Particular Specification for Large Diameter Bored Piles with Bell-outs

1.0 Definition

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 reverse circulation drill (RCD) incorporating an under-reaming head.

2.0 Design Requirements

2.1 Design Assumptions

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. Combining the end-bearing capacity and rock socket side resistance to increase the load-carrying capacity shall not be allowed.

Bedrock is defined as rock mass of at least 5 m plus the socket length (as defined in Fig. 1), and being Grade III or better rock (as defined in GEOGUIDE 3, “Guide to Rock and Soil Descriptions” prepared by Geotechnical Engineering Office and published by GIS, Hong Kong).

For design purpose, the maximum bearing pressure of piles on bedrock shall not exceed the following:

(a) 5 MPa for Grade III or better rock (granite and volcanic) with total core recovery greater than 85% for any one metre within the rock mass and minimum uniaxial compressive strength (UCS) not less than 25 MPa (equivalent point load index strength PLI$_{50}$ not less than 1 MPa)

(b) 7.5 MPa for Grade II or better rock (granite and volcanic) with total core recovery greater than 95% for any one metre within the rock mass and minimum uniaxial compressive strength (UCS) not less than 50 MPa (equivalent point load index strength PLI$_{50}$ not less than 2 MPa)

The point load index strength of rock is the equivalent value for 50 mm diameter cores.

(c) 3 MPa for Grade III or better meta-sedimentary rock with total core recovery greater than 85% for any one metre within the rock mass.

The use of the above presumptive values does not preclude the requirement for consideration of settlement of the structure.
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 300 mm below the bedrock level (see Fig. 1).

Where steep bedrock profile is identified, the founding levels of adjacent piles should 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.

* Notwithstanding GS Clause 5.04(i), 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.

OR

* 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 7.5 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.

* delete as appropriate (reference should be made to the Guidelines on the Design of Large Diameter Bored Piles with Bell-outs for selection of different criteria)

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 Supervising Officer (SO).

2.2 Reinforcement Detail

Reinforcement should be provided as shown in Fig. 1. The depth ‘H’ in Fig. 1 is bell-out tool dependent. It shall be verified on site and agreed with the SO before commencement of pile installation.

2.3 Drilling before Construction

Site borings to pre-determine the piles founding levels 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.
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 pile founding level and rock properties. 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 the socket length (as defined in Fig. 1) shall be taken below the bedrock level for inspection and testing. 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. However, this predicted founding 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.

3.0 Testing

3.1 Ultrasonic Echo Sounding Test

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.

4.0 Controlling and Monitoring the Verticality, Alignment and bell-out size of Bored Piles

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 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 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.

5.0 Design Submissions

In addition to those stated in GS Clause 5.02 and Clause 4.0 of this Particular Specification, the Contractor may submit for SO’s approval the information on the proposed materials, method of installation for piling works and quality control measures prior to the piling design submissions.

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.

6.0 Other Requirements

Unless otherwise specified, requirements related to Large Diameter Bored Piles as stipulated in the General Specification for Building shall also apply to Large Diameter Bored Piles with Bell-out.
FIG. 1  TYPICAL DETAIL OF LARGE DIAMETER BORED PILE WITH BELL-OUT