Mass Concrete Placement

2012 Texas Department of Transportation’s 86th Annual Transportation Short Course

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TxDOT Specification Requirements (Item 420)

• Mass placements are defined as placements with a least dimension greater than or equal to 5 ft., or designated on the plans. For monolithic mass placements, develop and obtain approval for a plan to ensure the following during the heat dissipation period:
  – the temperature differential between the central core of the placement and the exposed concrete surface does not exceed 35°F and
  – the temperature at the central core of the placement does not exceed 160°F.

• Identify the members to require mass concrete controls on the plans and create individual bids items for this concrete.
TxDOT Specification Requirements (Cont.)

- Base this plan on the equations given in the Portland Cement Association’s Design and Control of Concrete Mixtures. Cease all mass placement operations and revise the plan as necessary if either of the above limitations is exceeded. Include a combination of the following elements in this plan:
  - selection of concrete ingredients including aggregates, gradation, and cement types, to minimize heat of hydration;
  - use of ice or other concrete cooling ingredients;
  - use of liquid nitrogen dosing systems;
  - controlling rate or time of concrete placement;
  - use of insulation or supplemental external heat to control heat loss;
  - use of supplementary cementing materials; or
  - use of a cooling system to control the core temperature.
TxDOT Specification Requirements (Cont.)

• Furnish and install 2 sets of temperature recording devices, maturity meters, or other approved equivalent devices at designated locations. Use these devices to simultaneously measure the temperature of the concrete at the core and the surface. Maintain temperature control methods for 4 days unless otherwise approved. Maturity meters may not be used to predict strength of mass concrete.

• Furnish concrete with placement temperature between 50 and 75°F.
What about Drilled Shafts?

• Item 416, “Drilled Shaft Foundations”
  – 416.3.F.Concrete. “Mass concrete placement requirements do not apply to drilled shafts.”
  – Use Class C or Class SS Concrete
  – Could allow up to 700 lbs. cement per cubic yard (Per Item 421, Class SS requires minimum of 650 lbs/CY)
  – Allows up to 95ºF concrete placing temperature
Why do we care?

High Temperature

Thermal Gradients

Pictures from TxDOT ConcreteWorks Implementation 5-4563
What to do about it?

Conduct a Research Study! Why?

• The calculations are tedious

• Guidance provided by ACI and PCA is vague

• Information in literature concerning temperature rise of various materials is dispersed

• The problem becomes even more difficult when cracking tendency is considered. Our specification does not specifically address this!
ConcreteWorks Program
Temperature Prediction

Heat of Hydration
- Cement Composition
- Effect of SCMs
- Cement Fineness
- Amount of Cement
- Chemical Admixtures
- w-cm Ratio
- Mix Temperature

Environmental Cycle
- Air Temperature
- Wind Speed
- Relative Humidity
- Cloud Cover
- Solar Radiation
- Air Pressure

Heat Transfer
- Element Geometry
- Element Size
- Submerged
- Form Properties
- Curing Method
- Surface Color
- Aggregate Type

≤ 35°F ?

Slide from TxDOT ConcreteWorks Implementation 5-4563 – UT CDC
Steps to minimize cracking

• Keep maximum core temperature down
  – Start with a low temperature
  – Use favorable mix
  – Use cooling pipes
• Insulate the forms
• Leave forms in place a minimum of 4 days
• Don’t remove forms in windy, cool conditions
Cooling the Concrete

Compliments to Mark Bloschock, PE
Cooling Pipes
Form Insulation

Photo by Mark Bloschock, PE
Sensor Placement
Temperature Sensor Placement
TABLE OF ELEVATIONS

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<th>PIER 3 NS &amp; SB</th>
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PLAN

(SHOWING NORTHBOUND STRUCTURE)

GENERAL NOTES:
- Collocated Foundation Load = 3160 Tons/Dr. Sh.
- Used to assist in controlling core heat per mass concrete placement specifications. Alternate methods may be submitted and used as approved by the engineer.

COLORADO RIVER BRIDGE

PIER NOS. 2 AND 3

HL93 LOADING

SHEET 1 OF 4

Texas Department of Transportation
Bridge Division

NOTES:
- Rev. 05-03-10
- Used by: SHEAT 1 OF 4
- PLT (Dr. Sh.)
- SHEAT 1 OF 4
- FEDERAL ASSISTANCE

IN}-1

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Texas Department of Transportation
Sensor Location Study

Study Conducted and Finding
Compiled by:
Ryan Barborak, P.E.
TxDOT/CST
Temperature Variation wrt Column Height (Overall Height = 29ft)*
Sensor Placement Location Study

Study and compilation of findings by Ryan Barborak, P.E., TxDOT/CST
Effects of Formwork

Date and Time

11/17/07 11/18/07 11/19/07 11/20/07 11/21/07 11/22/07 11/23/07
12:00 AM 12:00 AM 12:00 AM 12:00 AM 12:00 AM 12:00 AM 12:00 AM

Temperature (°F)

- Rubber
- Steel
- Wood
- Middle

Ranges:
- 40 - 90°F
- 90 - 130°F

Notes:
- 11/18/07 12:00 AM: Rubber
- 11/19/07 12:00 AM: Steel
- 11/20/07 12:00 AM: Wood
- 11/21/07 12:00 AM: Middle
D-C N-W Bent #20 Footing Max. Temp Comparison

ConcreteWorks Theoretical 138°  Actual Recorded Data 142°
Mass Concrete

- TxDOT – Trinity River Footing
  - 8’ Thick Large Footing
  - 3,600 psi Design
  - 533 lbs Cementitious (373 I/II, 160 Cl. F Fly Ash)
  - Concrete Temperature 67 F
  - Limit Core Temperature to 160 F
  - Limit Delta to 35 F
  - ConcreteWorks Predicted 144 F
  - Field results showed 145 F
  - Maximum measured Delta – 35 Through the Thickness
Trinity River Footing Field Results

Footing 13 Field Results

- Time (Hr)
- Temp (°F)
- Core Temp (°F)
- Side Face Temp (°F)
- Top Temp (°F)
- Bot Temp (°F)
- Delta Side
- Delta Top
- Delta Bot

Texas Department of Transportation
Drilled Shaft Study
MASS CONCRETE AT THE US 281 BRIDGE IN MARBLE FALLS
US 281 at Colorado River Bridge
Marble Falls, Texas
US 281 at Colorado River Bridge Crossing
• Original bridge washed out in the ’30s
• Reconstructed in 1936
• Widened in the 1975
• To be replaced in 2010
Project Information

Project Letting: May 2010
Awarded Amount: $28,647,844
Contractor: ARCHER-WESTERN CONTRACTORS, LTD.
96” Drillshaft Cage
Sensors are placed on diagonal X-bracing
Pouring 96” Drillshaf
Placing Temp. Shoring Drill Shafts

Concrete at truck was 75 F – But sensor’s initial reading was 80 F
Removing Remaining Slurry and Water from Concrete
Pouring Pier Base
Pier 2
Pier 2 Concrete Placement
Pier 2 Concrete Placement
Pier 2 Concrete Placement
Pier 2 Concrete Placement
10 Hours Into Pour ~200CY
Completed Pier Table 2 Walls
Pier 3 Drilled Shaft – Upper Sensor Summer Placement

Class SS Concrete
658 lbs/CY Type IP Cement

Sensor Date/Time
Aug 07 00:00 Aug 09 00:00 Aug 11 00:00 Aug 13 00:00 Aug 15 00:00 Aug 17 00:00

Sensor Temperature (°F)
80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165

Sensor 1 (Core) Sensor 2 (Surface)
Pier 2 Drilled Shaft – Lower Sensor
Winter Placement

Class SS Concrete
658 lbs/CY Type IP Cement
Pier 2 Drilled Shaft – Upper Sensor
Winter Placement

Class SS Concrete
658 lbs/CY Type IP Cement
Pier 2 Column – Lower Sensor Spring Placement

Class C Concrete
564 lbs/CY Type IP Cement
Pier 2 Column – Upper Sensor
Spring Placement

Class C Concrete
564 lbs/CY Type IP Cement

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QUESTIONS?