

## **Particular Specification for Reinforced Massive Concrete Structures**

### 1. Definition

Reinforced Massive Concrete Structures include pile caps, transfer plates and structural members where the least dimension exceeds 1.5 metres.

### 2. Method Statement

At least two months before commencement of concreting, the Contractor shall submit a method statement for temperature control. The information to be submitted shall include, but not be limited to, the following:

- (a) concrete mix details including heat of hydration and specific heat characteristics of the cementitious constituents, expected concrete temperature rise and the proposed initial concrete placing temperature;
- (b) formwork type and insulation;
- (c) curing details related to temperature effects;
- (d) maximum and minimum concrete placing temperatures;
- (e) minimum and maximum times before formwork is stripped;
- (f) any additional methods for controlling the concrete temperature;
- (g) concrete temperature monitoring proposals which shall be sufficient to demonstrate that the requirements of the Contract will be met;
- (h) analyses and calculations to prove that the proposals will meet the requirements of the Contract.

### 3. Concrete Trial Mixes

Trial mixes shall not be prepared until the SO has approved the Contractor's mix design in writing. Trial mixes shall be prepared under the supervision of the SO at least 35 days before the commencement of concreting.

#### 4. Temperature Rise Evaluation Test

A Temperature Rise Evaluation Test (TRET) shall be made. The test shall consist of an insulated 800mm×800mm×800mm concrete block constructed to the approval of the SO. The block shall be instrumented with a minimum of three centrally located thermocouples connected to an automatic data logger and hourly readings shall be taken until the temperature has fallen to more than 10°C below the peak temperature. The insulation of the concrete block shall be complete and equivalent to at least 200mm of expanded polystyrene with additional protection provided as necessary. The concrete block shall be constructed and instrumented to the approval of the SO. The information gained during this test shall be used by the Contractor in the formulation of the temperature control methods for the mix. The concrete blocks shall be retained for a minimum of 3 months or as directed by the SO in a manner to ensure that damage or degradation does not occur. The results of the TRET shall be used in conjunction with the Contractor's proposed insulation/cooling methods to evaluate compliance with the temperature control requirements.

#### 5. Concrete Temperature Limits

Temperature control for concrete shall comply with the following requirements:

- (a) The Contractor shall employ effective means such as shading the aggregates, pre-cooling mixing water and adding flaked ice to ensure the temperature of concrete prior to and including the time at which it is placed shall not exceed 25 °C.
- (b) After the concrete has been placed, its peak temperature in any part of the structure shall not be permitted to rise above 85 °C.
- (c) After the concrete has been placed, the maximum temperature difference between a point at the centre of a concrete section and the adjacent surface shall not be greater than 20 °C times the shortest distance, in metres, between the concrete section centre and the surface.
- (d) The Contractor shall employ effective means such as insulation, selection of appropriate pour cycle times, or heating/cooling as necessary, to ensure that at any time within 21 days after the concrete has been placed, the temperature differential between any point in the freshly placed concrete of any structural element at a distance of 600mm from a construction joint and the corresponding point 600mm from the construction joint in the adjacent previously placed structural element, shall not exceed 20 °C.

#### 6. Concrete Temperature Measurement

- (a) The initial placing temperature of the concrete shall be measured by inserting a calibrated probe-type thermometer, with a  $\pm 1^{\circ}\text{C}$  accuracy, into each delivery of the concrete at the time of discharge from the vehicle transporting it or not later than 15 minutes thereafter. The thermometer shall be calibrated weekly.
- (b) The Contractor shall continuously compare the real time results of the on-going temperature monitoring with the predicted values and make appropriate adjustments to the temperature control methods used on current and subsequent pours to ensure compliance with this Particular Specification.
- (c) The temperature of the hydrating concrete shall be measured for each pour until 21 days after pouring using a sufficient number of calibrated thermocouples to demonstrate that the requirements of Clause 5 have been achieved, within a  $\pm 2^{\circ}\text{C}$  accuracy.
- (d) The thermocouples shall be suitably robust to withstand concrete placing, and be adequately protected and firmly fixed in position on the reinforcement cage. The thermocouples shall not be placed closer than 300mm to any cooling water pipes to ensure that they give representative temperature readings.
- (e) The output of the thermocouples shall be continuously recorded using an automated data logger. The power supply to the data logger shall be non-interruptible and the equipment shall be maintained and checked at least twice per day to ensure that they are operating satisfactorily.
- (f) The thermocouples shall be calibrated in conjunction with the working and backup data logger(s) and the calibration results shall be submitted at least 7 days prior to incorporation within the Works.
- (g) After installation of the thermocouples within the pour and immediately prior to concreting, the thermocouples shall be checked by comparing the relative ambient temperature readings. Any damaged or malfunctioned thermocouple shall be replaced prior to the commencement of concreting.
- (h) After the placing of concrete, the temperature readings shall be taken at a maximum of hourly intervals for the initial 7 days after placing. The monitoring frequency can be reduced to  $12 \pm 1$  hours thereafter until 21 days after placing or until the maximum temperature is less than  $15^{\circ}\text{C}$  above the daily minimum ambient temperature.
- (i) The output from the data loggers shall be down loaded daily by the Contractor. A copy of the data shall be given to the SO immediately after down loading in an agreed electronic and hard copy format.
- (j) Within 7 days from the completion of the temperature monitoring period the Contractor shall submit a report. The report shall include the individual tabulated

temperature results and calculated values indicating compliance, as required by this Particular Specification, for all maximum and differential temperature measurements. The report shall be presented in both tabulated and graphical format and shall include all thermocouples within the same measurement plane on the same graph to ensure that the temperature differentials between the core, surface and ambient are readily discernable. Any non-compliance with this Particular Specification shall be highlighted and proposals given for remedial works and ensuring compliance in subsequent pours. If the non-compliance is on the temperature limits as specified in Clause 5 above, the method statement shall be reviewed and re-submitted to the SO for approval before further concreting of reinforced massive concrete structure.

7. Special Measures Involving More Than a Single Pour

If the Contractor proposes to concrete the reinforced massive concrete structure in more than one operation, he shall demonstrate to the satisfaction of the SO that:

- (a) at all stages the temperature differential limits specified in Clause 5(c) will not be exceeded at any one time;
- (b) the maximum temperature of 85 °C will not be exceeded;
- (c) the stresses in the concrete structure due to temperature changes under strain will not induce tension cracks;
- (d) the construction joint will be treated to ensure monolithic action between the different pours.
- (e) the temperature differentials between two adjacent pours will comply with Clause 5(d).
- (f) the temperature of concrete prior to and including the time at which it is placed will comply with Clause 5(a).