SPECIAL PROVISION

PROJECT #
PIN #

SECTION 03390S

CONCRETE CURING

Delete Section 03390 and replace with the following:

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Concrete curing materials and methods.

B. This section does not apply to cast-in-place Portland Cement Concrete Pavement or dry cast precast concrete members unless specified otherwise.

1.2 RELATED SECTIONS Not Used

1.3 REFERENCES

A. ASTM C 309: Liquid Membrane-Forming Compounds for Curing Concrete

B. ASTM C 1315: Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete

C. UDOT Quality Management Plans

1.4 DEFINITIONS

A. Curing – Actions taken to maintain moisture and temperature conditions in a freshly placed cementitious mixture to allow hydraulic cement hydration and pozzolanic reactions to occur. The following final curing methods are specified in this Section:
   1. Forms-In-Place Method (FIPM)
   2. Liquid Membrane Curing Compound Method (LMCCM)
   3. Steam or Radiant-Heat Method (SRHM)
   4. Water Method (WM)
   5. Waterproof Cover Method (WCM)

B. Curing Period – The specified duration when specified curing methods must be maintained.

C. f'c – Specified 28-day minimum compressive strength.

D. Final Curing – Procedures implemented after the finishing of concrete to reduce the loss of moisture from the concrete surface.

E. Initial Curing – Procedures implemented anytime between placement and finishing of concrete to reduce the loss of moisture from the concrete surface.

1.5 SUBMITTALS

A. Manufacturer's product data sheets for curing compound, for review
   1. Include recommended installation instructions for information

B. Bridge deck and approach slab curing plan for review including at least the following:
   1. Description of fogging method
   2. Calculation of number of gallons of liquid membrane curing compound required and quantity to be on available site at time of concrete placement
   3. Description of procedure to implement the water method

PART 2 PRODUCTS

2.1 CURING COMPOUND

A. Refer to this Section, Part 3, Tables 1 and 2.

B. Limit Volatile Organic Compounds (VOC) content to 350 grams/liter maximum.

PART 3 EXECUTION

3.1 GENERAL

A. Prevent drying of exposed concrete surfaces after placing concrete and until applying the selected curing method.
   1. Keep exposed bridge deck and approach slab surfaces moist by initial curing with fogging.

a. Use fogging equipment with compressed air misters that atomize the water and produce a very fine mist and not a spray.
    1) Use equipment that allows for adjusting the rate of fogging depending on the conditions that are present.
    2) Maintain misters at least 5 ft above the concrete surface and aimed in a direction not lower than horizontal.
    3) Do not use fogging to apply excess water to the concrete surface to aid finishing.
    4) Do not affect the water/cement ratio of the concrete.
    5) Discontinue fogging when a fine coating of water or sheen is visible on the concrete surface.

2. Do not damage the concrete surface.

B. Cure formed surfaces using the FIPM for as long as practical.
1. Transition immediately to a curing method specified for the element when forms are removed before completing the specified curing period. Refer to this Section, Article 3.4.

3.2 CURE CAST-IN-PLACE CONCRETE

A. Cure exposed surfaces of newly placed cast-in-place concrete according to the curing methods and curing periods in Table 1.
1. Determine concrete compressive strength using field cured cylinders cured the same as the concrete member when compressive strength is used to determine the curing period.

B. Bridge Decks and Approach Slabs
1. Apply liquid membrane curing compound within 20 minutes of the tining or finishing operation.
    a. Use a work bridge that follows immediately after the finishing machine to allow application of the curing compound on bridge decks.
2. Implement the water method on the entire exposed surface of bridge decks, approach slabs, curbs, and sidewalks as soon as the concrete is sufficiently set to support the materials.

C. Concrete Barrier
1. Broom clean the formed surfaces of the barrier after removing forms.
2. Apply curing method to exposed concrete surfaces immediately after finishing operations are completed.

Table 1

Cast-in-Place Concrete Curing Requirements				
Element	Curing Methods for Exposed Surfaces [1]	Curing Period	Curing Compound	
			Type	Application Rate
Bridge Decks and Approach Slabs	• LMCCM and WM	14 days	ASTM C 309, Type I D, Class A	Manufacturer's recommended rate
Closure Pours in Bridge Decks and Approach Slabs	• LMCCM and WM	7 days and f'c [2]	ASTM C 309, Type I D, Class A	Manufacturer's recommended rate
Other Bridge Elements (superstructure, substructure, and foundation elements)	• LMCCM or • WM or • WCM	0.70 f'c or 7 days [2]	ASTM C 309, Type I D, Class A	100 ft^2/gal
Box Culverts [4] (including wingwalls, and aprons), Headwalls, Retaining Walls, Concrete Drainage Structures, Sign Structure Foundations	• LMCCM or • WM or • WCM	0.70 f'c or 7 days	ASTM C 309, Type I D, Class A	100 ft^2/gal
Concrete barrier	• LMCCM or • WM or • WCM	0.70 f'c or 7 days	ASTM C 309, Type I D, Class A [3]	100 ft^2/gal
Curbs, gutters, flatwork, sidewalks, driveways, concrete slope protection, and other concrete items not specified	• LMCCM	7 days	ASTM C 309, Type I D, Class A	100 ft^2/gal

Notes:
[1] Use FIPM for all formed surfaces. Specified curing methods apply to exposed concrete surfaces and any formed surfaces where the forms are removed before the curing period ends.
[2] The curing period for bridge elements that use high early strength concrete may be reduced to the greater of 3 days or the time required to achieve the specified 28 day minimum compressive strength.
[3] A curing compound meeting ASTM C 1315, Type 1, Class A may be used when subsequent removal of curing compound is not required.
[4] Follow the requirements for Bridge Decks and Approach slabs for box culvert top slabs if the box culvert top slab is to be used as a roadway surface.

3.3 CURE PRECAST CONCRETE

A. Cure exposed surfaces of newly placed precast concrete according to the curing methods and curing periods in Table 2.
   1. Determine the concrete compressive strength using field cured cylinders cured the same as the concrete member when compressive strength is used to determine the curing period.

B. Precast Concrete Deck Panels (full depth), and Precast Approach Slabs
   1. Apply liquid membrane curing compound within 20 minutes of the tining or finishing operation.
   2. Implement the water method on the entire exposed surface of the precast element as soon as the concrete is sufficiently set to support the materials.
      a. Including parapets if cast concurrently with the deck or approach slab

C. Precast Concrete Barrier
   1. Broom clean the formed surfaces of the barrier after removing forms.
   2. Apply curing compound to exposed concrete surfaces immediately after finishing operations are completed.

Table 2

Precast Concrete Curing Requirements				
Element	Curing Methods for Exposed Surfaces [1]	Curing Period	Curing Compound	
			Type	Application Rate
Precast Concrete Deck Panels (full depth), Precast Approach Slabs, (includes parapets when cast concurrent with precast deck and approach slab panels)	• LMCCM and WM	14 days	ASTM C 309, Type I D, Class A	Manufacturer's recommended rate
Precast Substructure Elements, Partial Depth Precast Deck Panels (non-prestressed)	• WM or • SRHM	0.7 f′c or 7 days	Not used	Not used
Prestressed Concrete Members (includes all pretensioned concrete members where pretensioning is required in the plans)	• SRHM or • WM or • WCM	Specified release strength (f'ci)	Not used	Not used
Precast Noise Walls, Precast Retaining/Noise Walls, MSE Retaining Wall Panels	• SRHM or • WM or • WCM	0.70 f′c or 7 days	Not used	Not used
Precast Box Culvert Structures and Precast Three-Sided Culvert Structures (wet cast and dry cast)	• SRHM or • WM or • WCM or • LMCCM	0.70 f′c or 7 days	ASTM C 309, Type I D, Class A	100 ft^2/gal
Wet Cast Concrete Drainage Structures (such as manholes, grade rings, catch basin grade sections, pipe end sections, precast inlets and boxes)	• SRHM or • WM or • WCM or • LMCCM	0.50 f′c or 7 days	ASTM C 309, Type I D, Class A	100 ft^2/gal
Modular Block (wet cast)	• WM or • WCM or • LMCCM	0.70 f'c or 7 days	ASTM C 309, Type I D, Class A	100 ft^2/gal

Table 2 (Continued)

Precast Concrete Curing Requirements

	Element	Curing Methods for Exposed Surfaces [1]	Curing Period	Curing Compound	
				Type	Application Rate
	Concrete Barrier	• LMCCM	7 days and until certified according to QMP [2]	ASTM C 1315, Type 1, Class A	100 ft^2/gal
	PCC Pavement Panels	• LMCCM and WM	14 days	ASTM C 309, Type I D, Class A	Manufacturer's recommended rate

Notes:
[1] Use FIPM for all formed surfaces. Specified curing methods apply to exposed concrete surfaces and any formed surfaces where the forms are removed before the curing period ends.
[2] QMP = UDOT Quality Management Plan: Precast-Prestressed Concrete Structures.

3.4 FORMS-IN-PLACE METHOD (FIPM)

A. Cure formed surfaces of concrete by retaining the forms in place without loosening

B. Complete the cure using one of the methods specified for the element when forms are removed before completing the specified curing period.
   1. Apply curing method within 20 minutes of removing the forms.
      a. Protect the concrete surface from losing moisture if the selected curing method is not applied within 20 minutes.
   2. Complete any necessary patching to damaged concrete surfaces when forms are removed before the end of the curing period and the LMCCM will be used to cure the concrete for the remaining cure duration.

3.5 WATER METHOD (WM)

A. Keep concrete surfaces wet by ponding, spraying, or covering with materials that are continuously and thoroughly wet.
   1. Acceptable materials for covering concrete surfaces include cotton mats, multiple layers of burlap, or other materials that retain water.
   2. Secure the cover materials to prevent wind or other forces from removing them.
   3. Keep the cover materials saturated throughout the curing period.
   4. Use a system of continuously active soaker hoses to keep materials thoroughly wet if a waterproof cover is placed over the top of the water method materials.

B. Do not erode or damage the finish.

C. Prevent excess water from impacting traffic on in-service roadways.

3.6 LIQUID MEMBRANE CURING COMPOUND METHOD (LMCCM)

A. Limitations
   1. Do not use curing compounds on surfaces of construction joints against which new concrete will be cast.
      a. Abrasive blast to completely remove known curing compound on joints before casting new concrete against the surface.
   2. Do not use curing compounds on surfaces that require a rubbed finish
   3. Do not use curing compounds on surfaces that will receive a concrete coating or penetrating concrete sealer within 3 months of curing compound application.

B. Apply liquid membrane curing compound uniformly at the rates specified in Tables 1 and 2.
   1. Use an airless power sprayer with a fan tip to apply curing compound.
      a. Do not use a roller to apply curing compound.

C. Immediately repair damage to the curing compound film during the specified curing period by re-spraying.

3.7 WATERPROOF COVER METHOD (WCM)

A. Exposed concrete surfaces must be wet before installing cover.

B. Cover exposed concrete surfaces with a material that prevents moisture loss from the concrete.
   1. Do not use materials that have lost their waterproof qualities.
   2. Place waterproof cover in direct contact with the concrete
   3. Prevent airflow beneath the cover.

C. Use this method only when the covering can be secured adequately to prevent displacement by wind.

3.8 STEAM OR RADIANT-HEAT METHOD (SRHM)

A. Use only for precast concrete members manufactured in prequalified plants.

B. Use a complete steam or radiant heat curing system that includes 24 hour temperature control and monitoring devices.
   1. Use temperature recording devices as necessary to verify that temperatures are uniform throughout the enclosure and within the limits specified.

C. Steam Heat Curing System
   1. Use a suitable enclosure to contain live steam and minimize moisture and heat losses.
   2. Use low-pressure and saturated steam.
   3. Maintain 90 to 100 percent relative humidity in the curing enclosure.
   4. Do not apply heat directly on the concrete or cause localized high temperatures.

D. Radiant Heat Curing System
   1. Apply heat by means of pipes circulating steam, hot oil, or hot water, or by electric heating elements.
   2. Use a suitable enclosure to contain the heat.
   3. Minimize moisture loss by covering exposed concrete surfaces with plastic sheeting.

E. Waiting Period
   1. Do not apply the initial application of heat before the initial set of the concrete except to maintain the minimum temperature within the curing enclosure.
   2. Maintain the temperature within the curing enclosure at not less than 50 degrees F.
      a. Live steam or radiant heat may be used to maintain the curing enclosure at the proper minimum temperature.
      b. Keep the concrete wet during this period.

F. Curing Temperature
   1. Increase the temperature within the concrete during the initial application of heat at an average rate not to exceed 40 degrees F per hour until the curing temperature is reached.
   2. Maintain the concrete temperature at between 50 degrees F and 160 degrees F.
   3. Maintain the curing temperature until the concrete achieves the specified strength for terminating the curing.

4. Decrease the concrete temperature at a rate not to exceed 40 degrees F per hour until reaching a temperature of not more than 20 degrees F above the air temperature to which the concrete will be exposed when discontinuing heat.

G. Transfer the stressing force to the concrete immediately after discontinuing steam curing or radiant heat curing for prestressed members.

END OF SECTION