-perforated invert uppermost. Draw the strip of geotextile filter, which shall be of sufficient width to allow an overlap of at least 50 mm, around the pipe and stitched together tightly with non-metallic wires. The stitching shall be tied off onto the pipe and the fabric bound every 300 mm to prevent dislocation during installation. Mark the filter sheath to ensure that the non-perforated invert is correctly positioned during installation.

(iii) During delivery and installation of raking drains, care must be taken to ensure that the pipe and geotextile filter sheath are not damaged. Submit the method of installing the raking drains to the SO for approval prior to installation.

(iv) Before installation of drain pipes, check cleanliness of the drillholes. Whenever any obstruction encountered inside a drillhole during pipe insertion, withdraw the pipe and clear the obstruction before re-insertion. No jacking or hammering of pipes shall be carried out during the whole process of pipe insertion.

(h) Drilling for raking drains.

(i) Do not use drilling lubricants other than clean water or air for drilling holes for raking drains. Use casings to prevent collapse of the hole and to permit unobstructed insertion of the pipes and geotextile filter sheath.

(ii) Position the drillhole entry point within a tolerance of $\pm$ 75 mm. Deviation in alignment shall not exceed $\pm$ 2° to the vertical and horizontal alignment as specified by the SO. Deviation from straight shall not exceed 20 mm in any 3 m length of drillhole. Maintain a positive gradient throughout the complete length of the hole, and measure the inclination of holes by a method agreed by the SO.

(iii) Temporarily plug drillholes or protect them to prevent entry of deleterious material after drilling.

(i) Keep records of drillholes for raking drains on the Site, and submit a drillhole log for each drillhole to the SO before installation of the raking drain starts. The drillhole log shall contain the following details:

(i) Drain reference number,

(ii) Location, inclination, bearings, diameter and length of hole,

(iii) Details of drilling progress,

(iv) Details of water seepage related to drilling progress, and

(v) Description of the materials encountered in the drillhole related to drilling progress.

PAINTING TO SPRAYED CONCRETE

Painting to sprayed concrete **26.70**

(a) Where ordered, paint the sprayed concrete with two coats of water-based paint for external use approved by the SO. The components of paint shall not be toxic or hazardous to health.

(b) Submit details of the paint products (e.g. specification and colour samples etc.) and method statement for the approval of SO prior to painting. The colour of the paint shall be "Antique" to **BS 5252F** and of the colour code as directed by the SO.

(c) Store paint and associated materials in a dry weatherproof store. Maintain the store in a cool, well ventilated condition. Tins of paint and associated materials shall be labelled to show their intended use, and shall be protected from exposure to conditions which may adversely affect the material. Store paint and associated materials in accordance with the manufacturers' recommendations, and do not use them after the recommended shelf life has been exceeded.

(d) Prepare the surface of sprayed concrete prior to applying the paint. The surface to be painted shall be clean, free of contaminants such as oils, grease, release agents, mortar splashes etc. All debris and loose materials shall be removed from the surface. Painting shall not be carried out in direct strong sunlight, hot windy conditions or in an environment with excessive dust.

(e) Mix paint in accordance with the manufacturer's instruction prior to application. Apply each coat of the paint to the surface using an airless spray at 12 m^2/L or equivalent to obtain a uniform finish or as recommended by the manufacturer. Allow sufficient time gap between the application of the first and second coat of paint as recommended by the manufacturer. Protect each coat of paint from rain for the first 24 hr after application.

SOIL-CEMENT FILL

Soil-cement **26.71**

(a) Soil-cement shall consist of Portland Cement (PC), sand and inorganic soil in the proportions 1:3:12 by mass unless otherwise stated. The mix proportion of soil-cement is 1:3:40 by mass when it is applied to the top layer (maximum 300 mm thick) or other areas as directed or agreed by the SO.

(b) PC shall comply with Clause 6.27.

(c) Sand shall be natural sand or crushed natural stone complying with **BS 1200:2019**.

(d) Inorganic soil shall be free from organic matter and shall contain not more than 30% of soil particles passing a 63 μm BS test sieve.

Mixing soil-cement **26.72**

Mix thoroughly soil-cement in a concrete mixer; hand-mixing of small quantities of soil-cement may be permitted by the SO. The method of mixing soil-cement shall be agreed by the SO.

Deposition and compaction of soil-cement fill **26.73**

(a) Place soil-cement fill in its final position and compact within 30 min of the cement being added to the mix.

(b) Compact soil-cement fill as stated in Clause 3.19 to obtain a relative compaction of at least 95% throughout.

MAINTENANCE STAIRWAYS

Maintenance stairways on slope **26.74**

(a) Typical details of concrete maintenance stairways on slopes up to 40° are as shown in Standard Drawings in **Appendix 9**.

(b) Typical details of staircase for slopes steeper than 40° are as shown in the Standard Drawing in **Appendix 9**.

AS-BUILT RECORD

Particular requirements **26.75** Conduct a topographical survey of all slopes and retaining walls formed, modified or partially modified under the Contract upon their completion or at any other time as appropriate during the construction period. Such survey shall be completed upon the substantial completion of the Works, and shall be submitted together with the as-built site formation layout, details drawings and design calculations to the SO not more than 28 days, or such other time as stated in the Contract, after the completion of the survey. The submission shall cover the following:

(a) the extent of man-made slopes, if any (including cut and fill slopes) is to be marked on the as-built drawings. The legend for cut slopes shall be different from that of the fill slopes;

(b) the contour lines shall terminate at the boundaries of the cut/fill slopes and there shall not be any contour lines within the cut/fill slopes;

(c) any surface protection such as hydroseeding, sprayed concrete, chunam, etc. and surface drainage system shall be marked clearly on the as-built drawings;

(d) any installation such as soil nails, dowel bars, horizontal drains, etc. shall also be marked on the as-built drawings. The respective grouting and testing records shall also be submitted. The elevation of the respective slopes shall be shown;

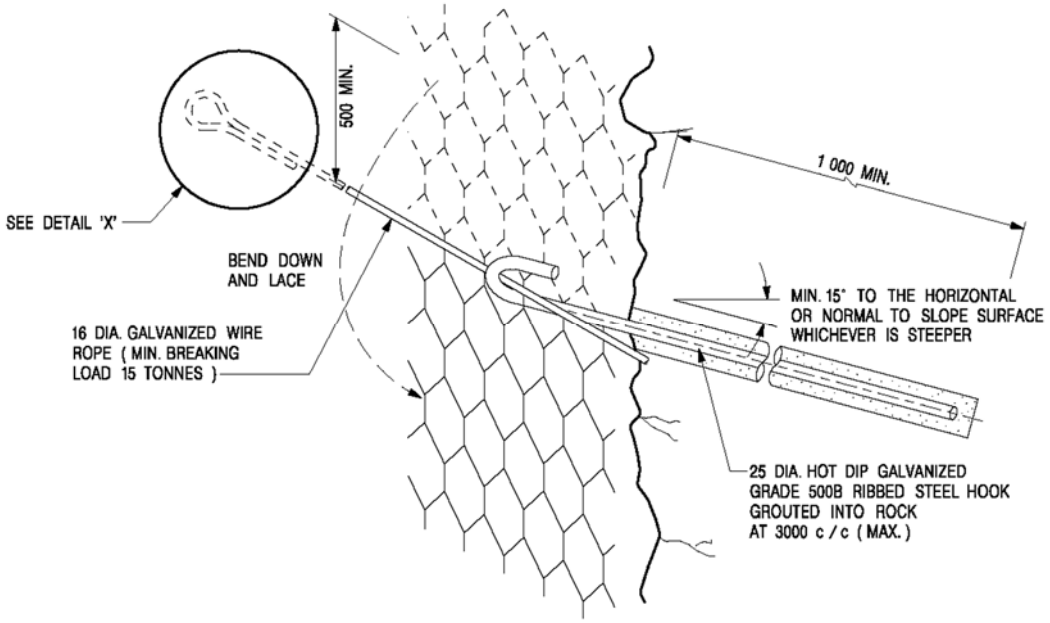
(e) any retaining walls layout and details; and

(f) any other geotechnical features.

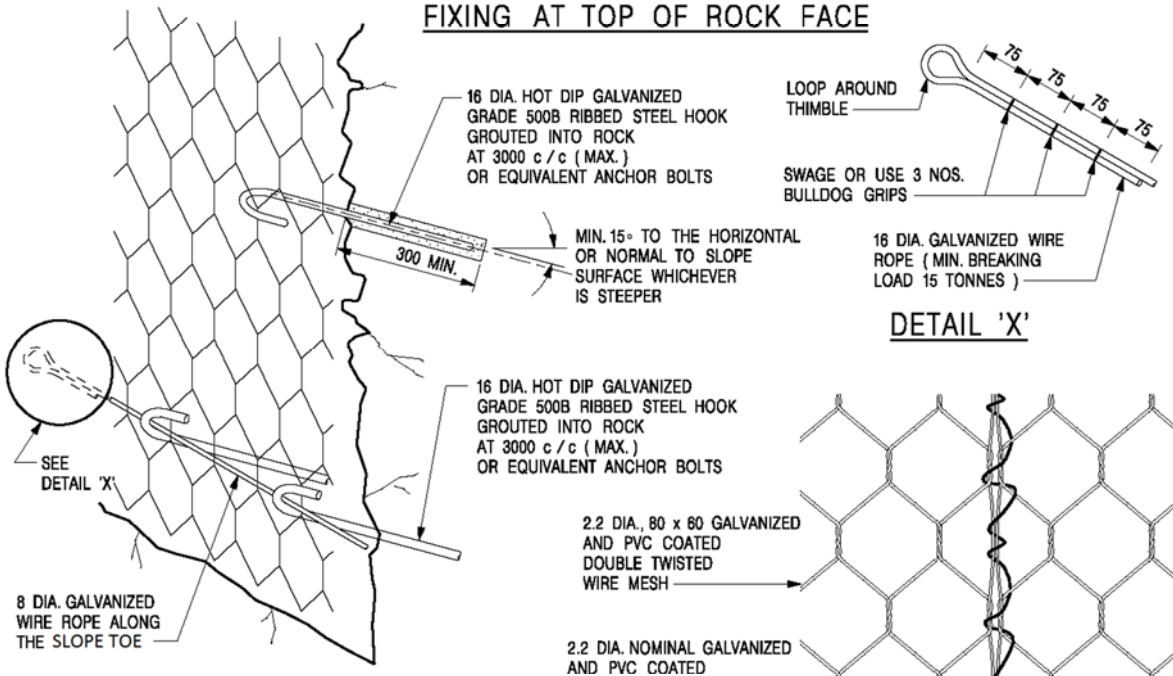
Appendix

Drawings

APPENDIX 1 Sheet 1 of 1



FIXING AT TOP OF ROCK FACE



DETAIL 'X'

FIXING MESH TO ROCK FACE AND AT BOTTOM OF ROCK FACE

LACING OF ADJACENT MESH SHEETS

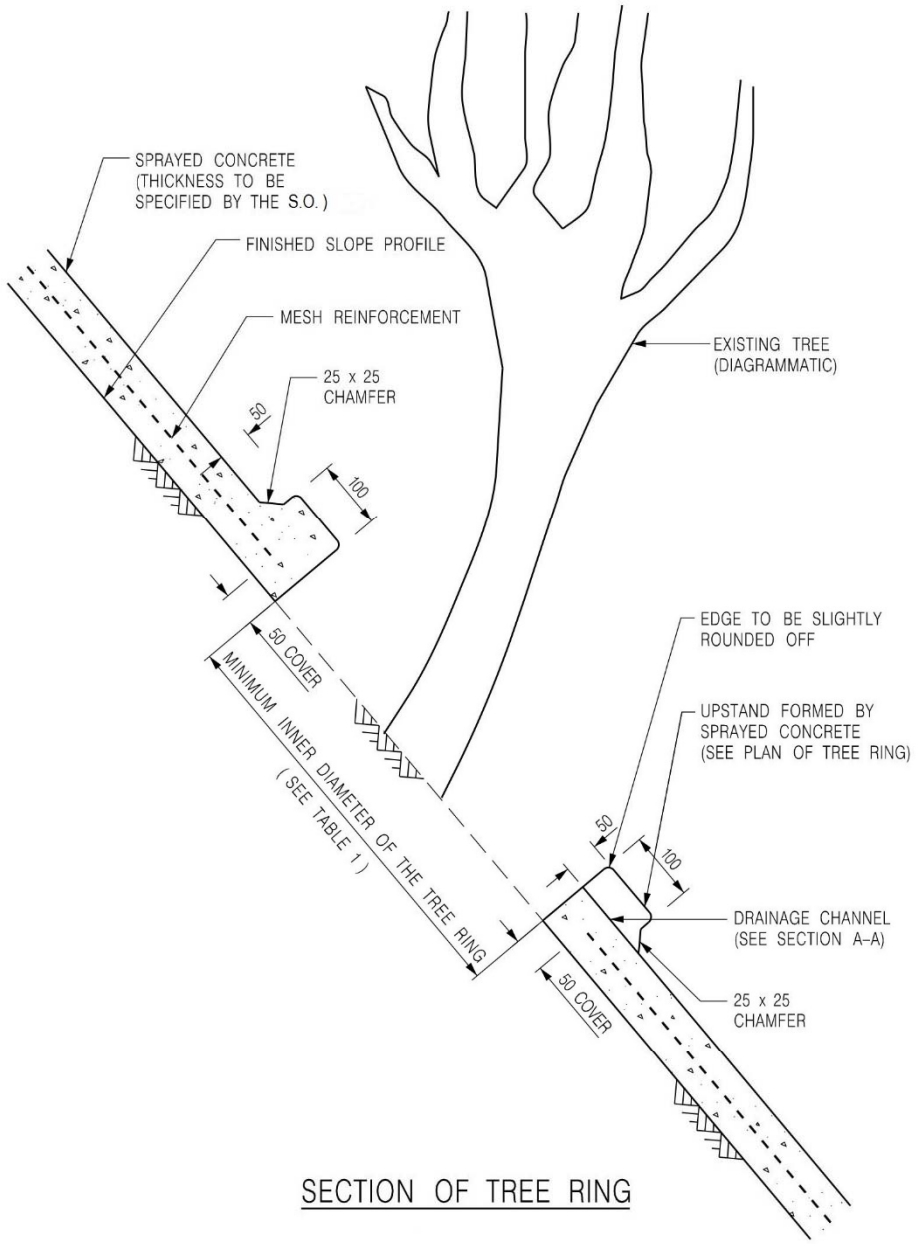
NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. PVC THICKNESS SHALL BE 0.4mm MINIMUM.
3. SPACING OF THE STEEL HOOKS OR EQUIVALENT ANCHOR BOLTS SHALL BE REDUCED WHERE APPROPRIATE TO ENSURE THAT THE WIRE MESH CLOSELY FOLLOWS THE ROCK SLOPE PROFILE PARTICULARLY ON RUGGED ROCK SURFACE.

(MODIFIED FROM CEDD STANDARD DRAWING NO. C2205/F)

FIXING OF WIRE MESH TO ROCK FACE	ARCHITECTURAL SERVICES DEPARTMENT	
	SCALE DIAGRAMMATIC	DRAWING NO. C2205
	DATE JULY 2015	

APPENDIX 2 Sheet 1 of 2



SECTION OF TREE RING

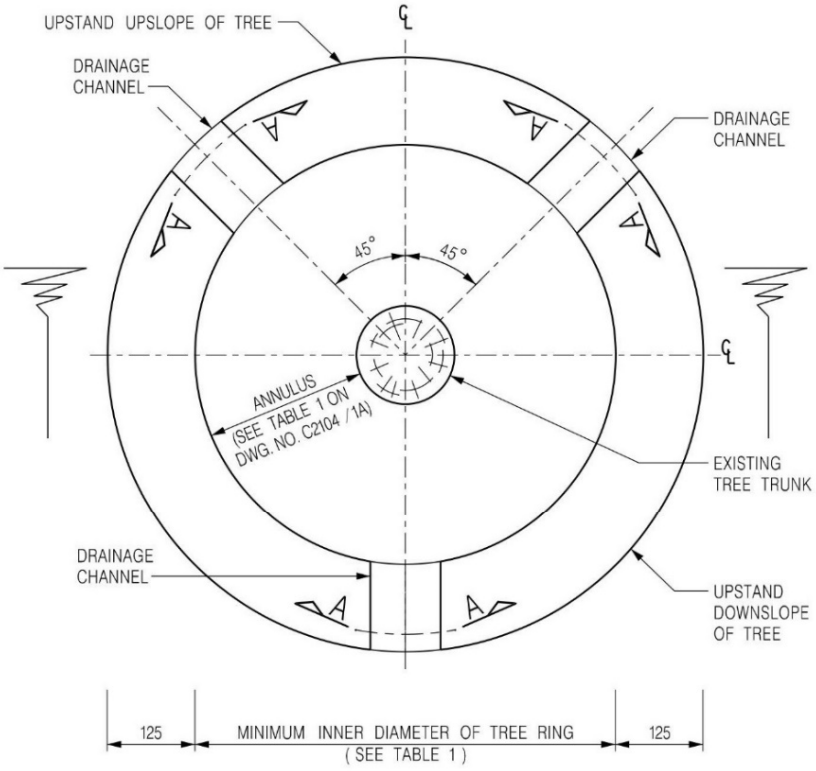
TABLE 1 : MINIMUM INNER DIAMETER OF TREE RING

SIZE GROUP OF TREE	TREE RING INNER DIAMETER (mm)
SMALL TREE	TREE TRUNK DIAMETER AT GROUND LEVEL PLUS 600 (300 ANNULUS ON ALL SIDES)
MEDIUM TREE	TREE TRUNK DIAMETER AT GROUND LEVEL PLUS 800 (400 ANNULUS ON ALL SIDES)
LARGE TREE	TREE TRUNK DIAMETER AT GROUND LEVEL PLUS 1000 (500 ANNULUS ON ALL SIDES)
SIZE GROUP OF TREE SHALL REFER TO THE ATTAINABLE 'MATURE SIZE' OF TREE TO BE RETAINED	

(MODIFIED FROM CEDD STANDARD DRAWING NO. C2104/1A)

TREE RING (SHEET 1 OF 2)	ARCHITECTURAL SERVICES DEPARTMENT		
	SCALE	DIAGRAMMATIC	DRAWING NO.
	DATE	MARCH 2021	C2104/1

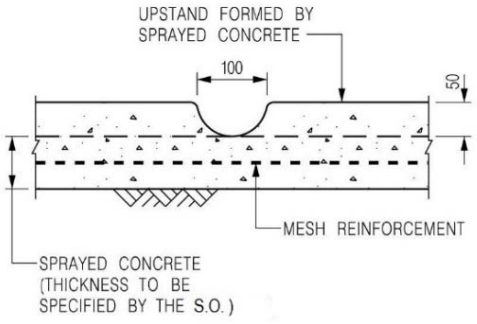
APPENDIX 2 Sheet 2 of 2



PLAN OF TREE RING

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. SURFACE FINISHES OF TREE RING SHALL BE U1, F2.
3. THE TREE RING SHALL BE POSITIONED SUCH THAT THE TREE IS AT THE CENTRE OF THE TREE RING OR AS DETERMINED ON SITE BY THE S.O.
4. CIRCULAR TREE RING WITH A CONSTANT TREE RING ANNULUS DIMENSION SHOULD BE ADOPTED IN GENERAL.
5. FOR GROUPS OF TREES LOCATED CLOSE TOGETHER, THE GEOMETRY OF THE TREE RING SHALL BE DETERMINED ON SITE BY THE S.O.
6. THE TREE RING DIAMETER SHALL BE DETERMINED IN RESPECT TO EXISTENCE OF ANCHOR ROOTS (IN PARTICULAR, TENSION ROOTS FOUND UPSLOPE) AND SHALL REFER TO THE ATTAINABLE 'MATURE SIZE' OF TREES TO BE RETAINED.
7. DEFINITION OF TREE SIZE AND SIZE OF COMMON TREE SPECIES SHALL REFER TO GEO PUBLICATION NO. 1 / 2011 AND THE LATEST TECHNICAL CIRCULARS / GUIDELINES ISSUED BY THE DEVELOPMENT BUREAU.
8. USE OF EROSION CONTROL MAT / WIRE MESH WITHIN A TREE RING SHALL BE AVOIDED.

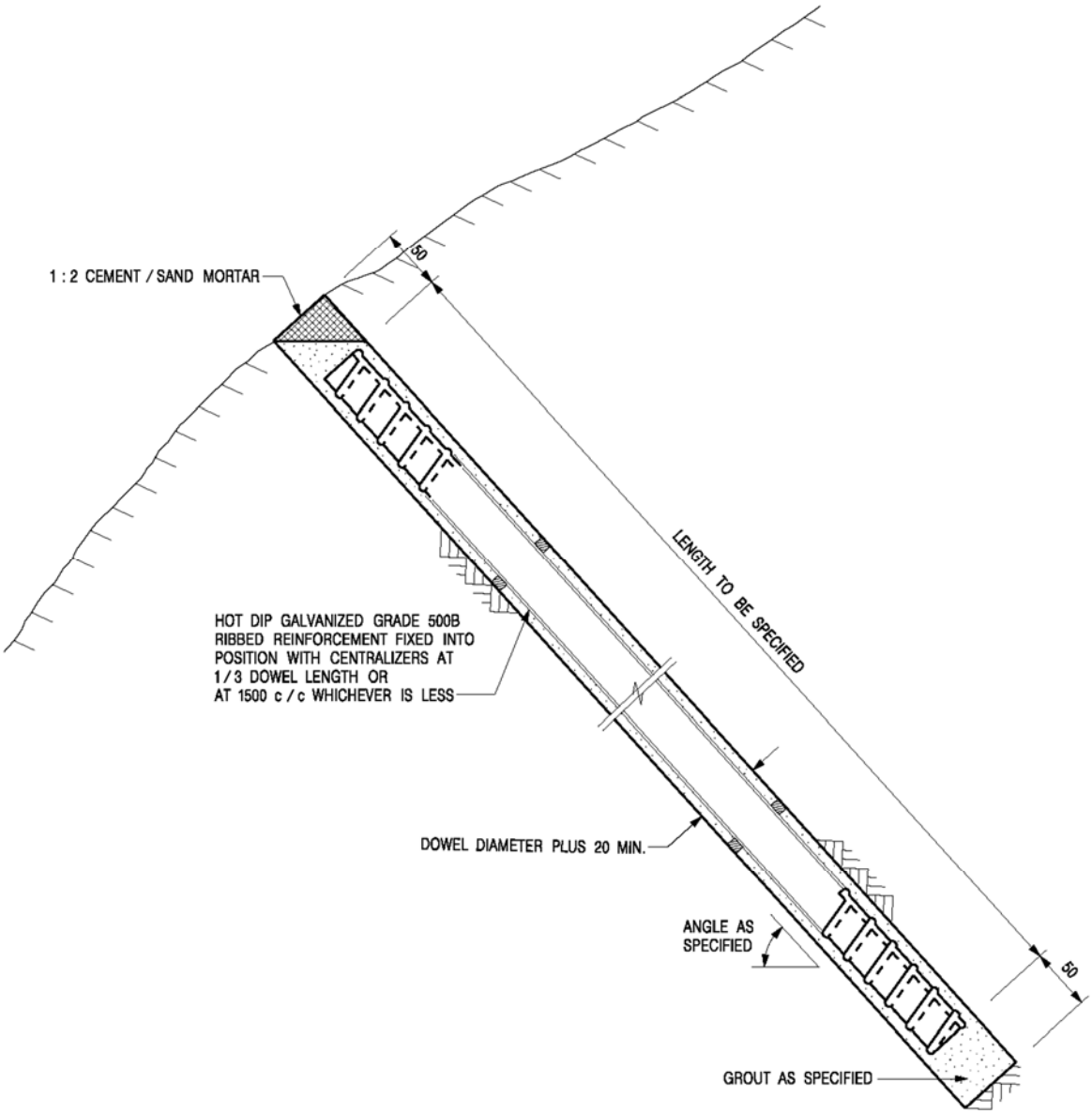


SECTION A–A

(MODIFIED FROM CEDD STANDARD DRAWING NO. C2104/2A)

TREE RING (SHEET 2 OF 2)	ARCHITECTURAL SERVICES DEPARTMENT	
	SCALE DIAGRAMMATIC	DRAWING NO. C2104/2
	DATE MARCH 2021	

APPENDIX 3 Sheet 1 of 1



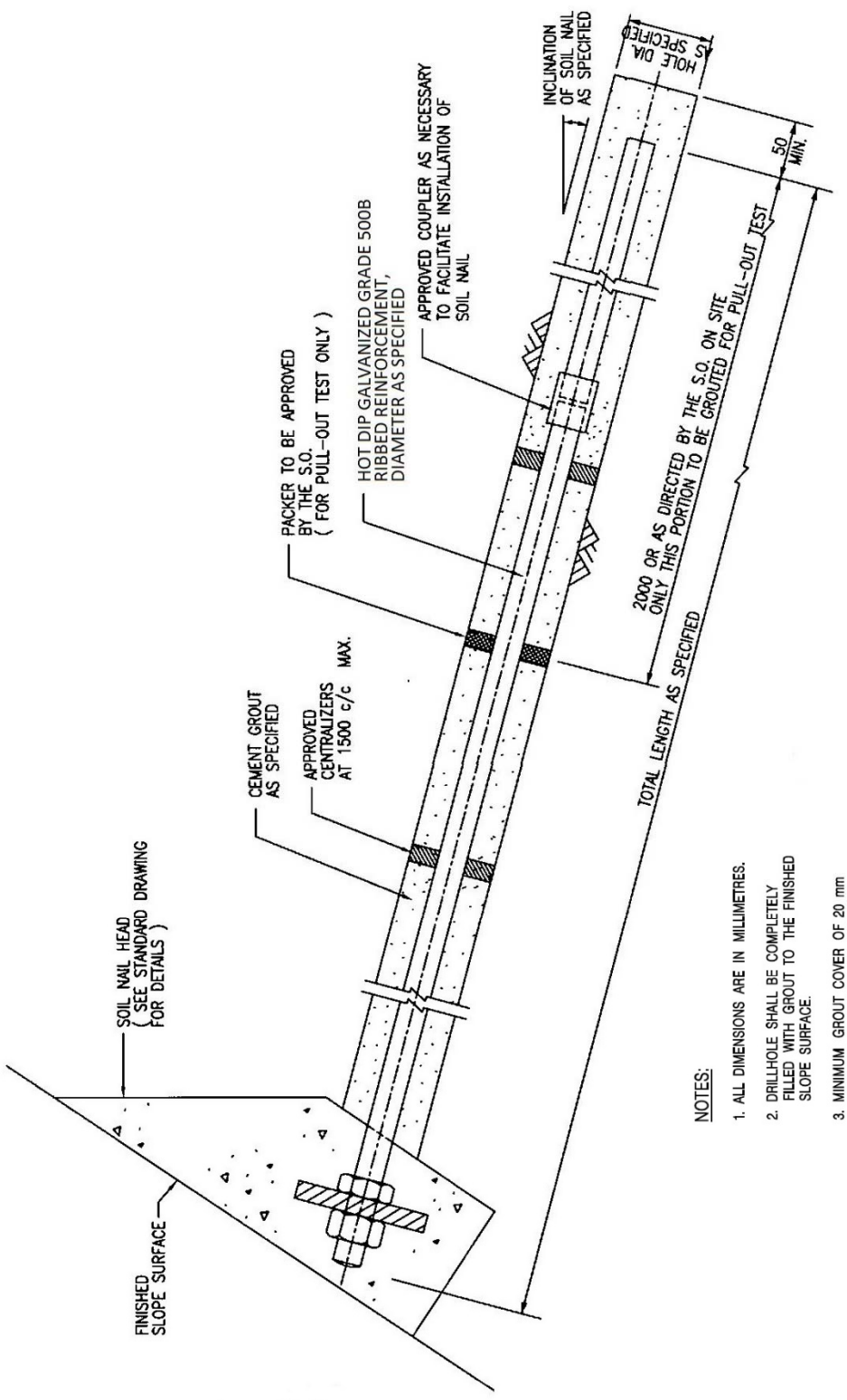
NOTES:

ALL DIMENSIONS ARE IN MILLIMETRES.

(MODIFIED FROM CEDD STANDARD DRAWING NO. C2202D)

TYPICAL ARRANGEMENT OF ROCK DOWEL	ARCHITECTURAL SERVICES DEPARTMENT	
	SCALE DIAGRAMMATIC	DRAWING NO. C2202
	DATE JULY 2015	

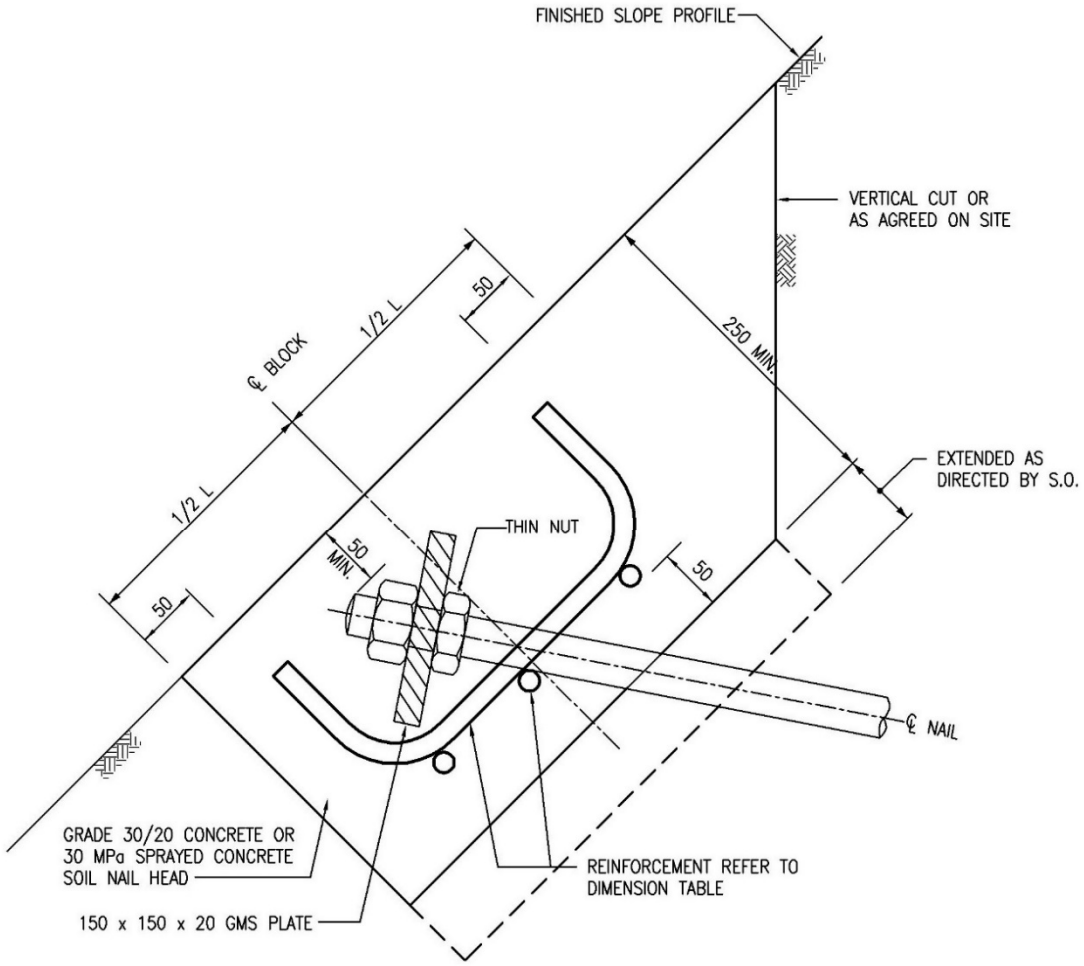
APPENDIX 4 Sheet 1 of 3



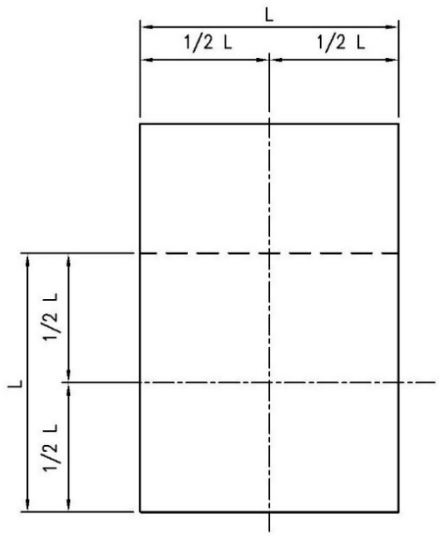
(MODIFIED FROM CEDD STANDARD DRAWING NO. C2106/1L)

TYPICAL DETAILS OF SOIL NAIL	ARCHITECTURAL SERVICES DEPARTMENT	
	SCALE DIAGRAMMATIC	DRAWING NO. C2106/1
	DATE MARCH 2021	

APPENDIX 4 Sheet 2 of 3



TYPICAL SECTION



VIEW NORMAL TO SOIL NAIL HEAD

DIMENSION TABLE

NAIL HEAD SIZE (L X L) (mm)	REINFORCEMENT
400 x 400	3B16 U-BARS BOTH WAYS
600 x 600	3B16 U-BARS BOTH WAYS
800 x 800	4B16 U-BARS BOTH WAYS

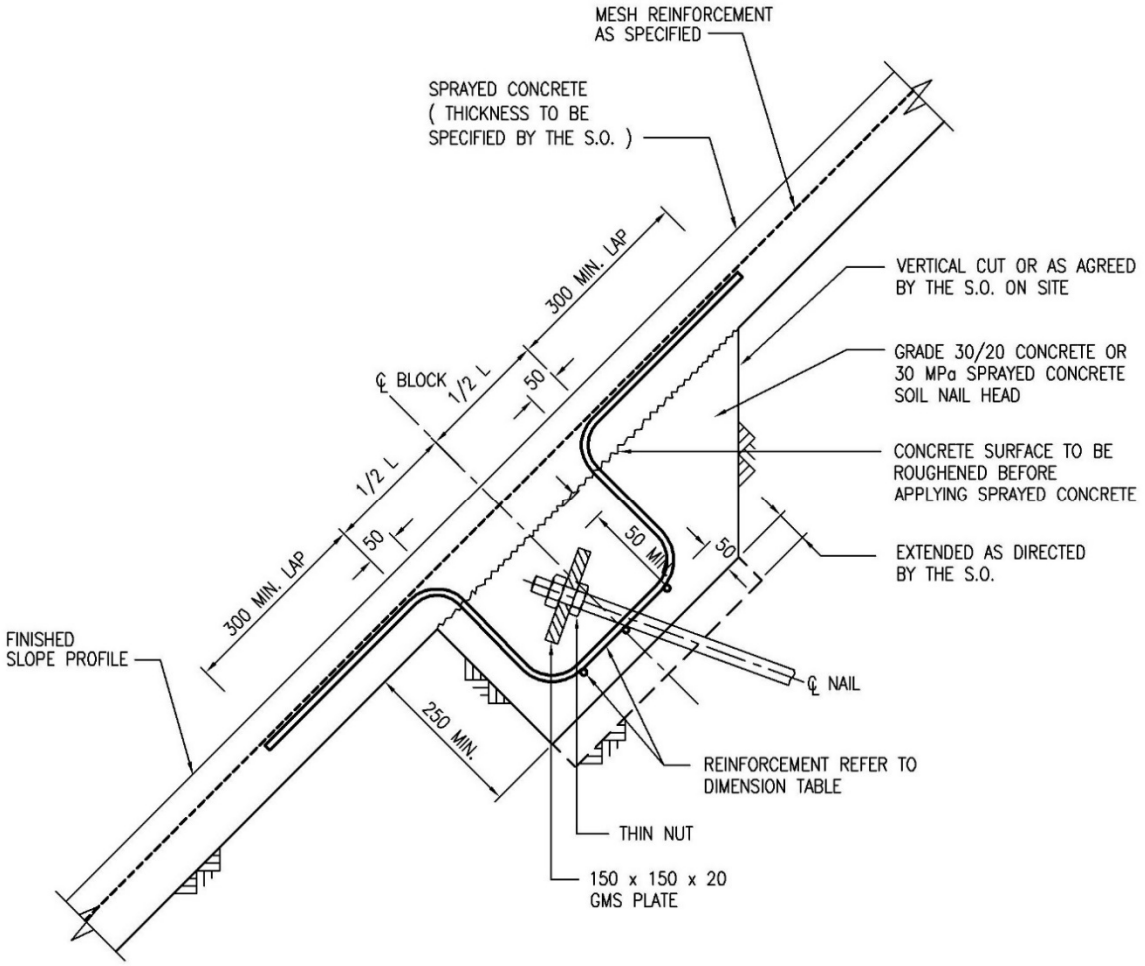
NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. THE SIZE OF SOIL NAIL HEAD SHALL BE SPECIFIED BY THE S.O
3. CONSTRUCTION OF SOIL NAIL HEAD SHALL BE REFERRED TO THIS G.S
4. B DENOTES GRADE 500B RIBBED REINFORCEMENT.
5. FOR SOIL NAIL HEADS CONSTRUCTED BY 2-STAGE SPRAYED CONCRETE ACCORDING TO THIS G.S. THE THIN NUT SHALL BE OMITTED.

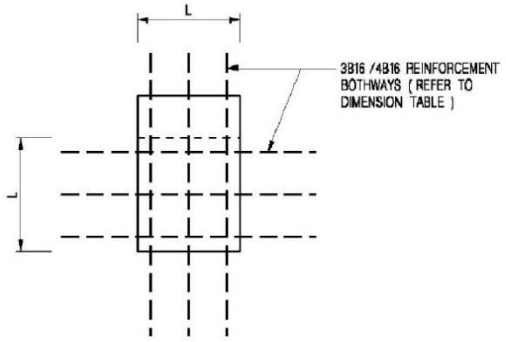
(MODIFIED FROM CEDD STANDARD DRAWING NO. C2106/2K)

SOIL NAIL HEAD DETAILS	ARCHITECTURAL SERVICES DEPARTMENT	
	SCALE DIAGRAMMATIC	DRAWING NO.
	DATE MARCH 2021	C2106/2

APPENDIX 4 Sheet 3 of 3



TYPICAL SECTION



VIEW NORMAL TO SOIL NAIL HEAD

DIMENSION TABLE

NAIL HEAD SIZE (L X L) (mm)	REINFORCEMENT
400 x 400	3B16 U-BARS BOTH WAYS
600 x 600	3B16 U-BARS BOTH WAYS
800 x 800	4B16 U-BARS BOTH WAYS

NOTES :

1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. MINIMUM CONCRETE COVER TO MESH REINFORCEMENT SHALL BE 25mm OR OTHERWISE SPECIFIED.
3. THE SIZE OF SOIL NAIL HEAD SHALL BE SPECIFIED BY THE S.O.
4. CONSTRUCTION OF SOIL NAIL HEAD SHALL BE REFERRED TO THIS G.S.
5. B DENOTES GRADE 500B RIBBED REINFORCEMENT.
6. FOR SOIL NAIL HEADS CONSTRUCTED BY 2-STAGE SPRAYED CONCRETE ACCORDING TO THIS G.S., THE THIN NUT SHALL BE OMITTED.

(MODIFIED FROM CEDD STANDARD DRAWING NO. C2106/3L)

SOIL NAIL HEAD DETAILS FOR SPRAYED CONCRETE SLOPE SURFACE

ARCHITECTURAL SERVICES DEPARTMENT

SCALE	DIAGRAMMATIC	DRAWING NO.
DATE	MARCH 2021	C2106/3

APPENDIX 5 Sheet 1 of 4

ARCHITECTURAL SERVICES DEPARTMENT

Soil Nails Installation : Drilling & Grouting Records

Contract No. _____ *Contractor* _____
Works Order No. _____ _____

Slope details

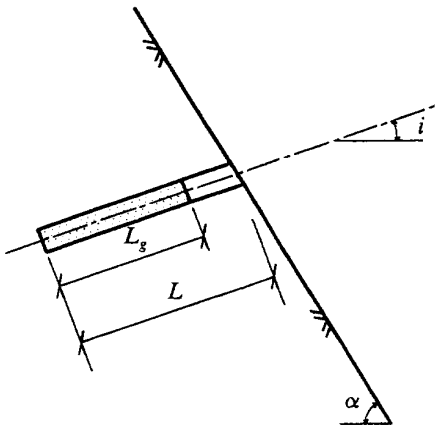
Slope No. _____ *Cross-section* _____ *Slope top* _____ *mPD*
Slope angle, α _____ *bottom* _____ *mPD*

Soil nail hole details ***(Soil nail No.*** _____***)*** ***Bar details***

head _____ *E* *Hole diameter* _____ *mm* *Length,* L_b _____ *m*
Co-ordinates _____ *N* *Total length, L* _____ *m* *Diameter, d* _____ *mm*
R.L. _____ *mPD* *Inclination, i* _____ *Steel grade* _____

Drilling records
Date drilled _____
Drilling method _____
Flushing medium _____

Grouting records
Date grouted _____
Grouting time _____ *min*
Grouted length, L_g _____ *m*
(L_g *= L for permanent soil nails)*
Grout mix _____
w/c ratio _____
Grouting pressure _____
Calculated grout volume _____
Flow cone efflux time _____
Cube strength (MPa)
7/28 day _____ / _____



Remarks *(on soil/rock conditions around soil nail)*

Accumulated drilling time (min)

mPD *mPD*

Tested by _____ *Date* __/__/__ *Checked by* _____ *Date* __/__/__
(Signature, Name & Post) *(Signature, Name & Post)*

(geotspec.ap5)

APPENDIX 5 Sheet 2 of 4

ARCHITECTURAL SERVICES DEPARTMENT

Soil Nails Installation: Pull Out Test Records

Contract No. _____ *Contractor* _____

Works order No. _____ _____

Slope details

Slope No. _____ *Cross-section* _____ *Slope top* _____ *mPD*

Slope angle, α _____ *Bottom* _____ *mPD*

Soil nail hole details ***(Soil nail No.* _____*)*** ***Bar details***

Head _____ *E* *Hole diameter* _____ *mm* *Length, L* _____ *m*

Co-ordinates _____ *N* *Total length, L* _____ *m* *Diameter, d* _____ *mm*

R.L. _____ *mPD* *Inclination, i* _____ *Steel grade* _____

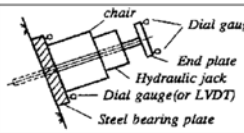
Loading sequence ***(T_p = 90% steel bar yield load or the ultimate soil / grout bond load or as directed by SO)***

Seating Load, T_a = _____

Cycle 1, T_{DL1} = _____

Cycle 2, T_{DL2} = _____

Test Load, T_p = _____



Steel bearing plate
Length = mm
Width = mm
Thickness = mm

Time d/h/m	Time elapsed min	Load		Bearing plate movement			Nail head movement		
		Gauge	kN	Gauge 1	Gauge 2	Average (mm)	Gauge 1	Gauge 2	Average (mm)

Tested by _____ *Date* ___/___/___ *Checked by* _____ *Date* ___/___/___.

(Signature, Name & Post) *(Signature, Name & Post)* *(geotspec.ap5)*

APPENDIX 5 Sheet 3 of 4

ARCHITECTURAL SERVICES DEPARTMENT

Soil Nails Installation: Pull Out Test Records

Contract No. _____ *Contractor* _____

Works order No. _____ _____

Slope details

Slope No. _____ *Cross-section* _____ *Slope top* _____ *mPD*

Slope angle, α _____ *Bottom* _____ *mPD*

Soil nail hole details ***(Soil nail No.* _____*)*** ***Bar details***

Head _____ *E* *Hole diameter* _____ *mm* *Length, L* _____ *m*

Co-ordinates _____ *N* *Total length, L* _____ *m* *Diameter, d* _____ *mm*

R.L. _____ *mPD* *Inclination, i* _____ *Steel grade* _____

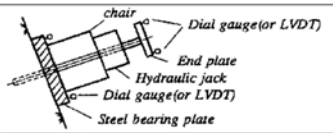
Loading sequence ***(T_p = 90% steel bar yield load or the ultimate soil / grout bond load or as directed by SO)***

Seating Load, T_a = _____

Cycle 1, T_{DL1} = _____

Cycle 2, T_{DL2} = _____

Test Load, T_p = _____



Steel bearing plate
Length = mm
Width = mm
Thickness = mm

Time d/h/m	Time elapsed min	Load		Bearing plate movement			Nail head movement		
		Gauge	kN	Gauge 1	Gauge 2	Average (mm)	Gauge 1	Gauge 2	Average (mm)

Tested by _____ *Date* ___/___/___ *Checked by* _____ *Date* ___/___/___.

(Signature, Name & Post) *(Signature, Name & Post)* *(geotspec.ap5)*

APPENDIX 5 Sheet 4 of 4

ARCHITECTURAL SERVICES DEPARTMENT

Soil Nails Installation : Performance Test Records

Contract No. _____ *Works Order No.* _____	*Contractor* _____

Slope details

Slope No. _____	*Cross-section* _____ *Slope angle, α* _____	*Slope top* _____ *mPD* *bottom* _____ *mPD*

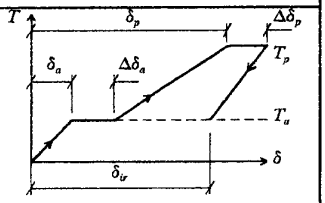
Soil nail hole details ***(Soil nail No. _____)***		***Bar details***
head _____ *E* *Co-ordinates* _____ *N* *R.L.* _____ *mPD*	*Hole diameter* _____ *mm* *Total length, L* _____ *m* *Inclination, i* _____	*Length, L_b* _____ *m* *Diameter, d* _____ *mm* *Steel grade* _____

Loading sequence (T_p > 1.5 working load but < 80% steel bar yield load or as directed by the SO)

Seating load, T_a = 0.20T_p = _____
Test Load, T_p = _____

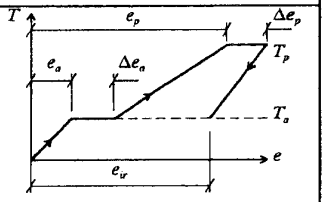
Bearing plate movement (mm)

$\delta_a/\Delta\delta_a$ = ___/___
$\delta_p/\Delta\delta_p$ = ___/___
δ_{ir} = _____

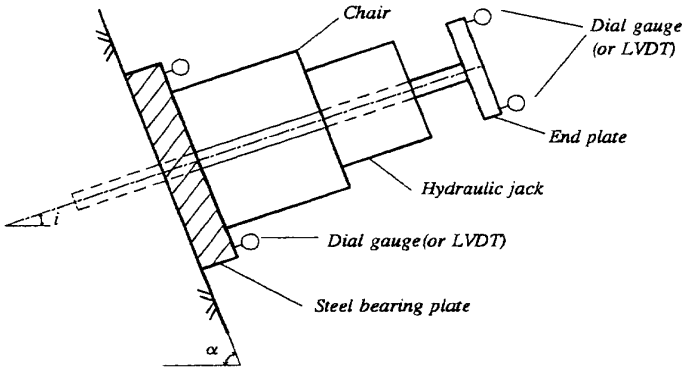


Soil nail head movement (mm)

$e_a/\Delta e_a$ = ___/___
$e_p/\Delta e_p$ = ___/___
e_{ir} = _____



(Bearing plate length/width/thickness = / / mm)



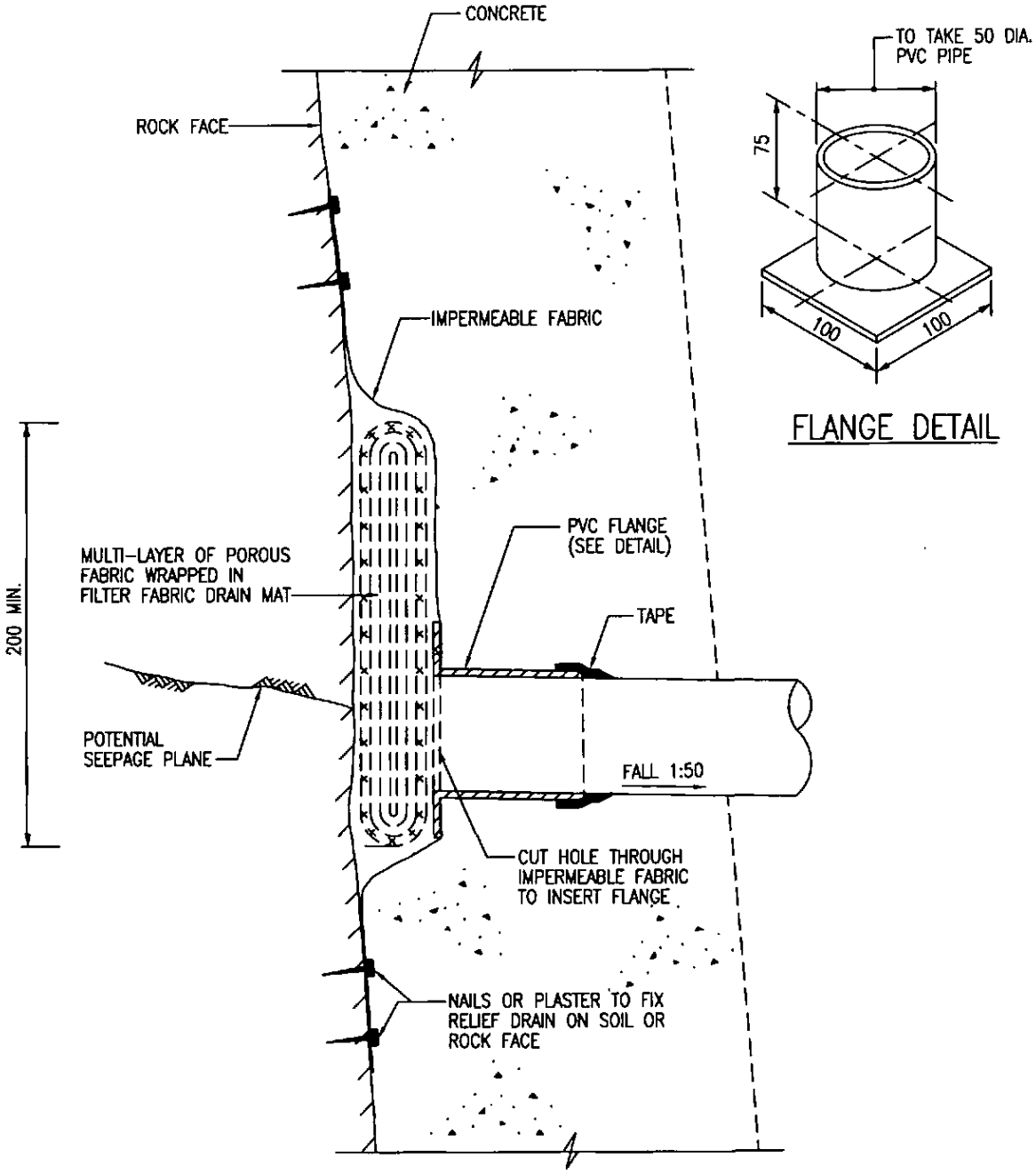
Time d/h/m	*Time elapsed min*	*Load*		*Bearing plate movement*			*Nail head movement*		
		Gauge	*kN*	*Gauge 1*	*Gauge 2*	*Average (mm)*	*Gauge 1*	*Gauge 2*	*Average (mm)*

Tested by _____ *Date* ___/___/___
(Signature, Name & Post)

Checked by _____ *Date* ___/___/___
(Signature, Name & Post)

(geotspec.ap5)

APPENDIX 6 Sheet 1 of 1



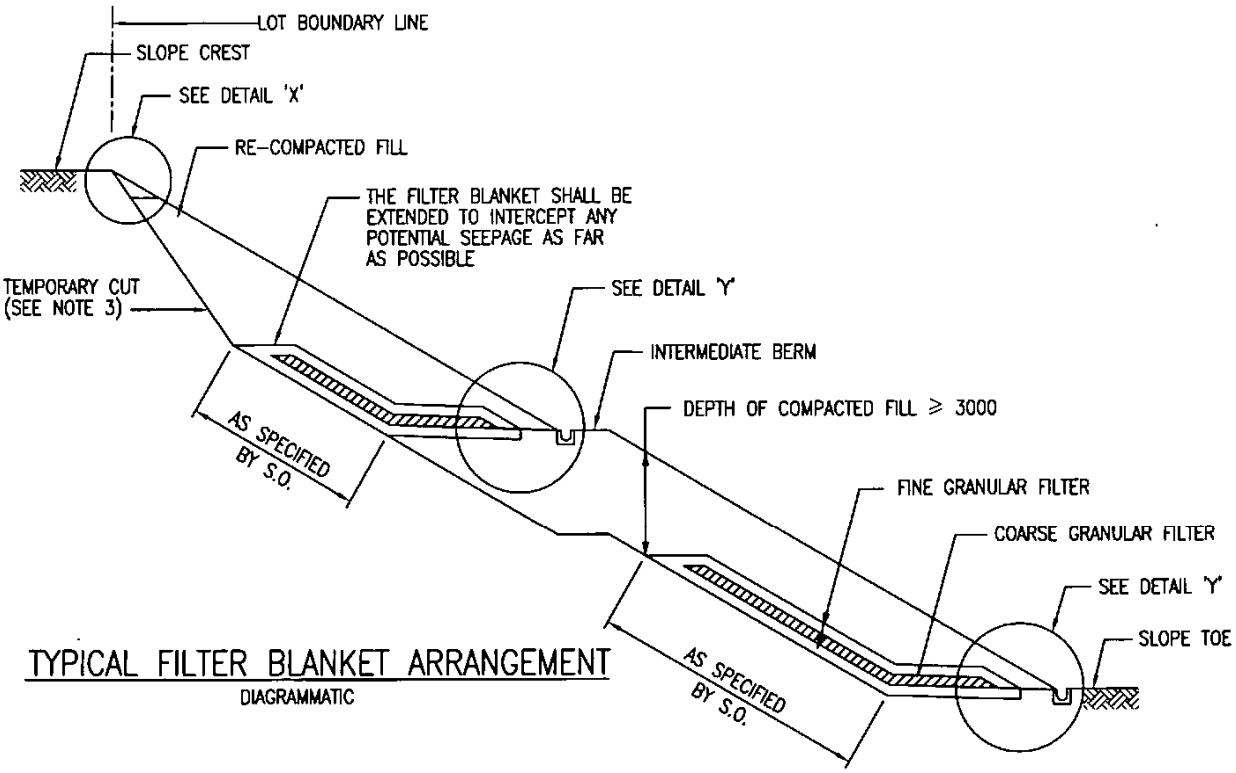
NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. FOR SPECIFICATIONS OF FILTER FABRIC, SEE THIS P.S.

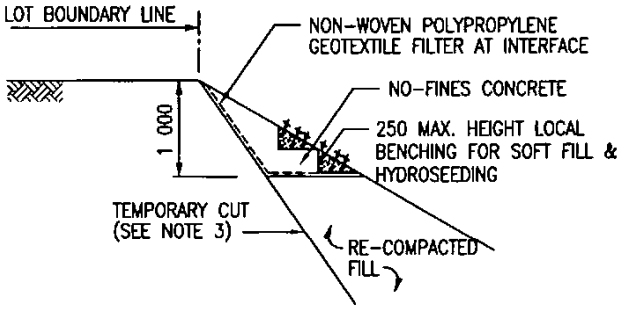
(MODIFIED FROM CEDD STANDARD DRAWING NO. C2404D)

RELIEF DRAIN DETAILS	ARCHITECTURAL SERVICES DEPARTMENT	
	SCALE DIAGRAMMATIC	DRAWING NO. C2404
	DATE JUNE 2009	

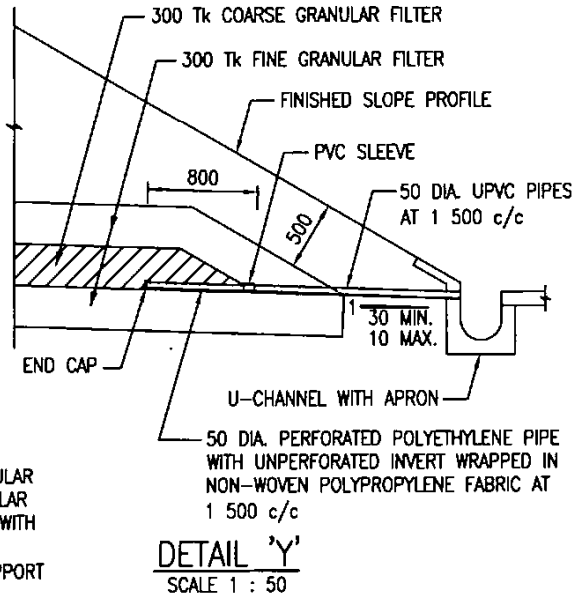
APPENDIX 7 Sheet 1 of 1



TYPICAL FILTER BLANKET ARRANGEMENT
DIAGRAMMATIC



DETAIL 'X'
DIAGRAMMATIC



DETAIL 'Y'
SCALE 1 : 50

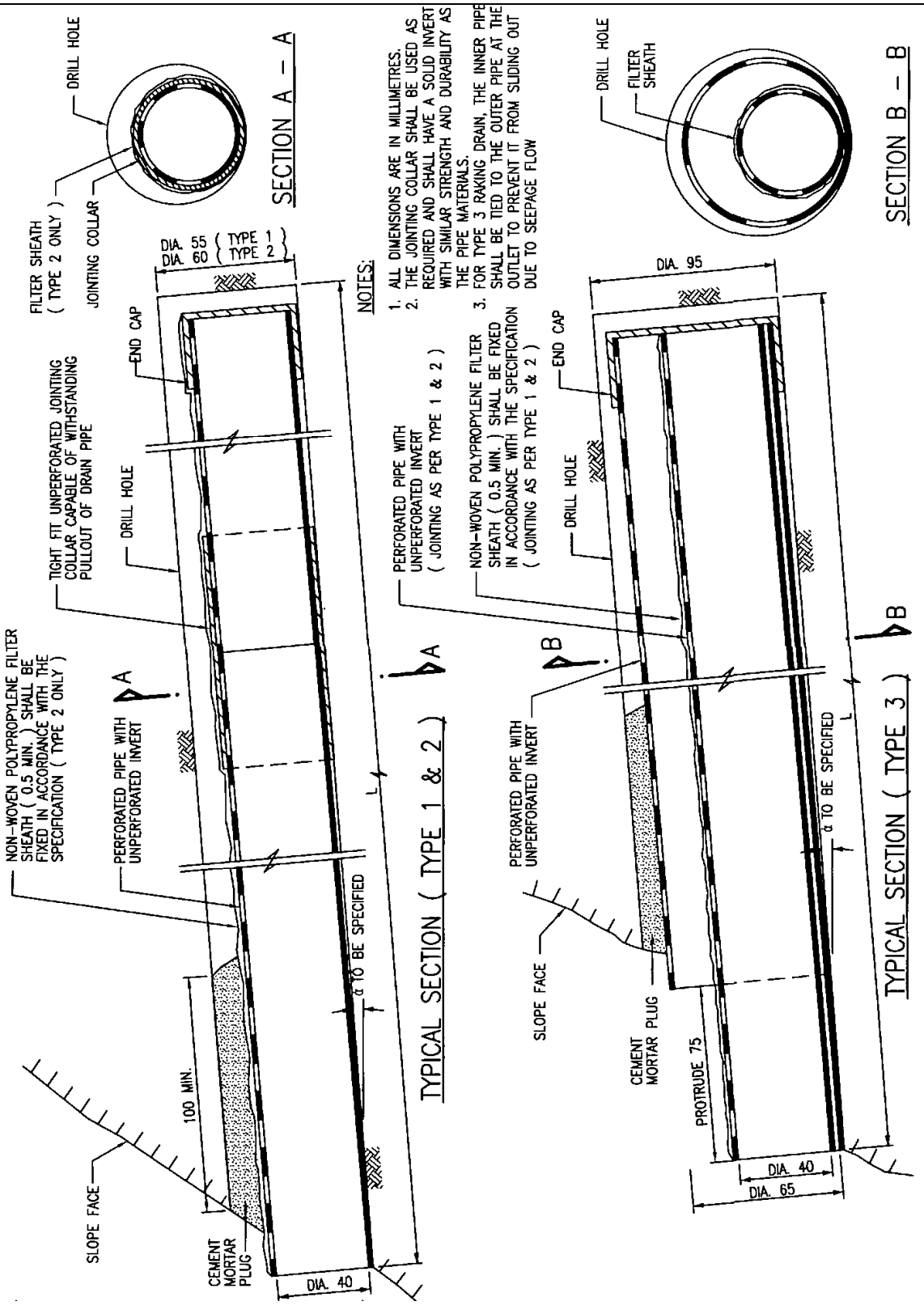
NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. FINE GRANULAR FILTER SERVES AS FILTER FOR SOIL. COARSE GRANULAR FILTER SERVES AS FILTER FOR FINE GRANULAR FILTER. THE GRANULAR FILTERS SHALL BE DESIGNED BY THE CONTRACTOR IN ACCORDANCE WITH GEO PUBLICATION NO. 1/93.
3. DIMENSIONS OF TEMPORARY CUT TO BE SPECIFIED BY THE S.O. SUPPORT TO THE TEMPORARY CUT SHALL BE DESIGNED BY THE CONTRACTOR.
4. SINGLE LAYER OF 500mm THICK GRANULAR FILTER LAYER SHALL BE USED FOR ROCKFILL.

(MODIFIED FROM CEDD STANDARD DRAWING NO. C2302F)

FILTER BLANKET FOR FILL SLOPE AND FILLING DETAILS AT SLOPE CREST	ARCHITECTURAL SERVICES DEPARTMENT	
	SCALE DIAGRAMMATIC	DRAWING NO. C2302
	DATE JUNE 2009	

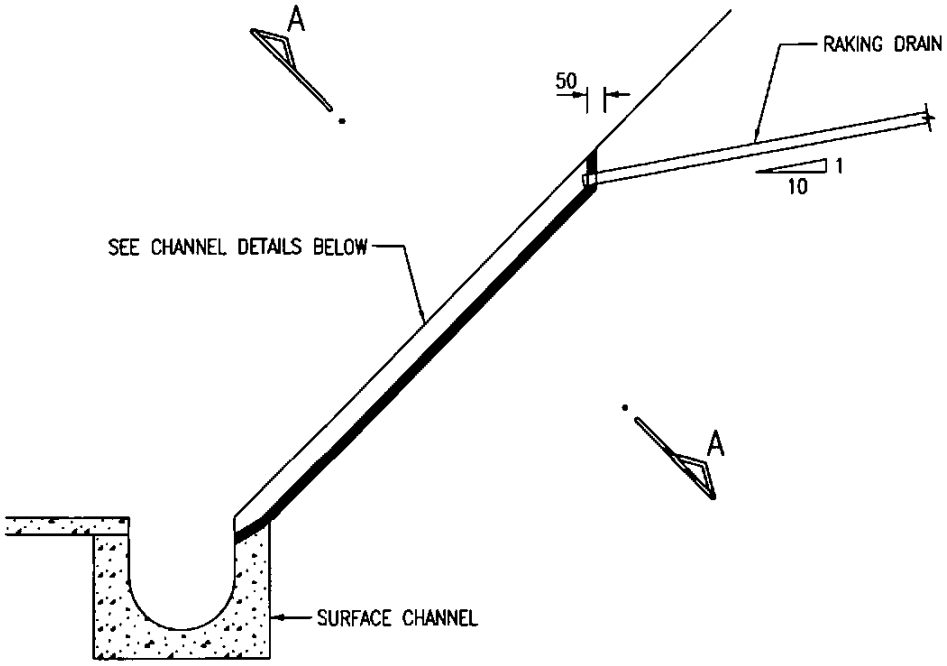
APPENDIX 8 Sheet 1 of 2



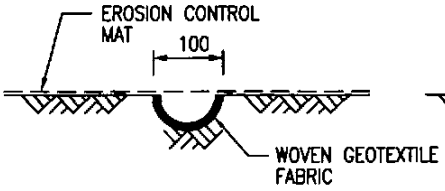
(MODIFIED FROM CEDD STANDARD DRAWING NO. C2403E)

TYPICAL ARRANGEMENT OF RAKING DRAINS	ARCHITECTURAL SERVICES DEPARTMENT	
	SCALE DIAGRAMMATIC	DRAWING NO.
	DATE JUNE 2009	C2403

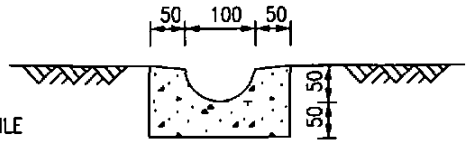
APPENDIX 8 Sheet 2 of 2



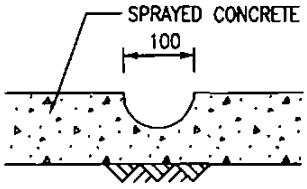
SECTION THROUGH CONNECTING CHANNEL
SCALE 1 : 20



SECTION A – A
SCALE 1 : 10
(FOR SOIL SLOPE WITH EROSION CONTROL MAT)



SECTION A – A
SCALE 1 : 10
(FOR SOIL SLOPE WITHOUT EROSION CONTROL MAT)



SECTION A – A
SCALE 1 : 10
(FOR SHOTCRETED SLOPE)

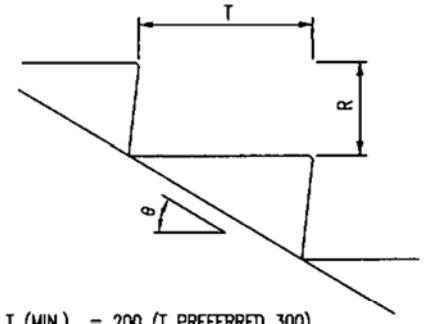
NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. CONNECTION FOR ROCK SLOPE SHALL BE OMITTED.

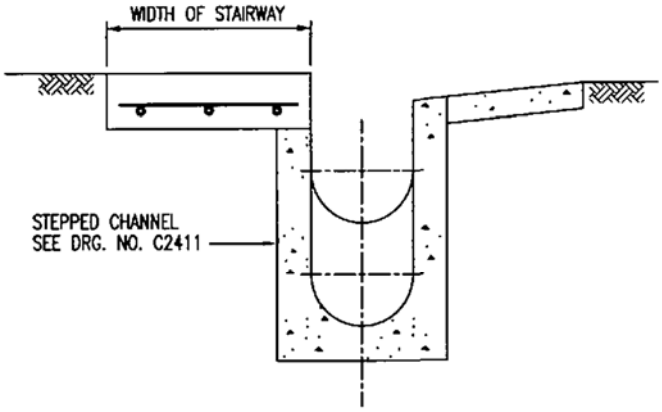
(MODIFIED FROM CEDD STANDARD DRAWING NO. C2414C)

RAKING DRAIN CONNECTION TO SURFACE CHANNEL	ARCHITECTURAL SERVICES DEPARTMENT	
	SCALE DIAGRAMMATIC	DRAWING NO.
	DATE JUNE 2009	C2414

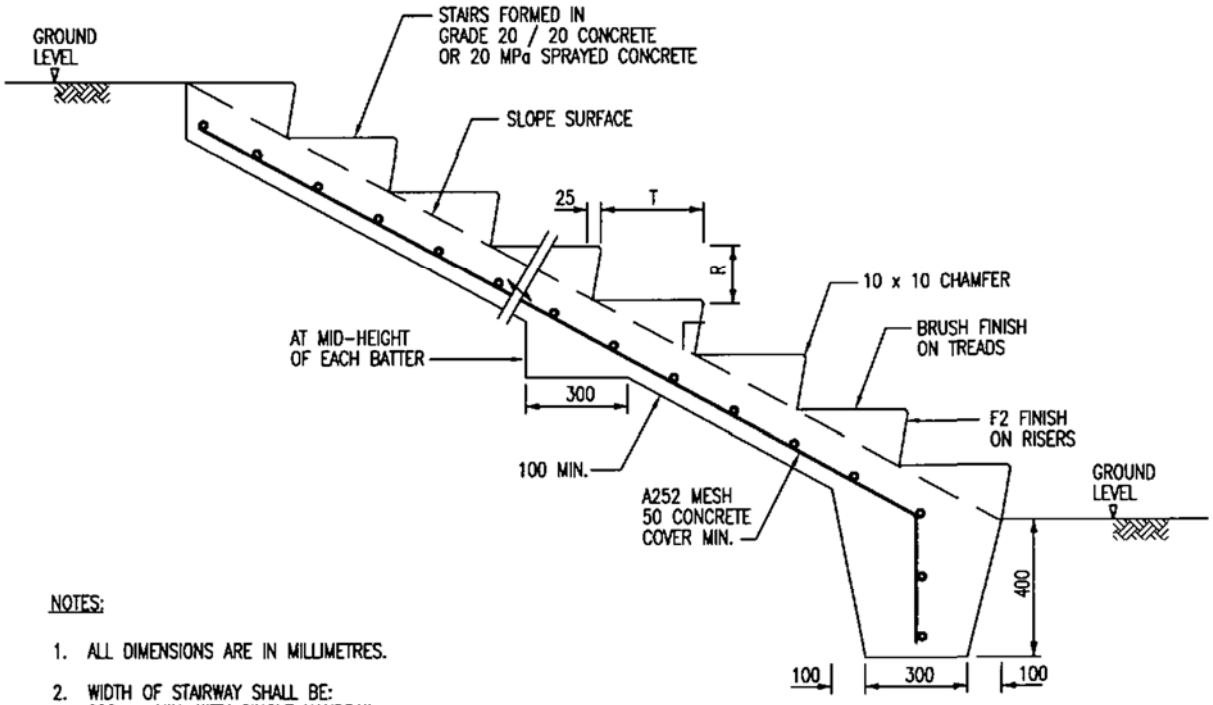
APPENDIX 9 Sheet 1 of 4



T (MIN.) = 200 (T PREFERRED 300)
R (MAX.) = 200
R = T x TAN θ
T x R = 50 000 APPROX.



CROSS SECTION OF COMBINED STAIRWAY & STEPPED CHANNEL



NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. WIDTH OF STAIRWAY SHALL BE: 600mm MIN. WITH SINGLE HANDRAIL (SEE STD. DRG. NO. C2103) OR SPECIFIED ON DRAWINGS.
3. HANDRAIL TO BE INSTALLED ON DOWNHILL SIDE OF STAIRWAY.
4. MINIMUM LAP LENGTH OF 320mm FOR A252 MESH SHALL BE PROVIDED.

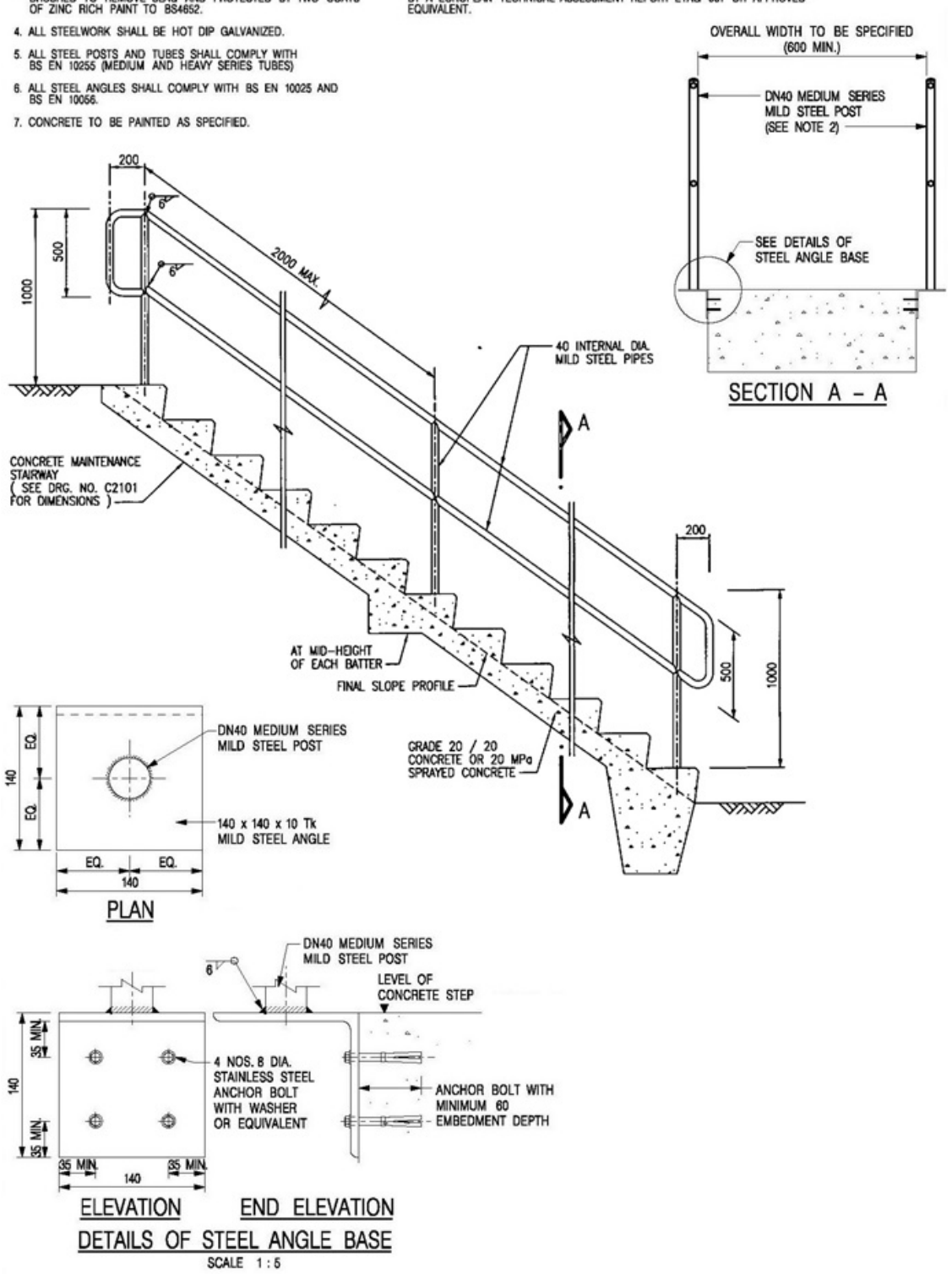
(MODIFIED FROM CEDD STANDARD DRAWING NO. C2101D)

DIMENSIONS FOR CONCRETE MAINTENANCE STAIRWAY ON SLOPES UP TO 40°	ARCHITECTURAL SERVICES DEPARTMENT	
	SCALE DIAGRAMMATIC	DRAWING NO. C2101
	DATE JULY 2015	

APPENDIX 9 Sheet 2 of 4

NOTES:

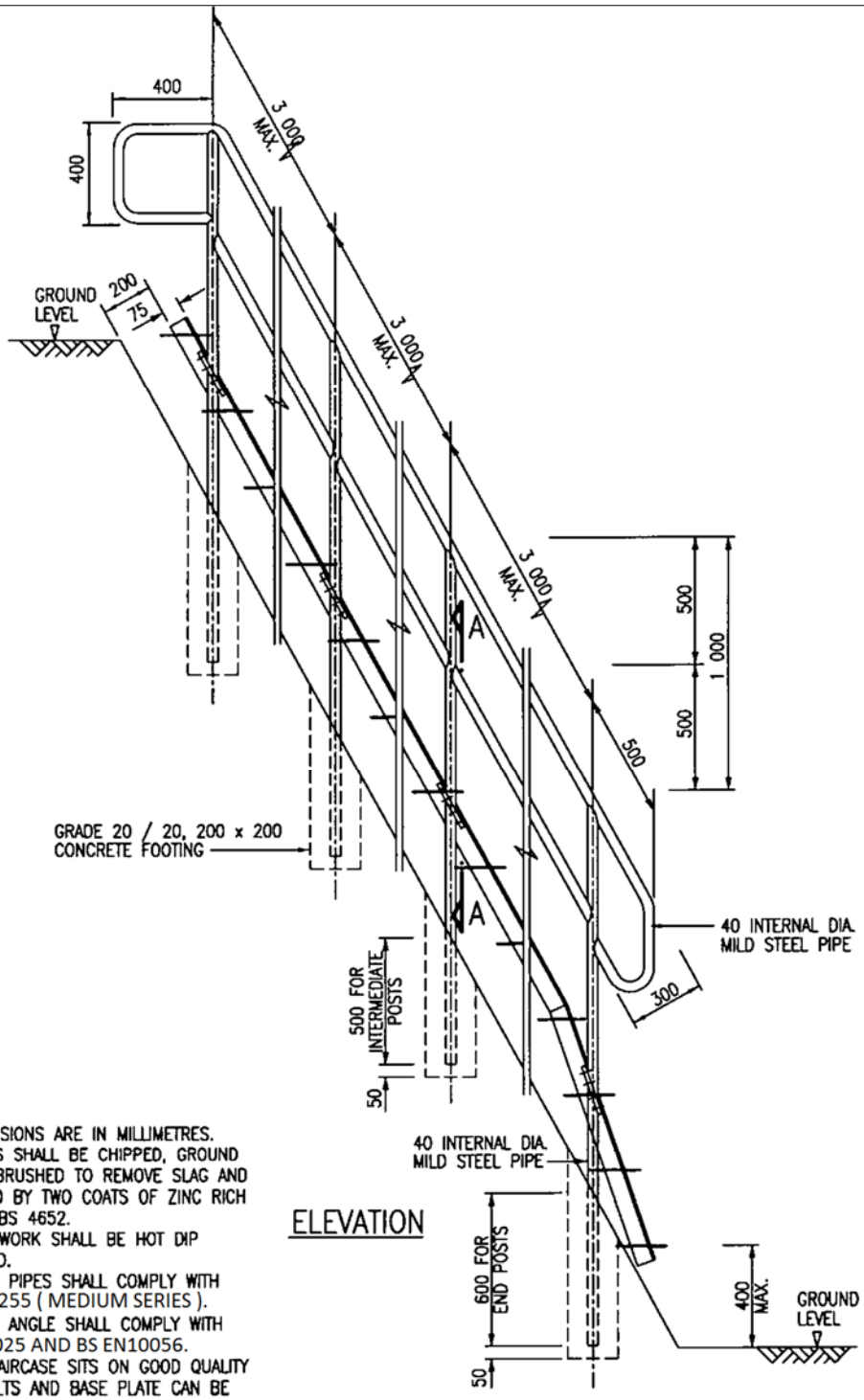
1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. HANDRAIL SHALL BE PROVIDED TO THE SIDE(S) WHERE A PERSON IS LIABLE TO FALL OVER 2m.
3. ALL WELDS SHALL BE CHIPPED AND GROUND SMOOTH AND BRUSHED TO REMOVE SLAG AND PROTECTED BY TWO COATS OF ZINC RICH PAINT TO BS4652.
4. ALL STEELWORK SHALL BE HOT DIP GALVANIZED.
5. ALL STEEL POSTS AND TUBES SHALL COMPLY WITH BS EN 10255 (MEDIUM AND HEAVY SERIES TUBES)
6. ALL STEEL ANGLES SHALL COMPLY WITH BS EN 10025 AND BS EN 10056.
7. CONCRETE TO BE PAINTED AS SPECIFIED.
8. ALL EXPOSED STEELWORK SURFACES SHALL BE TREATED AND PAINTED IN ACCORDANCE WITH THE GENERAL SPECIFICATION AND PARTICULAR SPECIFICATION
9. ALL STAINLESS STEEL ANCHOR BOLTS AND WASHERS SHALL HAVE A DECLARATION OF PERFORMANCE FOR THE CONSTRUCTION PRODUCT COVERED BY A EUROPEAN TECHNICAL ASSESSMENT REPORT ETAG 001 OR APPROVED EQUIVALENT.



(MODIFIED FROM CEDD STANDARD DRAWING NO. C2103/K)

HANDRAILING TO MAINTENANCE STAIRWAY ON SLOPE	ARCHITECTURAL SERVICES DEPARTMENT	
	SCALE DIAGRAMMATIC	DRAWING NO. C2103
	DATE JULY 2019	

APPENDIX 9 Sheet 3 of 4



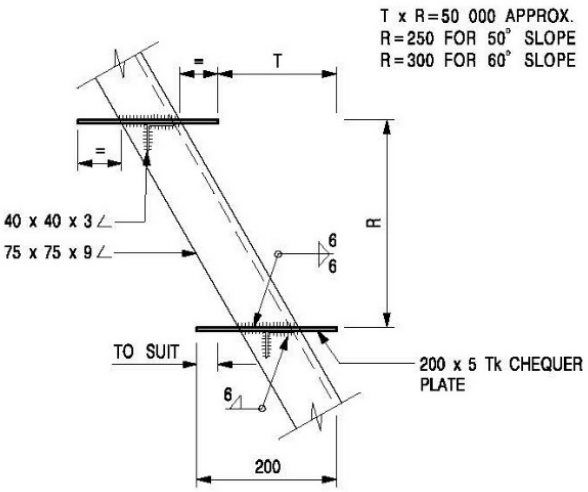
ELEVATION

NOTES:

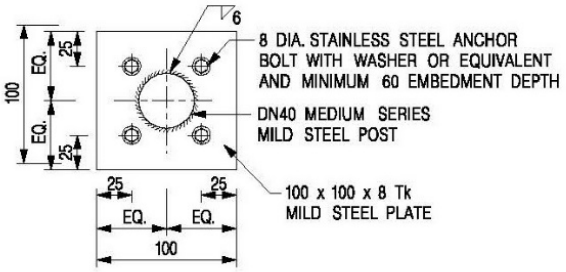
1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. ALL WELDS SHALL BE CHIPPED, GROUND SMOOTH, BRUSHED TO REMOVE SLAG AND PROTECTED BY TWO COATS OF ZINC RICH PAINT TO BS 4652.
3. ALL STEELWORK SHALL BE HOT DIP GALVANIZED.
4. ALL STEEL PIPES SHALL COMPLY WITH BS BN 10255 (MEDIUM SERIES).
5. ALL STEEL ANGLE SHALL COMPLY WITH BS EN10025 AND BS EN10056.
6. WHERE STAIRCASE SITS ON GOOD QUALITY ROCK, BOLTS AND BASE PLATE CAN BE USED AS APPROPRIATE. SEE DETAILS OF BASE PLATE AS AN ALTERNATIVE.
7. ALL EXPOSED STEELWORK SURFACES SHALL BE TREATED AND PAINTED IN ACCORDANCE WITH THE GENERAL SPECIFICATION.

(MODIFIED FROM CEDD STANDARD DRAWING NO. C2102/1)

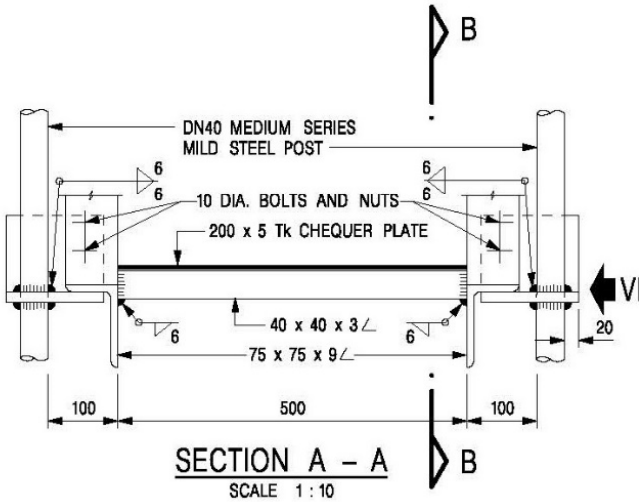
STEEL STAIRCASE FOR SLOPE STEEPER THAN 40° (SHEET 1 OF 2)	ARCHITECTURAL SERVICES DEPARTMENT	
	SCALE DIAGRAMMATIC	DRAWING NO. C2102/1
	DATE JULY 2015	



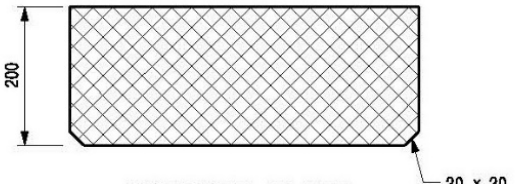
SECTION B – B
SCALE 1 : 10



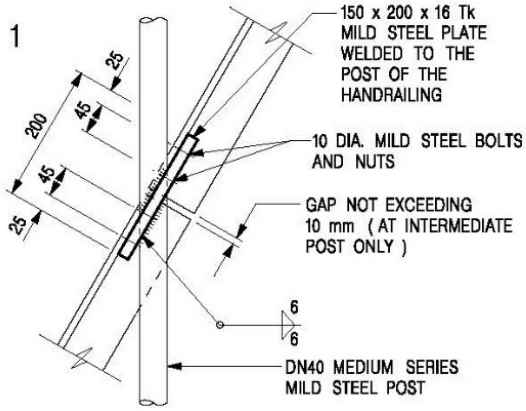
DETAILS OF BASE PLATE
(ALTERNATIVE ARRANGEMENT OF THE POST)
SCALE 1 : 5



SECTION A – A
SCALE 1 : 10



CHEQUER PLATE
SCALE 1 : 10



VIEW 1
SCALE 1 : 10

NOTE:

1. ALL STAINLESS STEEL ANCHOR BOLTS AND WASHERS SHALL HAVE A DECLARATION OF PERFORMANCE FOR THE CONSTRUCTION PRODUCT COVERED BY A EUROPEAN TECHNICAL ASSESSMENT REPORT ETAG 001 OR APPROVED EQUIVALENT.

(MODIFIED FROM CEDD STANDARD DRAWING NO. C2102/2A)

STEEL STAIRCASE FOR SLOPE STEEPER THAN 40° **(SHEET 2 OF 2)**	ARCHITECTURAL SERVICES DEPARTMENT	
	SCALE DIAGRAMMATIC	DRAWING NO. C2102/2
	DATE JULY 2019	

SECTION 27

MODULAR INTEGRATED CONSTRUCTION

(This section shall be read in conjunction with the **General Specification on Building Services Installations in Government Buildings of the HKSAR** under separate publication with respect to the specific requirements on building services installation.)

Definition of Modular Integrated Construction **27.1**

Modular Integrated Construction (MiC) is a construction method that employs the technique of having freestanding volumetric modules (with finishes, fixtures, fittings, etc.) manufactured off-site and then transported to site for assembly. A volumetric module is defined as a three-dimensional module that is assembled with finishes, fixtures and fittings, etc. Freestanding is a description for the condition where a module is structurally stable and ready for occupation when connected with appropriate building services provisions.

MiC application may cover single modules or combinations of various modules forming a floor area or a spatial unit of considerable scale (e.g. major parts of a typical floor), and fully integrated with the associated building services, structural and connection details. The design shall take into comprehensive and holistic consideration on standardization, buildability, mode of delivery (including transportation to site, temporary storage and lifting into place) and on-site installation with due regard to the specific site conditions for the modules.

MultiTrade Integrated Mechanical, Electrical and Plumbing (MiMEP) integrates multi-trade of building services equipment/components into a single assembly of prefabricated modules, with necessary support and minor architectural elements, manufactured off-site and then transported to site for installation. Refer to the **General Specification on Building Services Installations in Government Buildings of the HKSAR** for the requirements of MiMEP.

Contractor's responsibilities **27.2**

The Contractor shall be responsible for the planning, coordination, design, construction, testing and commissioning of all architectural, structural and building services installations works for the implementation of MiC and MiMEP.

The Contractor shall employ MiC Designers for architectural, structural and building services works for the design and supervision of off-site production and on-site installation of the MiC works. The Contractor shall fulfil his obligations on organization, management, planning, supervision and co-ordination of the MiC Designers as described in Clauses 27.3 and 27.4.

The Contractor shall refer to the **General Specification for Building Services Installation in Government Buildings of the HKSAR** on the specific requirements of MiC and MiMEP for building services installations.

MIC DESIGNERS AND THEIR RESPONSIBILITIES

MiC Architectural Designer **27.3**

The designer for architectural works (herein called 'MiC Architectural Designer') shall be both (i) a Registered Architect in Hong Kong and (ii) an Authorized Person (List of Architects) as defined under the Buildings Ordinance. He/she shall possess minimum 5 years post Registered Architect qualification experience in the design, supervision and coordination of construction projects and at least 2 years of experience in the design, supervision and coordination of MiC projects. The MiC Architectural Designer shall be the leading consultant responsible for the overall design coordination and management of other designers, namely the MiC Structural Designer and MiC building services designer to ensure that the design of off-site modular construction elements well-integrated and fully complied with statutory requirements and the relevant specifications to the acceptance of the SO.

All architectural drawings, design calculations and submissions, if any, for the proposed MiC system, including shop drawings, builder's works drawings, construction method statements and material submissions, shall be prepared under the direct supervision of and certified by the MiC Architectural Designer, and submitted by the Contractor to the SO for approval.

The MiC Architectural Designer shall provide adequate site supervision at the prefabrication factory to check that the modular unit production works are constructed to the approved design, required standards and quality. The MiC Architectural Designer's supervision at the prefabrication factory shall comply with the minimum requirements for Authorized Persons as required by **PNAP ADV-36**, **Code of Practice for Site Supervision and Technical Memorandum for Supervision Plans** issued by the Buildings Department. The MiC Architectural Designer's supervision shall also cover the on-site construction works related to the assembly and installation of modules to form the building.

The MiC Architectural Designer shall ensure that the proposed design and detailing of modular construction works are compatible with the overall design and non-MiC portion of the building in terms of architectural expressions and regulatory compliance.

MiC Structural Designer **27.4**

The design of structural works for MiC shall be carried out under the supervision of a Registered Structural Engineer (MiC Structural Designer) included in the Register of Structural Engineers kept by the Building Authority. The MiC Structural Designer shall also be a member of the Hong Kong Institution of Engineers (Structural Discipline) or equivalent with a minimum of 8 years of post-professional qualification experience in building design and construction.

All structural drawings and design calculations, for the structural works of the proposed MiC system shall be prepared under the direct supervision of and certified by the MiC Structural Designer. The Contractor's submission of method statement, construction materials, shop drawings and builder's works drawings shall also be checked and certified by the MiC Structural Designer.

The MiC Structural Designer shall provide adequate off-site supervision at the prefabrication factory to check that the module production works are constructed to the approved design, required standards and quality. The MiC Structural Designer's supervision at the prefabrication factory shall comply with the contract requirements and the requirements for Registered Structural Engineers as required under **PNAP ADV-36**, **Code of Practice for Site Supervision and Technical Memorandum for Supervision Plans** issued by the Buildings Department. The MiC Structural Designer's supervision shall also cover the on-site construction works related to the assembly and installation of modules to form the building.

The MiC Structural Designer shall ensure that the proposed design, interfacing and detailing of MiC works are compatible with the overall design of the building structure (non-MiC portion) and foundations meeting the design models and assumptions adopted.

MiC Building Services Designer **27.5**

The requirements of MiC Building Services Designer shall refer to the **General Specification for Building Services Installation in Government Buildings of the HKSAR**.

INFORMATION TO BE PROVIDED

Programme for the Works **27.6**

Within 6 weeks of the date of acceptance of the tender, submit a detailed programme for the Works to show:

(a) Submission of drawings and details of the proposed MiC system, design calculations, shop drawings for off-site fabrication works and samples of materials.
(b) Ordering and manufacture of components.

(c) Preparation of mock-up samples required and construction of mock-up modules at prefabrication yard
(d) Testing of materials in laboratory.
(e) Delivery of modules.
(f) Installation including on-site trial installation of modules.
(g) Field tests.

The Contractor shall allow sufficient time in the programme for preparation of all relevant design submissions and for the process of checking and approval by the SO and other relevant authorities.

Provision of drawings calculations and submissions

27.7

The Contractor shall produce and submit all drawings, 3D BIM files, calculations and submissions for the design and construction of architectural, structural and building services works of the proposed MiC system to the SO for approval.

First submittals and resubmittals shall be complete and in the required form. Resubmittals shall include requested corrections and shall respond to previous comments.

Each sheet that is revised shall bear a revision date and number. Revisions shall be flagged with a conspicuous revision symbol and number. Failure of a submittal to be complete, in the proper form, responsive to comments, or identified with revisions shall, at the SO's discretion, be a cause for non-approval and return of documents without review.

Failure of reviewing comments to note a non-compliance with the Specification and Drawings shall not relieve the Contractor from his obligation to comply. The failure of the Contractor to note a noncompliance on a given submittal shall not preclude a directive by the SO for the Contractor to comply on future submittals.

The Contractor shall be responsible for all incurred submissions, coordination, and liaison work so as to obtain approvals and clearances from the relevant authorities having jurisdiction for the proposed off-site module construction process prior to commencement of the manufacturing work.

(a) Provide detail drawings for structural works of the MiC system showing:

(i) General arrangement and sizes of all structural members with material specifications and setting out dimensions including elevations and sections.

(ii) Details of beams, columns, walls, slabs and all other structural elements.

(iii) Connection details between modules and connection details between modules and parent structure.

(iv) Movement joint details, if any, between modules and in-situ part to cater for thermal and shrinkage effects.

(v) Details for filling gaps between modules and between modules and parent structure

(vi) Shop drawings showing but not limited to plans, sections, elevations and connection details of the different types of prefabrication components used.

(b) Provide structural design calculations for the MiC system including:

(i) A detailed description of the structural system and the basic anatomy of stability including lateral load resisting system, by which the applied loads are transferred to the in-situ parent structure of the building.

(ii) A detailed report supported by calculations to demonstrate the approach and methodology adopted to deal with robustness of structure.

(iii) Materials, design methods, design parameters, assumptions, computer programs used, codes used and limitations of stresses and deformation.

(iv) A summary of lateral loads applied to the modules and distribution of the lateral forces on individual frames at each floor level. Calculation of lateral deflection and other serviceability requirements.

(v) The design data on dead and imposed loads (including allowance for partitions, screeds, dynamic effects and the like).

(vi) Design calculations for all structural members and connections including all necessary temporary works for transportation of modules from off-site factory to site, and lifting and erection of modules.

(vii) The computer input and output files (soft copy) for structural analysis and design together with full explanation on modelling, assumptions and parameter settings. Conduct sensitivity analysis to demonstrate that appropriate values for the critical parameters and attributes were adopted when necessary.

(c) The Contractor shall be responsible for all submissions, coordination, and liaison work so as to obtain approvals from the relevant authorities having jurisdiction for the proposed MiC system prior to commencement of the manufacturing work.

Construction method statement **27.8**

(a) The Contractor shall submit detailed method statements including equipment to be used, sequence of works, quality supervision and site control for construction of the proposed MiC system to the SO for approval.

(b) Detailed method statement for construction of structural works of the MiC system including but not limited to:

(i) Method statement of off-site production of modules including quality assurance and quality control of the works.

(ii) Method statement of completed MiC modules identification, traceability, protection, storage, transportation and lifting arrangements.

(iii) Sequence of erection and method statement of on-site erection of modules including quality assurance and quality control of the works.

(iv) Erection drawings showing but not limited to erection sequence, assembly and erection method, permanent structural connection and joint details, and propping and temporary support details.

DESIGN REQUIREMENTS

Architectural design requirements **27.9**

(a) The layout plan and overall design shall comply with statutory requirements under Building Ordinance and the subsidiary regulations. Particular attentions are drawn to the following statutory requirements:

(i) The height of storeys shall comply with **Cap. 123F Building (Planning) Regulations**.

(ii) Adequate maintenance and repair access to the outer surface of external walls, claddings, curtain walls and roofs of a building or projections from the external walls, claddings, curtain walls and roofs shall be provided in compliance with **Cap. 123Q Building (Construction) Regulation**.

(iii) Design requirements for MiC in **PNAP ADV-36** issued by the Buildings Department shall be complied.

(iv) The fire protection or performance of elements of construction of MiC shall be addressed. Non-code compliant designs shall be justified for having equivalent performance as the prescriptive standards and, where necessary, supported by fire engineering assessments as stated in the **Code of Practice for Fire Safety in Buildings 2011**.

(b) Modularization

The architectural features, structural components and E&M elements should be standardized as far as practicable and subject to the SO's approval.

The division of MiC units shall be the best possible solution to the satisfaction of the SO, taking into consideration the layout of the rooms, the internal finishes divisions, the building services installations and shall the minimization of external wall joints.

The non-structural partition walls should be designed as removable elements to allow for future additional & alteration works.

(c) Early Coordination

The Contractor shall be responsible to engage coordination among the SO, Contractor, MiC Designers and other relevant parties so as to determine the layout, floor and ceiling height. The first coordination meeting shall be arranged at least 3 months before the procurement of the MiC unit.

(d) Dimension on Plan

The size of modules should allow the transportation from factory to the Site.

(e) Dimension on Section

The size of modules should allow transportation from factory to the Site.

The single or double slabs detail should be determined.

The useable room space should be maximized.

(f) Alignment of Verticality and Horizontality

The alignment of floor, wall and ceiling at joints between modules should be carefully determined. Joints between MiC units should be properly designed to achieve smooth continuation of finishes across different units. Details at the junctions should be designed to the satisfaction of the SO.

The interfacing details between MiC modules and in-situ part should be carefully determined to the satisfaction of the SO.

(g) Water-Tightness / Weather-proofing / Damp Proofing / Condensation Prevention Between Modules

The vertical and horizontal joints of modules shall be water-tight. Particular attention shall be paid to the joints in drainage pipes and building envelope to avoid water leakage.

The modules shall be designed and constructed to prevent water from entering the modules (e.g. by means of waterproofing membrane over the modules); and allow water to be properly discharged and drained out completely between modules. No water shall be trapped between the modules at final completed buildings. The floor areas intended for wet activities (e.g. toilet rooms, disable toilet, pantry, cleaner room) shall be treated with waterproofing system approved by the SO to ensure water-tightness.

Joints, support and elements of the module shall be designed and insulated to avoid "cold bridge" effect.

Sufficient insulation shall be provided for each module to prevent condensation due to local weather condition and temperature difference between modules.

The modules shall also be made weather-tight to prevent water ingress, particularly during the transportation phase, temporary storage phase, and erection phase.

(h) Joints between modules

The vertical and horizontal joints between modules and in-situ part should be maximum 15 mm wide when exposed to view or otherwise approved by the SO. The construction tolerance shall refer to Clause 27.25.

The method statement for installation should indicate clearly how proper alignments can be achieved to prevent any abortive works.

(i) Design for movements

The MiC system should be designed to accommodate cumulative movements, usually by the provision of joints, occurred throughout the various construction stages and during its service life. Consideration should be given to the various causes of movements such as creep deformation, shrinkage, differential movement, thermal movement, etc. with due regard to the fact that such movements may be short-term or long-term and may or may not be coexistent or occur concurrently. Allowance should also be made for fabrication and installation tolerances.

(j) Fire protection of steel

For MiC system adopting steel frame modules, the fire protection or fire resistance rating of steel member at interior side shall comply with those specified in Code of Practice for Fire Safety in Buildings 2011. The material and method statement shall be submitted for approval by the SO.

(k) Coating for steel with exposure to external weather

For steel member with exposure to external weather, suitable coating or enclosure shall be applied to prevent corrosion. The Contractor shall submit the proposal of protection method (e.g. paint system for exterior, concrete surround with external finishes, galvanization thickness, etc.) for approval by the SO.

Structural design requirements **27.10**

(a) The design, fabrication, installation and construction of the modules and/or components shall comply with contract requirements and the relevant standards and requirements under the Building Ordinance and its subsidiary regulations.

(b) Design requirements for MiC in **PNAP ADV-36** issued by the Buildings Department shall also be followed.

(c) In principle, a building structure comprising modules must possess adequate stability, robustness and integrity to comply with all relevant design code and statutory requirements. As such, the proposed MiC system / modules (whether forming or not forming part of the building structure) shall be fully coordinated with the design of the building structure to ensure overall compatibility with the structural design models and assumptions adopted.

(d) Vertical connections between modules having a direct effect on the building stiffness and its response under lateral loads shall be detailed to satisfy the design intent. Horizontal connections between modules forming the floor diaphragm must be designed and detailed such that the horizontal forces can be effectively transferred to the building's lateral load resisting system.

(e) Vertical joints shall be designed for eccentricity or imperfection in accordance with the design code requirements. They should also be designed to cater for offsets and misalignment due to construction tolerances arising from the assembly of modules on site.

(f) In addition to the normal elemental design under permanent design actions, the modules shall be designed for the transient situation to cater for any temporary static and/or dynamic forces during lifting, transportation, storage and erection. Serviceability limit checks should be performed to prevent cracks to the precast concrete elements or distortion of steel frame.

(g) Appropriate precautionary measures should be provided to ensure the modules would not be subjected to inclined or unbalanced forces during hoisting operation. The lifting points should be strategically positioned such that sufficient bond anchorage can be developed to hoist the entire module safely and the load distribution to all lifting points is reasonably uniform.

(h) Where necessary, customized design delivery frame should be provided to protect the modules from structural damages, distortion and unbalanced stresses during transportation.

(i) Permanent structural elements that are required to provide temporary support to construction access, parking, erection deck for the holding / lifting / erection / installation of the modules shall be strengthened accordingly against the corresponding temporary loadings at the Contractor's own cost.

(j) Checking calculation shall be carried out to demonstrate that loadings transferred from the proposed MiC system and/or modules shall not cause over-loading of the parent supporting structures, columns and foundations. Should over-loading is found, all time and cost associated with the re-design and/or any additional works incurred in construction shall be borne by the Contractor.

(k) The structural joints and connections between the modules and with the main building framework shall be designed to accommodate horizontal and/or vertical movement due to deformation and deflection of the main building structure under gravity loads, and wind, creep, shrinkage, thermal effects, etc. Allowance should also be made for fabrication and installation tolerances.

(l) In case part of the proposed modules are designed to serve as lost formwork system for casting of structural concrete members on site, viable method for

ensuring the quality of completed in-situ concrete works shall also be included in the proposal.

(m) Relevant Codes and Standards for design of modules shall include but not limited to the following:

(i) **Code of Practice on Wind Effects in Hong Kong** issued by the Buildings Department.

(ii) **Code of Practice for the Structural Use of Concrete** issued by the Buildings Department.

(iii) **Code of Practice for Fire Safety in Buildings** issued by the Buildings Department.

(iv) **Code of Practice for the Structural Use of Steel** issued by the Buildings Department.

(v) **Code of Practice for Dead and Imposed Loads** issued by the Buildings Department.

(vi) **Code of Practice for Foundations** issued by the Buildings Department.

(vii) **Code of Practice for Precast Concrete Construction** issued by the Buildings Department.

(viii) Relevant Practice Notes for Authorized Persons and Registered Structural Engineers (PNAP) issued by the Buildings Department.

(ix) **BS 8007**: Design of Concrete Structures for Retaining Aqueous Liquids.

(x) Architectural Services Department, Structural Engineering Branch, **Drafting Manual for Reinforced Concrete Structures**.

Where the above standards cannot adequately cover the design intent, other British Standards shall be adopted. Should British Standards have not adequately covered, reference shall be made to relevant Eurocodes.

Building services design requirements **27.11** The requirements shall refer to the **General Specification for Building Services Installation in Government Buildings of the HKSAR**.

MATERIALS AND WORKMANSHIP

General **27.12**

(a) Unless otherwise approved by the SO, the standards of materials and workmanship including all related testing requirements that are currently specified in other Sections of the General Specification shall be complied with.

(b) The structural system of the proposed MiC can be in the form of concrete, steel or hybrid concrete/steel system to suit the main building structure design.

(c) If steel material is used for forming part of the module, the steel section shall be galvanized in accordance with Section 15 with suitable provision on fire protection in accordance with statutory requirements.

(d) In general, all structural concrete works shall comply with Sections 6 and 7, and all structural steelwork shall comply with Section 15.

(e) At concrete, all fixing including bolts shall be cast-in. Post installation by drill-in anchor bolts is not permitted unless approved by the SO.

(f) All fixings cast in concrete shall either be made of stainless steel, hot-dip galvanized rolled steel or hot dip galvanized cold formed steel.

(g) Requirements of grout material for structural joints shall refer to Appendix 1.

DELIVERY, TEMPORARY STORAGE AND TRANSPORTATION

Delivery, logistic, protection and temporary storage of MiC units **27.13**

The Contractor shall be responsible for the delivery, logistic, protection and temporary storage of MiC units from the off-site factory to the Site for assembly. The Contractor shall coordinate with Nominated Sub-contractors and Specialist Contractors on the provision for logistics (such as tower cranes, hoists, loading and unloading platforms, access and temporary openings etc.) and coordinate for the storage of off-site prefabricated building components, such as Modular Integrated Construction (MiC) or Multi-trade Mechanical, Electrical and Plumbing (MiMEP), etc.

(a) If physical size of the MiC units exceeds that permitted under the **Road Traffic (Traffic Control) Regulations**, the Contractor shall liaise with the Transport Department and tunnel / bridge operators where required to submit the road transportation proposal for approval of the "Long Load" and "Wide Load" permit. The Contractor shall provide suitable escort vehicles as required by Regulations. All cost involved in relation to the delivery of the MiC unit to site should be borne by the Contractor.

(b) Adequate protection shall be provided to prevent damage to the pre-assembled modules during delivery and temporary storage. They shall be protected from the ingress of water and foreign matters. MiC modules shall be covered with shrink wrap/protection sheet or equivalent means to the SO's satisfaction in order to protect them from exposure to weather and prevent damage prior to site assembly work.

(c) Upon delivery of the modules to the Site, the Contractor shall arrange inspection with various parties. Any damaged parts or components shall be recorded and replaced before on-site assembly work, unless the damaged part is fully accessible for rectification or replacement after the module is put in place on site.

(d) The Contractor shall demonstrate due consideration on the provision of site facilities including sufficient loading and unloading area, hoisting facilities, access route, module dimensions and weight, and plant room space for delivery of the MiC and MiMEP modules.

QUALITY CONTROL AND SUPERVISION

Quality assurance scheme **27.14**

(a) Modules shall be fabricated by a factory with ISO 9000 or equivalent quality assurance certification. The Quality Assurance Scheme of the MiC prefabrication factory shall cover the items as stipulated in the quality control requirements of **PNAP ADV-36** issued by the Buildings Department.

(b) The Contractor shall submit the Quality Assurance Scheme to the SO for approval at least 14 days before commencement of the production work in the prefabrication factory. The MiC Designers shall provide a written confirmation that the submitted Quality Assurance Scheme has adequate provisions in ensuring the quality of production complying with the contract requirements and the accepted plans.

(c) The requirements and standards for quality control of the MiMEP shall refer to the **General Specification for Building Services Installation in Government Buildings of the HKSAR**.

Quality traceability system **27.15** The MiC prefabrication factory shall establish and incorporate an information management system and code identification system. Radio frequency identification (RFID) technology shall be adopted for quality traceability of elements / modules to record the conformity of materials used, the manufacturing process, the logistics in delivery and the installation details.

Record of quality supervision **27.16** The Contractor should keep an inspection report, including the identification of various parties responsible for conducting the quality supervision, details of the inspection, auditing and testing of the off-site fabrication works, and providing the log book for inspection when requested.

Paper record and digital record **27.17** The Contractor shall keep paper record and/or digital records (by adopting system such as Digital Works Supervision System (DWSS)), including photographs and videos during inspection and testing in the off-site factory and on-site assembly process, for examination by the SO and representatives of the statutory authorities. In addition, videos can be kept at a proper storage for record and review, anytime as required by the SO.

Compliance with approved design, required specification and quality **27.18** The Contractor shall ensure that all off-site fabrication and on-site installation works are constructed to the approved design, method statement, required specification, standards and quality. The quality control and supervision of structural works shall be in compliance with the contract requirements and the requirements stipulated in PNAP ADV-36, PNAP APP-158, Code of Practice for Site Supervision and Technical Memorandum for Supervision Plans issued by the Buildings Department.

Quality inspection and checking at critical stages **27.19** The Contractor shall carry out quality inspection and checking at critical stages of the prefabrication works in the factory which shall include but not limited to the following: -

(a) Reinforced Concrete Module

(i) QC inspection on mould dimension, squareness, verticality and cleanliness

(ii) Reinforcement installation and QC inspection

(iii) Cast-in item installation and QC inspection

(iv) QC check on mould assembly and closing of mould

(v) QC inspection on concrete

(vi) Casting

(b) Steel frame Module

(i) QC inspection on welding procedures and specification, welding procedure qualification records, welder certificates, welding consumables, etc.

(ii) QC inspection on the dimension and accuracy of 2D and 3D jigs (for assembling steel sections / frames securely in correct position for welding)

(iii) Respective steel members being placed inside a 2D jig, welded to form 2D frame and QC inspection of welded joints and fabrication tolerances

(iv) Respective 2D frames being placed inside a 3D jig, welded to form a 3D shell and QC inspection of welded joints and fabrication tolerances

(v) Trial stacking (according to the actual position) at factory to ensure the accuracy of the steel shell

Inspections after pre-assembling of modules **27.20** The following inspections shall be carried out after the modules are pre-assembled:

(a) Level and alignment

(b) Verticality, bulging and twisting of modules

(c) Position of continuity

(d) Location of cast-in items (and pull-out test by accredited laboratory)

(e) Fire and corrosion protection

(f) Structural opening position and dimension

INSTALLATION

Mock-up at prefabrication yard **27.21**

(a) The Contractor shall complete mock-ups of selected representable types of modules and key connections at the prefabrication factory for review, comment, alteration and acceptance. The mock-up shall be made accessible for inspection of the SO / SO's representatives in the prefabrication factory. The Contractor shall programme the construction of mock-up modules in such a sequence as to enable the SO and SO's representatives to progressively inspect the works before the completion of entire mock-up.

(b) The mock-up units shall demonstrate the framing system, connection details of the modules to the in-situ parent structural elements, all interior fitting out and connection details between the modules. The Contractor shall allow for modification of the mock-up at their own cost to address the comments given by the SO during the inspection and approval process.

(c) The Contractor shall not proceed with mass production of the modules prior to acceptance of mock-up by the SO. The SO reserves the right to reject any materials ordered, works commenced, installed and/or completed before the SO's approval had been given. All time and cost implications arising out of the same shall be borne by the Contractor.

On-site trial installation of modules **27.22**

(a) The Contractor shall complete a trial installation of module(s) on site for review, comments, alteration and acceptance. The trial installation shall be made accessible for the SO's inspection. The Contractor shall programme the construction trial installation in such a sequence as to enable the SO to progressively inspect the works before the installation of the module is completed. The extent and details of the trial installation shall be agreed with the SO.

(b) After the MiC units are delivered to the Site and before the on-site trial installation process, the Contractor shall arrange necessary inspection and checking, especially if there is concern over possible deformation damage or the like during transit and difficulty in replacing /repairing the components after assembly on site. The Contractor shall also arrange joint inspection by relevant parties to monitor the on-site assembling process.

(c) The Contractor shall verify on site regarding the provision of preparatory builder's works (e.g. wall/floor openings, surface for fixing of modules' frame, delivery route, provision for hoisting/lifting facilities, etc.) before the delivery of the MiC units.

(d) The trial installation shall demonstrate that the typical lifting arrangement, work sequence, temporary works, structural connections, etc. as stated in the method statement can be realized, and the construction tolerances and workmanship are all in compliance with the contract requirements.

(e) The Contractor shall not proceed with any installation of other modules prior to acceptance of trial installation by the SO. The SO reserves the right to reject any works commenced, installed and / or completed and before the SO's acceptance had been given. All cost and time implications arising out of or in connection with the same shall be borne by the Contractor.

(f) Upon the SO's review that the trials are conducted satisfactorily, the trial shall be set as the types of materials, standard and quality of workmanship for installation. Unless otherwise instructed by the SO, the installation of all remaining modules on site shall be carried out to exact conformity to the standard and quality of workmanship.

Lifting of modules **27.23**

(a) The crane employed must be able to handle the weight of the modules, and all lifting frames and accessories, but at the same time be able to provide enough coverage for the intended building blocks.

(b) When the employment of high capacity tower crane is considered necessary by the Contractor, special attention must be paid to the adequacy of the supporting structures / ground condition to sustain the higher loads. The Contractor shall be responsible for the design and construction of any additional supporting structures and/or foundations for supporting the tower crane at his own cost.

Grouting works **27.24**

Requirements of grouting works for structural joints on site shall refer to Appendix 1.

Alignment and tolerances **27.25**

(a) Special attention shall be given to the vertical and horizontal alignments during installation. The Contractor shall submit detailed method statement with quality control measures to demonstrate clearly how proper alignments and tolerances can be achieved to prevent excessive gaps, tilting, etc. The Contractor's proposal shall take into account of all possible interfaces when erecting adjoining modules and/or constructing in-situ elements.

(b) The production and erection tolerances of the modules shall comply with those specified in **Code of Practice for Precast Concrete Construction** and/or **Code of Practice for the Structural Use of Steel** issued by the Buildings Department. The Contractor shall propose a set of production and erection tolerances for approval by the SO.

(c) The maximum permitted tolerances in construction shall be in accordance with **BS 5606** unless otherwise specified in the Contract. Measures shall be submitted for approval and put in place to correct the deviations in levels and positions, as erection proceeds, to ensure that the maximum permitted tolerances are not exceeded.

Inspection of MiC work at prefabrication factory **27.26**

(a) The SO may carry out inspection of the factory production process outside Hong Kong. The Contractor shall submit a schedule for MiC works, which require off-site inspection by the SO, for the approval of SO at least 14 days before commencement of the production work in the prefabrication factory.

(b) The Contractor shall also give reasonable advance notice to the SO of not less than 48 hours to allow the SO to carry out the off-site inspection at the prefabrication factory. The Contractor shall provide necessary temporary office accommodation in the factory to facilitate SO to execute the inspection duties. Any works/tests that have been carried out without adequate advance notice shall deem to be rejected unless demonstrated to the satisfaction of the SO.

(c) The Contractor shall provide access and attendance during the SO's off-site inspection. The SO may require samples of material, workmanship, installation and the like to be provided for review. The SO may call for meetings on quality matters and the Contractor's attendance is necessary.

PROVISION FOR MAINTENANCE

Provision for maintenance **27.27**

(a) The provision of access points, inspection pits or accessible recesses to facilitate inspection and repair/replacement of structural connections, water-carrying pipes, building services and joints shall be considered during the early design stage of the MiC system. The Contractor shall propose design details of these access panels with inspection and repair/replacement methodology for comment by future maintenance agents of these elements at the design stage.

(b) For MiC system adopting steel frame modules, adequately sized and obstacle-free access panels shall be provided to facilitate inspection on critical locations such as steel beams and column connections. The Contractor shall propose these access panel details and inspection methodology for inclusion in the structural drawings for approval by the SO prior to fabrication works.

(c) If inspection and maintenance activities are necessary at critical locations of the MiC system, safely accessible access panels of adequate size and demountable mechanism with sufficient working space shall be provided for agreement by future maintenance agents of the building at the design stage to facilitate the necessary inspection and repair works.

(d) Adequate means of access for maintenance and repair of the external building elements of building shall be provided in accordance with the **Building (Construction) Regulation (Cap.123Q) (B(C)R)** and **Code of Practice on Access for External Maintenance 2021**. For buildings with MiC units, the Contractor shall provide maintenance strategies with the maintenance access proposal for both external and internal building elements to demonstrate the proposed means of access for maintenance and repair methodology during design stage for approval by the SO.

(e) Innovative or smart maintenance approaches to fit for the MiC design shall be suggested by the Contractor, if appropriate, and agreed with the management department and future maintenance agents of the building in early design stage.

MAINTENANCE MANUAL

Information in maintenance manual **27.28**

(a) A maintenance manual for the MiC system shall be provided by Contractor upon completion of the Works, to enable future operator and maintenance agents to understand all issues related to the usage, maintenance and alteration limitations of the units. The Contractor shall seek agreement from the SO and future maintenance agents on the timeframe for submission of the draft maintenance manual. The draft maintenance manual shall be prepared as early as practical for comment by the SO and future maintenance agents so as to ensure the required information will be included in the final submission.

(b) Apart from as-built records and general information on the construction, layout, materials, general cleaning, inspection and maintenance procedure of the modular units, the manual shall draw particular emphasis to aspects which are not commonly anticipated in conventional in-situ building works such as the following but not exhaustive:

(i) Particular routine inspection and checking requirements for integrity of modular units, including the diagnosis method for particular signs of failures/ defects.

(ii) Demarcation plan for distinguishing in-situ structures and MiC modules.

(iii) Inspection frequency and method to check any displacement of modular unit and the allowable limit.

(iv) Inspection frequency and method, site test and repair works required if defects are identified at the structural, architectural and building services connections (e.g. connection between modules, connection between module and in-situ structure, sealants, water stop, etc.).

(v) Inspection frequency, testing method and repair works suggested if defects are identified at the waterproofing or joint sealants of the building envelope (e.g. external walls and roofs).

(vi) Location and design details of inspection pits and access panels.

(vii) Access method and sequence to reach building services and structural elements of MiC system for inspection and repairs with drawings and/or animations showing sequences for dismantling/ assembling/ replacing defective parts of critical MiC elements, if applicable.

(viii) Instructions for drilling and fixing requirements inside the modular units.

(ix) Instructions for alterations (e.g. alteration of internal partitions, building services, structural components for support the building services components, etc.).

(x) Instructions for addition (e.g. installation of addition fittings or equipment, etc.), including demarcation on plan indicating areas where fixtures shall be allowed to be mounted on.

(xi) Instructions for change of use (e.g. available structural loading, fire-rated coating, building services routings and capacities, etc.).

(xii) Instructions for replacing or repairing of installed finishes, fixtures, fittings, building services, parts and fixtures, etc.

(xiii) Warranties, Guarantee, Manufacturers' Certificates, information on expected life expectancy, etc. for structural elements, building envelope, waterproofing, fire resistance rating and essential building elements, such as the connections and sealants, insulation layer, etc.

(xiv) Original manufacturers, designers and consultants for MiC units.

(c) 3-dimensional as-built model showing whether the parts of the modules are with or without warranties shall be provided as if applicable. The requirements of Building Information Modelling (BIM) for maintenance shall refer to the latest version of the Building Information Modelling Guide for Facilities Upkeep, as appropriate.

(d) Information of innovative or smart maintenance approaches for the modular units, including but not limited to management of data, users, hardware and software required, system requirements and system administrator, if any, shall be included.

(e) Steps to supplement the required parts of the modular units from the manufacturers or their correspondence suppliers shall be included.

(f) List of spare parts with quantities for the units, if any, to be kept on site for future maintenance or replacement works shall be included.

(g) Maintenance access proposal showing safe, adequate and appropriate accesses to external building elements and internal spaces for future maintenance and repair shall be included.

(h) Maintenance schedule for architectural, structural, waterproofing materials, sealants, protective coating and building services, etc. shall be proposed by the Contractor for reference by the maintenance agents.

APPENDIX 1: GROUTING WORKS FOR STRUCTURAL JOINTS

1.0 Grout Material

1.1 Grout shall be a designed grout mix or an approved pre-packaged grout product which contains Portland cement, selected sand/filler and non-shrink additives, complying with the following requirements: -

(a) Grout shall be non-shrink, low bleeding in the plastic state and be fluid.

(b) Minimum cube strength of grout at 28 days shall be 35 MPa or the specified concrete strength of the adjoining structures, whichever is higher.

(c) Measurements for bleeding or grout settlement shall be taken at ambient temperature at 15-minute intervals. The amount of bleeding of grout shall not exceed 2% of the initial volume after the first 3 hours and no interim readings shall exceed 4%. Any water separated at the surface must be reabsorbed by the grout within 24 hours after mixing.

(d) Free expansion or volume change of grout when measured at the end of 24 hours after mixing shall be between 0% and 5%.

(e) The fluidity of grout shall be measured by the flow cone test method. Grout shall have an efflux time between 12 seconds and 30 seconds.

(f) Admixture shall be approved by the SO and shall contain no chloride, nitrate, sulphate, or aluminium powder.

(g) Water for grout shall be clean fresh water having a temperature not exceeding $30^{O}C$ nor less than $5^{O}C$.

(h) Pre-packaged grout product shall be prepared and applied strictly in accordance with the manufacturer's specification and requirements.

2.0 Mix Proportions of Grout

2.1 The maximum water/cement ratio shall be 0.44.

2.2 Quantity of sand/filler used shall not exceed 30% of the mass of cement.

2.3 Admixtures shall be used strictly in accordance with the recommendations of the manufacturer and shall be free of any chemical liable to promote corrosion of the grouted steel reinforcement/fixings or cause damage to the grout.

2.4 Chlorides from all sources, i.e. cement, water, sand, filler and admixture shall not exceed 0.1% by mass of the cement.

3.0 Trial Mixes of Grout

3.1 Details of grout mix and production method shall be submitted to the SO for approval. A trial mix for grout shall then be carried out to demonstrate that the proposed materials, mix proportions and method of production, taking into account the ambient temperature and any other relevant factors, will produce grout which complies with the specified requirements,

3.2 Trial mixes shall be completed 35 days before the grout mix is used in permanent work.

3.3 Make three separate batches of grout under conditions similar to those used for production of grout in the Works and use materials typical of the proposed supply.

3.4 Make six 100 mm cubes from each batch for testing, three at 7 days and three at 28 days. Cubes shall be cured and tested in accordance with Clause 6.55 of the **General Specification for Building**.

3.5 Trial mix proportions will be approved if the average strength of the nine cubes tested at 28 days exceeds the specified grout strength by 5 MPa and the properties of the trial mix including amount of bleeding, free expansion, fluidity, etc. comply with the requirements in Clause 1.0.

3.6 If the result of any test for amount of bleeding, free expansion, fluidity or crushing strength of trial mixes for grout does not comply with the specified requirements, particulars of the proposed changes to the materials, grout mix or method of production shall be submitted to the SO. Further trial mixes shall be made until the result of every test complies with the specified requirements.

3.7 Notwithstanding approval of the trial mix, the SO may require further trial mixes where circumstances change or inconsistent workmanship is observed.

4.0 Grouting Trials

4.1 Grouting trials for placing grout material in structural joints between the prefabricated modules, and for connection of modules to the in-situ parent structures shall be carried out to demonstrate that the proposed materials, grout mix, method of production and method of grouting will produce a grouted joint which complies with the specified requirements. The number and details of grouting trial shall be agreed with the SO.

4.2 Grouting trial shall be completed at least 21 days before installation of the modular units in the permanent works, unless otherwise approved by the SO.

4.3 Grouting trials shall be carried out using the materials, grout mix, method of production and method of grouting submitted to the SO.

4.4 The grouting trial shall incorporate all relevant parts and components as if these will be used in the actual proposal of modular integrated construction system.

5.0 On-site Grouting

5.1 General

(a) The method of preparing and placing grout material in structural joints between the modules, and for connection of modules to the in-situ parent structures shall be approved by the SO before installation of the modules. Prepare and construct joints strictly in accordance with the drawings and in accordance with the relevant manufacturer's recommendations so as to provide continuous weather-tightness of buildings.

(b) Unless approved by the SO, grout should only be used to fill voids or gaps with maximum dimension less than 150 mm. Agree with the SO the method to measure the grout intake volume.

5.2 Grouting Equipment

(a) Mixing equipment shall be of a type capable of producing grout of homogeneous colloidal consistency, whilst imparting only a slow motion to the body of the grout.

(b) Injection equipment shall be capable of continuous operation with minimal variation of pressure and shall include a system for recirculating grout when grouting operations are interrupted. Injection delivery pressure shall generally not exceed 1 MPa.

(c) All equipment shall be thoroughly washed through with clean water at either the completion of each series of operations or after 3 hours have elapsed since the previous cleaning, whichever is the shorter period.

5.3 Grouting

(a) Mix grout for a minimum of 2 minutes and not more than 4 minutes until uniform consistency is obtained. After mixing, the grout shall be continuously agitated in a holding tank and screened before injection. The grout shall be placed within the time limits specified by the manufacturer of the additives.

(b) Grout shall be used within 30 minutes of mixing unless a retarder is incorporated in the grout. If a retarder is used, the time shall be determined by a test procedure agreed by the SO.

(c) Agree with the SO the method to measure the grout intake volume. Do not commence grouting without prior approval

(d) All surfaces in contact with grout shall be free of dirt, oil, grease, laitance and other contaminants that may act as bond breaker. Concrete surfaces shall be roughened to expose sound concrete and clean before grouting.

(e) All voids to be grouted shall be free of standing water at all times and shall be thoroughly clean and dry before grouting.

(f) All joints shall be liquid tight and sealed using an approved flexible sealant and non-absorbent compressible backing material. Sealant and backing material shall be compatible and shall be applied strictly according to the manufacturer's instructions.

(g) Carry out grouting by tremie method and, unless agreed by the SO, the grout pipes shall not be lifted up before the completion of grouting.

(h) Grout injection shall be carried out in one continuous operation and shall be at a steady rate that will avoid segregation and trapping of air in the void.

6.0 Records of Grouting

6.1 Prepare records of grouting operations in the format and quantity as required by the SO. Records shall include the following:

(a) Date when each structural joint was grouted.

(b) Mix proportions of the grout.

(c) Details of admixture introduced.

(d) Details of any interruptions.

(e) Location of grouting.

(f) Supervising staff.

(g) Grout injection pressure, if applicable.

(h) Volume of grout used.

6.2 Submit the records of grouting operations to the SO within 3 days of completing the relevant grouting.

7.0 Testing of Grout

7.1 Employ an approved independent laboratory to carry out the tests for Bleeding, Free Expansion and Flow Cone Efflux of grout. All test reports shall be submitted directly to the SO in sealed envelope from the approved laboratory.

7.2 Make, cure and test grout cubes for compressive strength tests. All grout cubes should be appropriately marked and delivered to the Public Works Laboratories (PWL) for testing, as directed by the SO

7.3 For tests, a batch of grout is any quantity of grout used for grouting structural joints in one continuous operation.

7.4 Test for Bleeding and Free Expansion

(a) Provide one sample of the grout from each 25 batches of grout, or from the amount of grout produced in a day, whichever is the lesser. Samples shall be protected from changes in moisture before tests are carried out.

(b) Each sample shall be divided into 3 specimens. Each specimen shall be tested to determine the amount of bleeding and volume change of the grout in accordance with **ASTM C940**.

7.5 Test for Fluidity

(a) Provide one sample of the grout from each 25 batches of grout, or from the amount of grout produced in a day, whichever is the lesser. Samples shall be protected from changes in moisture before tests are carried out.

(b) Each sample of grout shall be tested in accordance with **ASTM C939** to determine the Flow Cone Efflux time. Agree with the SO the frequency of the test.

7.6 Test for Crushing Strength

(a) Provide one sample of the grout from each 25 batches of grout, or from the amount of grout produced in a day, whichever is the lesser. Samples shall be provided not more than 1 hour after the grout has been mixed and protected from changes in moisture before test cubes are made.

(b) Cubes shall be prepared using 100 mm cube moulds. Make two cubes from the sample. Strength compliance requirements shall follow Clause 6.55 of the **General Specification for Building**.

7.7 If the result of any tests for amount of bleeding, free expansion, fluidity or crushing strength of grout does not comply with the specified requirements, the Contractor shall propose changes to improve the materials, grout mix or method of production. The Contractor shall also carry out any necessary remedial measures at their own expense to demonstrate that the grouted joints can fulfil the original design assumption.

- End -