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10 CURING

10.1 GENERAL

10.1.1 Scope

- 1 This part covers the requirements for the curing of concrete.
- 2 Related Sections and Parts are as follows:

This Section

Part 1, General

Part 4, Water

Part 6, Property Requirements

Part 15, Hot Weather Concreting

Part 16, Miscellaneous.

10.1.2 References

- AASHTO M 148,Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
- ACI 308Guide to External Curing of Concrete
- ASTM C156.....Standard Test Method for Water Loss [from a Mortar Specimen] Through Liquid Membrane-Forming Curing Compounds for Concrete
- ASTM C309,.....Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
- ASTM C1315.....Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete
- BS 7542,Method of test for curing compounds for concrete.
- ISO 9001Quality management systems -- Requirements

10.1.3 Submittals

- 1 The Contractor shall submit to the Engineer the proposed method of curing for approval.

10.1.4 Quality Assurance

- 1 The Contractor shall submit to the Engineer for approval the details of proposed curing media, if any. Details shall include chemical tests for the product in accordance with BS 7542 and details of quality assurance procedures, including ISO 9001 certificates if held.

10.1.5 Storage

- 1 Chemical curing compounds shall be stored in accordance with manufacturer's recommendations.

10.2 CURING

10.2.1 General

- 1 The Contractor shall ensure that curing is provided for 24 hours per day including holidays and that all related necessary plant and labour resources are also available.
- 2 Special attention shall be given to the curing of vertical and overhanging surfaces to ensure satisfactory curing.
- 3 The Contractor shall adopt curing measures that preclude the possibility of thermal shock to the concrete during curing. This may be achieved by ensuring that the temperature of the water used for curing does not differ from that of the concrete by more than 15 °C.

- 4 Curing shall continue for at least 7 days and until it attains an in-place compressive strength of the concrete of at least 70% of the specified compressive or flexural strength, whichever period is longer. Curing shall not stop unless otherwise approved by the Engineer.
- 5 When low W/cm is used, the concrete shall be preferably cured by water.

10.2.2 Water for Curing

- 1 Water used for any curing purposes shall conform to the requirements of Part 4 of this Section.

10.2.3 General Requirements

- 1 Freshly placed concrete shall be protected from sun, wind, rain, exposure and excessive drying out.
- 2 All concrete shall be cured for a period of time required to obtain the full specified strength, but not less than seven consecutive days. The method of curing shall be by water for the first seven days and by water or membrane until the concrete has reached the full specified strength.
- 3 For mixtures with a low to zero bleeding rate, or in the case of aggressively evaporative environments, or both, the curing shall start at early anytime between placement and final finishing of the concrete. The curing shall be by reducing the moisture loss from surface using fogging systems and the use of evaporation reducers such as monomolecular water curing compound.
- 4 Exposed surfaces shall be protected from air blown contamination until 28 d after the concrete is placed.
- 5 The method of curing shall ensure that sufficient moisture is present to complete the hydration of the cement, and shall be to the approval of the Engineer. The method of curing shall not:
 - (a) disfigure permanently exposed surfaces
 - (b) affect bonding of subsequent coatings
 - (c) increase the temperature of the concrete.
- 6 During the curing period, exposed concrete surface shall be protected from the direct rays of the sun.
- 7 When liquid membrane is used to cure the concrete, it shall not be applied if bleeding water is present on the surface of the concrete.
- 8 The applied film of the liquid membrane shall be continuous and protected from rain and any damages for at least 14 days.

10.2.4 Curing of Formed Surfaces

- 1 Formed surfaces, including the underside of beams, girders, supported slabs and the like, by moist curing with the forms in place for the full curing period, or until the forms are removed.
- 2 When the forms are stripped, curing shall continue by any approved method.
- 3 When liquid membrane curing is used, it shall be applied immediately after de-shuttering. In such cases the concrete surface shall be prepared prior to the application of the membrane as recommended by the manufacturer.
- 4 Water curing is not required when liquid membrane is used.

10.2.5 Curing of Unformed Surfaces

- 1 Unformed surfaces shall be protected as soon as possible after the concrete has been placed by polythene sheeting. When sufficiently hard, hessian or other absorbent material shall be placed on the concrete surface and shall be kept wet for the required period. The hessian shall be overlaid with a sheet of 1000 gauge polythene to assist in the retention of water. Alternatively a curing method approved by the Engineer may be used.
- 2 Once the concrete is sufficiently hard, the top exposed surface of walls, columns and beams shall be water cured and covered with wet hessian for the required curing period.

10.2.6 Moisture Curing

- 1 Moisture curing shall be performed by :
 - (a) covering the surface of the concrete with water and keeping it continuously wet
 - (b) continuous use of fine fog water sprays
 - (c) covering the surface with a saturated absorptive cover and keeping it continuously wet.
 - (d) Burlap, cotton mats, and other absorbent materials can be used to hold water on horizontal or vertical surfaces.
 - (e) Wet straw or hay can be used for wet-curing small areas, but there is the danger that wind might displace it unless it is held down with screen wire, burlap, or other means
- 2 Where method (a) is employed, the bunds used shall not be made from fill from excavations or any other areas where there is the possibility of chloride contamination.

10.2.7 Moisture Retaining Cover Curing

- 1 The concrete surface shall be covered with a suitable absorptive covering, such as wet hessian.
- 2 The absorptive covering shall be overlaid with a 1000 gauge polythene sheet.
- 3 The cover shall be in the widest practical widths and shall have 100 mm side and end laps.
- 4 Any penetrations or tear in the covering shall be repaired with the same material and waterproof tape.

10.2.8 Liquid Membrane Curing

- 1 Liquid membrane curing shall be in accordance with the requirements of BS 7542, ASTM C 309 or C1315 when tested at the rate of coverage use on the job.
- 2 ASTM C 156 shall be used as a test method to evaluate water-retention capability of liquid membrane forming compounds. ASTM C 1151 provides an alternative laboratory test for determining the efficiency of liquid membrane-forming compounds.
- 3 Membrane forming curing compounds shall be applied in accordance with the manufacturer's recommendations immediately after any water sheen which may develop after finishing has disappeared from the surface and within 2 h of stripping formwork on formed surfaces.
- 4 Membrane forming curing compounds shall not be used on surfaces against which additional concrete or other material is to be bonded unless:
 - (a) it is proven that the curing compound will not prevent bond, or
 - (b) positive measures are taken to remove it completely from those areas which are to receive bonded applications
 - (c) on fair faced concrete surfaces.

10.2.9 Steam Curing

- 1 An enclosure shall be formed around the concrete using tarpaulin or other suitable means.
- 2 Application of steam shall not be commenced until at least 2 h after final placement of concrete.
- 3 Steam shall be applied at a temperature between 65 °C and 80 °C.
- 4 Excessive rates of heating and cooling shall be prevented during steam curing and temperatures in the enclosure shall not be allowed to increase or decrease by more than 22 °C per hour.
- 5 The maximum steam temperature shall be maintained in the enclosure until concrete has reached its specified strength.

10.2.10 Pavements and other slab on ground

- 1 Curing shall ensure that no plastic shrinkage crack will occur, this can be done by protective measures such as sun shields, wind breaks, evaporation reducers, or fog spraying should be initiated immediately to reduce evaporation.
- 2 Mats used for curing can either be left in place and kept saturated for completion of the curing, or can be subsequently replaced by a liquid membrane-forming curing compound, plastic sheeting, reinforced paper, straw, or water

10.2.11 Buildings, bridges, and other structures

- 1 Additional curing shall be provided after the removal of forms
- 2 After the concrete has hardened and while the forms are still in place on vertical and other formed surfaces, form ties may be loosened when damage to the concrete will not occur and water applied to run down on the inside of the form to keep the concrete wet.
- 3 Care shall be taken to prevent thermal shock and cracks when using water that is significantly cooler than the concrete surface. Curing water should not be more than about 11°C cooler than the concrete.
- 4 Immediately following form removal, the surfaces shall be kept continuously wet by a water spray or water-saturated fabric or until the membrane-forming curing compound is applied. Curing

10.2.12 Mass concrete

- 1 Mass concrete is often cured with water for the additional cooling benefit in warm weather; however, this can be counterproductive when the temperature gradient between the warmer interior and the cooler surface generates stress in the concrete.
- 2 Horizontal or sloping unformed surfaces of mass concrete can be maintained continuously wet by water spraying, wet sand, or water saturated fabrics.
- 3 For vertical and other formed surfaces, after the concrete has hardened and the forms are still in place, the form ties may be loosened and water supplied to run down the inside of the form to keep the concrete wet
- 4 Care shall be taken to prevent thermal shock and cracks when using water that is significantly cooler than the concrete surface. Curing water should not be more than about 11°C cooler than the concrete.
- 5 Curing shall start as soon as the concrete has hardened sufficiently to prevent surface damage.

- 6 For unreinforced massive sections not containing ground granulated blast-furnace slag or pozzolan, curing shall be continued for not less than 2 weeks. Where ground granulated blast-furnace slag or pozzolan is included in the concrete, the minimum time for curing shall be not less than 3 weeks.
- 7 For reinforced mass concrete, curing shall be continuous for a minimum of 7 days or until 70% of the specified compressive strength is obtained, if strength is the key concrete performance criterion. For construction joints, curing shall be continued until resumption of concrete placement or until the required curing period is completed.
- 8 Curing shall not stop until favourable differential temperature is attained and at the approval of the Engineer.
- 9 For mass concrete, thermocouples shall be used to monitor the temperature differential of the concrete.

END OF PART