15 HOT WEATHER CONCRETING

15.1 GENERAL

15.1.1 Scope

1 This Part covers the precautions to be taken for hot weather concreting for all structural concrete except blinding concrete, where a minimum compressive strength is specified.

2 Related Sections and Parts are as follows:

This Section
Part 6,..... Property Requirements
Part 7,..... Concrete Plants
Part 8 ..... Transportation and Placing of Concrete
Part 10..... Curing

15.1.2 References

ACI 305R.....American Concrete Institute, Hot Weather Concreting

ASTM C1064/C1064M Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete

EN 1992-1-1.....Eurocode 2, Design of concrete structures. General rules and rules for buildings

EN 480 .....Admixtures for concrete, mortar and grout. Test methods

EN 934 .....Admixtures for concrete, mortar and grout

15.1.3 Definition of Hot Weather

1 The requirements of the following clauses of the specification are applicable during the hot weather period in Qatar.

2 The hot weather period shall be defined as starting when the maximum ambient air shade temperature on the Site exceeds 35 °C for three consecutive days. The end of the hot weather period shall be defined as the period when the maximum air shade temperature is below 35 °C on three consecutive days.

3 The Contractor shall establish a thermometer on Site that records the ambient air shade temperature. The thermometer shall be established at a position to provide representative air temperature for the Site conditions. If requested by the Engineer the Contractor shall arrange for the calibration of the Site thermometer.

4 Hot Weather" shall mean any combination of the following conditions that tends to impair the quality of freshly mixed or hardened concrete by accelerating the rate of moisture loss and rate of cement hydration, or otherwise causing detrimental results such as:

(a) High ambient temperature (when the shade temperature is above 40 deg C on a rising thermometer, 43 deg C on a falling thermometer),

(b) High concrete temperature,

(c) Low relative humidity,

(d) High wind speed

(e) the rate of evaporation exceeds 0.75 kg/m^2/h

15.1.4 System Description

1 The Contractor shall undertake hot weather concreting procedures that are effective in controlling the following potential problems associated with concreting in hot weather:

(a) increased water demand of the mix
(b) increased rate of slump loss
(c) increased rate of setting
(d) increased tendency for plastic shrinkage cracking
(e) decreased long-term strength
(f) increase tendency for drying shrinkage and cracking
(g) increased tendency for differential thermal effects with consequent cracking
(h) decreased durability from cracking where there is increased permeability.

15.1.5 Submittals

1 The Contractor shall prepare weekly in advance his proposed concreting programme showing the quantities to be placed and the anticipated placing hours.

2 At least one month before the start of the hot weather period the Contractor shall submit his specific proposals for the control of the concrete temperature for the constituent materials; cement, water aggregates.

3 Where required the Contractor shall submit to the Engineer his proposals for the use of liquid nitrogen for cooling which shall include details of previous project application and the intended methods to be used and quantities of liquid nitrogen.

15.2 PLACING TEMPERATURE

1 This Subpart of the specification applies at all times of the year and at all times of the day.

2 Maximum fresh concrete temperature (at placement) shall not exceed 32°C unless construction testing to verify a proposed concrete mixture will function satisfactorily at a concrete temperature greater than 32°C. No concrete shall be placed if the concrete temperature is above 35°C

3 Concrete shall not be placed if the shade temperature exceeds 40ºC.

4 The temperature of each truck of concrete shall be measured using either a glass, dial type or electronic thermometer, just before the placing of the concrete and the temperature recorded on the delivery ticket. The maximum temperature at placing shall apply to the entire load of concrete in the truck or conveyer.

5 The Contractor shall allow for the increase in concrete temperature in the period from dispatch from the plant while in transportation or whilst awaiting placement on Site and take adequate measures to ensure the maximum temperature is not exceeded.

15.3 PLANNING CONCRETING

1 During the hot weather period as defined in Clause 15.1.3 of this Part, the Contractor shall plan concreting operations such that no concreting takes place between the hours of 10:00 hours and 17:00 hours.

2 The Contractor shall arrange concrete pours such that the programme of works can be achieved without concreting during the period from 10:00 hours to 17:00 hours.

3 The Contractor shall nominate one member of his staff to be the co-ordinator for the supply of concrete. The co-ordinator's responsibilities shall include ensuring the batched rate matches that of delivery and placement and the preparations needed before commencing a concrete pour.

15.4 MIX DESIGN

1 In the hot weather period, the Contractor shall review all concrete mix designs to ensure that the design slump or workability specified is achieved without increase in the mix water content. The Contractor shall make modifications to the mix design to allow for increased slump loss during transportation in hot weather.

2 This shall be achieved by adjusting the proportion of admixture, plasticiser or super plasticiser. The permitted range of admixture shall be clearly stated on the concrete mix design with nominal values for cold weather and hot weather use.

3 Under no circumstances will the addition of extra water that increases the water cement ratio be permitted during hotter weather.

4 All concrete materials and proportions used in periods of hot weather shall be those that have a satisfactory record of use in such conditions.

15.5 TEMPERATURE CONTROL

15.5.1 General

1 The Contractor's specific proposals for the control of the concrete temperature shall include extent and type of shading of aggregates, method of chilling mix water and procedures for batching and mixing, transportation, placing and finishing, curing and protection.

2 These shall include calculations in accordance with ACI 305R, clause 3.1 "estimating concrete temperature". The Contractor shall calculate the temperature of freshly produced concrete based on the input temperatures of the constituent materials and the weights from particular mix designs. The calculations shall make allowance for the rise in temperature between mixing and placing due to the transportation and waiting period. The calculations shall successfully demonstrate that the temperature can be maintained below 32 °C at the point of placing.

15.5.2 Aggregates

1 All practical means shall be employed to keep the aggregates as cool as possible.

2 Stockpiles of aggregates shall be shaded from direct sunlight. Shades shall extend beyond the edge of aggregate storage areas and stockpile layouts shall be such that direct sunlight is not incident on the aggregates. Shades shall be constructed to allow access for mechanical shovels or means of conveyance. Shades and stockpiles shall be constructed so as to permit the free flow of air over the aggregates. Embedded cooling pipes may also be used to cool the aggregate.

3 Sprinkling of coarse aggregates to reduce temperature by evaporation or direct cooling shall not be permitted.

15.5.3 Water

1 Mix Water shall be cooled by storing in underground tanks or insulated tanks above ground.

2 The water shall be chilled by the use of proprietary chillers or the addition of ice to the water tank. Measures shall be taken to ensure that ice pieces are not inadvertently deposited directly into the mixer.

3 Water shall not be chilled below a temperature of 5 °C.

4 Tanks, pipes or trucks used for the storage or transportation of water shall be insulated and painted white.

5 The mechanical refrigeration equipment and insulated water storage shall be adequate for the anticipated hourly and daily production rates of concrete during the hot weather period.

6 Mixing water may also be chilled by injection of liquid nitrogen into an insulated holding tank, such procedures shall be to the approval of the Engineer.

7 Ice shall be completely melted in mixing water prior to adding water to the mixer.

15.5.4 Cement

1 The use of freshly ground cement at very high temperatures is not permitted.

2 The cement shall be kept below the temperature which there is a tendency of false set.

3 Under no conditions shall the temperature of the cement exceed 75 °C when it enters the mixture.

4 The Contractor shall make arrangements for storage on Site to allow cooling of freshly ground and delivered cement.

15.5.5 Addition of Ice

1 Crushed shaved or chipped ice can be used as part of the mixing water for reducing the concrete temperature.

2 The maximum nominal size of ice particles shall be 10 mm and all the ice must be melted before the completion of mixing of the concrete in the pan.

3 To ensure proper concrete mixing the maximum proportion by substitution shall be 75 % of the batch water requirement.

4 Crushed ice shall be stored at a temperature that will prevent lumps from forming by refreezing of particles.

5 The batching plant shall incorporate a mechanical system for correctly proportioning and weighing the ice to be added to the mixture.

6 The quantity of ice shall be deducted from the total batch water.

7 The Contractor shall ensure there are adequate quantities of ice in suitable refrigerated storage on the Site at the plant to meet the anticipated daily and hourly production rates of concrete during the hot weather period.

15.5.6 Liquid Nitrogen

1 Freshly mixed concrete maybe cooled by the injection of liquid nitrogen.

2 Care shall be taken to ensure that the concrete directly adjacent the injection nozzle is not frozen.

3 The use of liquid nitrogen for cooling concrete shall include a nitrogen supply vessel and injection facility for the batching plant or one or more injection stations for truck mixers.

4 The system may be set up at the Site for injection just before placing.

5 Proper safety precautions as advised by the supplier of the liquid nitrogen shall be used.

15.6 BATCHING AND MIXING

1 The drums of concrete mixer trucks shall be painted white to minimise solar heat gain.

2 Where a truck mixer has been left standing in the sun, the empty drum shall be sprayed with water and the drum flushed out with cold water before batching. Care shall be taken to ensure all water is removed from the drum before batching.

3 The temperature of the concrete shall be checked after discharge from the mixer and written on the delivery ticket. Temperature check shall be carried out at the plant on the concrete floor for every 50 m^3 produced or every hour which ever is the minimum.

4 A water-reducing, set-retarding chemical admixture conforming to the requirements of EN 480 Parts 1, 2 and 4 may be used in varying proportions under different air temperature conditions.

15.7 TRANSPORTATION

1 The transportation, placing, compaction and finishing of concrete shall be at the fastest possible rate. Delivery of concrete to the Site shall be properly scheduled to match the rate of placement and compaction.

15.8 PLACING AND FINISHING

1 If the temperature of the first truck of concrete of a particular pour is above the specification maximum temperature limit then placing shall not commence.

2 If a pour is in progress and the temperature of a particular truck exceeds the maximum permitted temperature the placing may be allowed to continue at the discretion of the Engineer in order to avoid the possible development of a cold joint.

3 However, no further concreting pours shall take place until the Contractor has submitted revised calculations, in accordance with ACI 305R clause 3.1 to demonstrate that the maximum temperature will not be exceeded in the future. Before beginning new pours the temperature of the concrete constituent materials shall be monitored to verify that they meet the assumptions of the calculations.

15.9 CURING AND PROTECTION

1 Curing and protection shall conform to the requirements of Part 10 of this Section.

2 Evaporation shall be minimised, particularly during the first few hours subsequent to placing concrete, by suitable means such as applying moisture by fog spraying or any other means acceptable to the Engineer.

15.10 INSPECTION AND TESTING

1 All thermometers used for the measurement of concrete temperature shall be calibrated weekly against a glass mercury thermometer. Calibration shall be carried out over the temperature range of 10 °C to 100 °C using a water bath with ice or heating.

2 The method used to determine acceptance of temperature controlled concrete should be in accordance with ASTM C1064.

3 All concrete test specimens for strength or other purposes shall be carefully protected and cured.

4 Specimens shall be protected from accidental damage by plant personnel or equipment on Site.

5 Specimens shall be kept moist by the addition of water or covering by suitable curing materials.

6 The exact time of preparation of the specimen on Site shall be noted and the time when it is transferred to the laboratory. These times shall be written on the test report.

END OF PART