IOWA DOT SPECIFICATIONS FOR MASS CONCRETE

Mass Concrete Workshop

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MASS CONCRETE SPECIFICATIONS

New and Improved!!

DS-15032 *(old)*

Effective 10/20/15

DS-15077 *(new)*

Effective 12/17/19

OVERVIEW

Mass Concrete DS-15077

- **Why is it needed?**
- **What does it require?**
  - From Contractor?
  - From Engineer?
  - From Inspector?

Why do we need a Mass Concrete Specification?

- **Mass concrete placements involve risk.**
- **Excess concrete temperatures can cause:**
  - Concrete chemistry changes.
  - Concrete cracking.
- **DS-15077 is intended to manage mass concrete risk.**

What information do we need?

DOT needs evidence that:

- **The Contractor has a plan to manage risk.**
  - Manage concrete temperatures.
- **The Contractor is following that plan.**
  - Confirmed by DOT inspection.
- **The plan is working.**
  - Specified temperatures are not exceeded.
  - Temperature-related problems are avoided.

How do we manage Mass Concrete risk?

- **Contractor develops a plan.**
  - DS-15077.03.A – Thermal Control Plan
- **Contractor follows that plan.**
  - DS-15077.03.B – Thermal Control Requirements
  - DS-15077.03.C – Production Concrete
- **Contractor monitors and reports on compliance.**
  - DS-15077.03.D – Temperature Reporting
- **Contractor revises plan (with approval) if needed.**
  - DS-15077.03.E – Corrective Actions

MASS CONCRETE: DS-15077

OBJECTIVE:

DS-15077.01.A

Produce a mass concrete placement free of cracks caused or worsened by concrete heat of hydration. Accomplish this through appropriate concrete mix design and control of concrete temperatures and temperature differences.

MASS CONCRETE: DS-15077

APPLICATION:

DS-15077.01.C

Mass concrete is defined as concrete placement with a least dimension greater than 4.5'. If any geometric portion of a placement qualifies as mass concrete, that entire placement shall be considered mass concrete.

TEMPERATURE REQUIREMENTS

Initial Temperature

- Higher initial temp = higher maximum temp.
- Lower initial temp reduce risk.

Maximum Temperature

- Excess maximum temp can cause undesirable concrete chemistry changes.

Differential Temperature

- Excess temperature differences (between concrete center and concrete face) can cause cracking.

INITIAL TEMPERATURE

DS-15077.03.B.1

Default Requirement

- Concrete temperature at the time of placement shall not exceed **70°F**.

Alternate Requirement

- Maximum concrete temperature at the time of placement **may be modified by the TC Engineer when certain conditions are met**.
- In no case shall maximum concrete temperature exceed **90°F**.

MAXIMUM TEMPERATURE

DS-15077.03.B.2

Default Requirement

- The maximum temperature shall not exceed **160°F**.
- **No exceptions** allowed by specification.

DIFFERENTIAL TEMPERATURE

DS-15077.03.B.3.b

Default Requirement

- Maximum temperature difference between the concrete center and concrete face **shall not exceed values in table**:

Table DS-15077.03-1: Temperature Diff. Limits	
Hours after placement	Maximum temperature difference, °F
0-24	20
24-48	30
48-72	40
72	50

DIFFERENTIAL TEMPERATURE

DS-15077.03.B.3.c

Alternate Requirement

- Temperature difference limit **may be modified by the TC Engineer when certain conditions are met**.
- Alternate Temperature Difference (ATD) is **mix specific**.
- Specific ATD **formula must be followed**.

THERMAL CONTROL PLAN (TCP)

15077.03.A.1

Develop and submit a written TCP including:

- Procedures to maintain compliance with specifications.
- Sufficient detail to demonstrate adequate planning.
- Calculations, when needed.

THERMAL CONTROL PLAN (TCP)

15077.03.A.1

General Requirements:

- Do not place concrete until TCP has received written approval.
- Approval of TCP does not relieve Contractor from meeting the specification.

THERMAL CONTROL PLAN (TCP)

TIER 1

- Basic Plan
- 4.5’ – 6.5’ least dimension.
- Engineering not required.

TIER 2

- Expert Plan
- > 6.5’ least dimension.
- Engineering required.

TIER 1 TCP

DS-15077.03.A.2

Least dimension 4.5’ – 6.5’

- Initial concrete placement temps must be kept below 70°F.
- Standard differential temperature requirements apply.

TIER 1 TCP

DS-15077.03.A.2

Tier 1 TCP must include:

- Procedures to satisfy specification (generic).
- Procedures to monitor concrete temperatures.
- Procedures for corrective action if needed.

TIER 2 TCP

DS-15077.03.A.3

Least dimension > 6.5’
(or Contractor’s option)

- Prepared by an expert Professional Engineer.
- Thermal modeling required.
- Alternate initial temp allowed.
- Alternate temp difference allowed.

TIER 2 TCP

DS-15077.03.A.3

Tier 1 requirements plus:

- Thermal properties of mix.
- Predicted concrete temperatures.
- Procedures to satisfy specification (specific).
- Conditions when TCP applies (weather, etc.)

MASS CONCRETE MIX DESIGN

Mass concrete behavior is mix dependent. Mix variables include:

- Heat generation.
- Rate of strength gain.
- Maximum strength.
- Crack resistance.

Mix designs can be optimized for performance. Tier 2 TCP's allow the Contractor to take advantage of this.

TIER 2: ALTERNATE INITIAL TEMP.

Hotter initial temp = hotter max temp

- But…

If the contractor can <u>prove</u> max temps won't be exceeded, hotter initial temps are OK.

- Allowed for Tier 2 plans only.
- Initial temps can't exceed 90°F.

TIER 2: ALT. DIFFERENTIAL TEMP.

Higher temperature differential = higher crack potential.

- But…

If the Contractor can <u>prove</u> their mix can handle it, higher temperature differentials are OK.

- Allowed for Tier 2 plans only.
- Laboratory test results required.
- Specific formula must be used.
- Differential temps can’t exceed 75°F.

THERMAL CONTROL OPTIONS

Contractor selects means and methods to manage concrete temperatures.

- **Max temperature strategies:**
  - Cooler mix design.
  - Pre-cool mix ingredients.
  - Post-cool concrete placement (cooling tubes).
- **Differential temperature strategies:**
  - Mix design + Tier 2 TCP (relax specifications).
  - Insulate/Heat face.
  - Cool core (cooling tubes).

CONCRETE PRE-COOLING

PROS:

- Small temp reductions can be cost effective (water stockpile, batch with ice).
- Helps manage max temperature.
- Reduces duration of thermal control.

CONS:

- Large temp reductions are expensive (liquid nitrogen).

CONCRETE INSULATION

PROS:

- Generally cost effective.
- Helps manage differential temperature.

CONS:

- Slows cooling of element.
- Makes it harder to manage max temperature.

EXTERNAL HEATING

PROS:

- May be cost effective.
- Helps manage differential temperature.

CONS:

- Slows cooling of element.
- Makes it harder to manage max temperature.
- Overheating or drying risk.

INTERNAL COOLING

PROS:

- Significantly shortens thermal control duration.
- Helps with max temp and differential temp.

CONS:

- Expensive and labor intensive.
- Requires source of water.
- Creates voids in element.

So, we have the Contractor's plan… now what?

DOT reviews the plan.

- **RCE –** receives plan.
- **CMB –** reviews plan.
- **BSB –** optional support.

DOT SUBMITTAL REVIEW

DS-15077.03.A

Major items to check for:

- Tier 1 / Tier 2 designation correct?
- Procedures to manage temp?
- Procedures to monitor temp?
- Prepared by a qualified Engineer (Tier 2)?
    - Concrete engineering properties?
    - Predicted concrete temps?
    - Alternate temperature limits?

OK… the plan has been accepted. What next?

Enforce compliance with the plan (RCE Office):

- Concrete protection (insulation or enclosure) per plan?
- Cooling tubes (when applicable) per plan?
- Initial concrete temps per plan?
- Ambient weather conditions (range) per plan?
- Temperature sensor locations per plan?

Monitor concrete temperatures (RCE Office):

- Temperature reports in compliance with DS-15077?

CONCRETE TEMP. MONITORING

DS-15077.03.B.5

- Temps recorded automatically.
- One recording per hour for full duration of thermal control.
- One pair (two sensors) at each location for redundancy.

STANDARD SENSOR LOCATIONS

DS-15077.03.B.5

4 locations normally required.

- Center of mass.
- Side face closest to center of mass.
- Side face second-closest to center of mass.
- Ambient air temperature (see spec requirements).

SPECIAL SENSOR LOCATIONS

DS-15077.03.B.5.e.2)

DS-15077.03.B.5.e.3)

Additional sensors when placements:

- Are very large.
- Within large water bodies.
- Include cooling tubes.
- Other unusual circumstances.

TEMPERATURE REPORTING

DS-15077.03.D

- Data reviewed at 8 hour intervals by contractor.
- Data promptly submitted to DOT.
- Final report within 7 days.
- Standard reporting format.
- Notify DOT of any non-compliant temperatures.

What if the Temperature Limits are exceeded?

DS-15077.03.E

- Future placement of mass concrete shall be suspended.
- Bring concrete into compliance, carefully if feasible.
- Develop a corrective action plan.
- Final determination by the Engineer (DOT). May include price adjustment, repair or replacement.
- All costs shall be Contractor responsibility.

SUMMARY

- **Mass concrete placements have risk.**
- **The contractor needs to manage this risk.**
  - Develop a good plan.
  - Follow the plan.
- **DS-15077 provides specifications for:**
  - Mass concrete criteria.
  - Concrete temperature restrictions.
  - Thermal control plan requirements.
  - Temperature monitoring and reporting.

QUESTIONS?