

28 Day Concrete Strength - Proactive vs. Reactive

PRESENTED TO: MN CONCRETE FORUM

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Low 28 Day Compression Strength

NOW WHAT?

Preparing for the Concrete Placement

- Preconstruction Meeting
 - Discuss placement, testing, and other issues
- Mix Designs
 - Submitted for approval by the design team prior to placement.
 - Number, size of aggregate, cementitious material, water cement ratio.
- Weather Issues
 - Hot and cold, wind
- Logistics
 - How it is placed on site after it leaves the truck
- Sampling Location
 - From truck or end of placement



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On-Site Testing

ASTM Procedures
 ✓ C31
 ✓ C231/173
 ✓ C143

An ACI Certified Technician will follow ASTM Testing Procedures

- C31: Standard Practice for Making and Curing Test Specimens in the Field
- C231: Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
 - Most commonly used
 - Calibration not to exceed three months
- C173: Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
 - Used lightweight aggregate mixes
- C143: Standard Test Method for Slump of Hydraulic-Cement Concrete
 - Considered applicable to plastic concrete having coarse aggregate up to 1-1/2 inch in size
 - Condition of mold may influence test results, calibration at least annually

On-Site Testing



ASTM Procedures
 ✓ C1064
 ✓ C1611

An ACI Certified Technician will follow ASTM Testing Procedures

- C1064: Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
 - Device accurate to +- 1 deg. F and verified at least every 12 months
 - Verification of measuring device to National Institute of Standards and Technology (NIST)
- C1611: Standard Test Method for Slump Flow of Self-Consolidating Concrete
 - Used to monitor the consistency of fresh unhardened self-consolidating concrete and it's confined flow

Visual Stability Index Values

Visual Index	Criteria
0 = Highly Stable	No evidence of segregation or bleeding.
1 = Stable	No evidence of segregation and slight bleeding observed as a sheen on the concrete mass.
2 = Unstable	A slight mortar halo is 10 mm (± 0.5 in.) and/or aggregate pits in the center of the concrete mass.
3 = Highly Unstable	Clearly segregating by evidence of a large mortar halo > 10 mm (± 0.5 in.) and/or a large aggregate pile in the center of the concrete mass.



On-Site Testing

Field Cured Cylinders

Sometimes required on projects, especially during cold weather. Very hard to have the samples match the in-place temperatures of the structure.

Not very representative.

Maturity Curve & Cippocs

Site Storage and Transportation of Test Samples

Initial Curing

- Store immediately after casting
- Temperature
 - 60-80 deg. F < 6000 psi
 - 68-78 deg. F > 8000 psi
- Time on-site up to 48 hrs.

MnDOT Intermediate Curing Period

- Specification 2461.3.G.5
- Time period: less than 7 days

Safe Transportation of Test Specimens

- Transport 8 hours after initial set
- Protect samples
- Transportation time less than 4 hours

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Laboratory Testing



- Certified Lab / Calibrated Equipment
- Final Curing ASTM C31
- Testing C39 or C78
 - Capping / Pad Caps
 - Alignment
 - Size measurements
 - Load rate; 35 +/- 7psi per second

Diameter (in)	Low Rate (lb/in)	High Rate (lb/in)	Average Rate (lb/in)
4	21,120	31,680	26,400
6	47,480	71,220	59,350


Review of Strength Test Results

- 7 Day Test Results
 - Indicator test: typically a 7day strength test will achieve between 67% to 75% of the 28 day test. Depends on amount and types cementitious material content.
- 28 Day Average Strength
 - ACI 318-14: average of two 6x12in or three 4x8in cylinders of the same sample tested at 28 days, or test age designed for f_c
- Break Types
 - ASTM C39 list six types of fracture types.
- Possible Reasons for Low Strength
- Reviewing of Field Test Results
 - Air content, concrete temperature, slump



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Extended Tests


- 56 Day Tests
 - If 28 day test is low, the Hold Cylinder is tested.
- Slow Strength Gaining Concrete
 - Used in mass concrete applications.
 - Compressive strength for acceptance is usually tested at 56 or 90 days.

ACI 318-14 Chapter 26 – Construction Documents and Inspection

- Qualified Testing Staff
 - ACI Grade 1 Certified concrete field testing technician per ASTM C1077, or equivalent program.
- 26.12.3.1 (b)
 - Strength of concrete is satisfactory if both requirements are met:
 - every arithmetic average of any three consecutive tests equals or exceeds f'_c
 - no strength test falls below f'_c by more than 500psi when f'_c is 5000psi or less; or by more than $0.10 f'_c$ if f'_c exceeds 5000 psi

Set Number	28 Day Lab Cure	28 Day Lab Cure	28 Day Lab Cure	Running Average
1	5630	5650	5640	5640
2	4760	4810	4790	4790
3	3870	3890	3880	4770
4	4020	4100	4060	4340
5	4060	4020	4040	3990


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ACI 318-14 Chapter 26 – Construction Documents and Inspection

- Chapter 27.4 Load Testing
 - Not used much for new concrete
 - Can determine the capacity of a structure with questionable strength
 - New or additional loading

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ASTM C42 –
Testing
Concrete
Cores and
Beams

Concrete Strength (ACI 214.4R)

- Core Location: bottom of the structure is stronger than top
- Core Orientation: lower strength when measured parallel to the casting plane

Core Size

- Use 4 in. core bit with a diameter at least 3.70 in., or at least 2X nominal size of course aggregate which ever is larger.

Direction of Drilling

- Report should state the direction of the load on the specimen with respect to the horizontal/casting plane of the concrete as placed.

Storage

- After coring, wipe off surface. Place and keep in plastic bags or nonabsorbent containers at all times except during preparation for a maximum time of 2 hours to permit capping before testing.

ASTM C42 –
Testing
Concrete
Cores and
Beams
(continued)

Length (ASTM C174)

- If the core is used to determine the thickness of pavements, slabs wall or other structural elements, use ASTM C174 procedures.

Density

- If the core will be tested for strength, measure the mass of the prepared core before capping.

Length to Diameter

- If the ratio of length to diameter (LD) of the specimen is 1.75 or less, correct the result by multiplying it by the appropriate factor given in the table in Section 7.9.1. Lengths less than its diameter after capping shall not be tested.

Capping

- Perpendicularity and planeness of the ends of the core needs to meet the specification in ASTM C39. Bonded capping is the most common. Unbonded caps are allowed as long as the gap between the core and retaining ring conforms to requirements of ASTM C1231.

ASTM C42 –
Testing
Concrete
Cores and
Beams
(continued)

Accepted Strength (ACI 318-14 Section 26.12.4.1.d)

- Concrete in an area represented by core tests shall be considered structurally adequate if (1) and (2) are satisfied.
- 1. The average of three cores is equal to at least 85 percent of F_c .
- 2. No single core is less than 75 percent of F_c .
-
- Ultimate acceptance is by the accepting agency typically the structural engineer

Petrographic Analysis

Petrographics is the microscopic analysis of concrete and its aggregate mixes.

ASTM C457 Air Void

- Determines the air content of hardened concrete, void frequency, spacing factor, and paste-air ratio of the air-void system in hardened concrete.

Other Tests

- Carbonation
- Aggregate Types
- Water Cement Ratio
- Bleed Water Tracks
- Cracking



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Thank you!

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