City Engineers Association of Minnesota
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“Appearance,” The Success or Failure Measurement of a Project

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What Goes Into It?

- Aggregates
- Cements
- Supplementary cementitious materials
- Water
- Admixtures

Proportions

- 9 - 15% Cement
- 15 - 16% Water
- 25 - 35% Fine aggregate
- 30 - 45% Coarse aggregate

Paste (cement + water)

Mortar (paste + fine aggregate)

Concrete (mortar + coarse aggregate)
Statewide Sources

- Quarries (482)
- Pits (5,021)
Deleterious Aggregates

- D-cracking carbonates
- Shale & D-cracking carbonate
- Iron oxides & carbonates
- Iron oxides
- Sandstone
- Wx basalt & rhyolite
- Wx phyllite/argillite
- Argillaceous carbonates
Aggregate Characteristics

- Aggregates with common features (e.g., limestone) may have very different properties.
- Aggregates from the same location may also have different properties based on their location within the deposit or formation.
- It is critical to know these differences.
Concrete Durability

- Ability of the concrete to survive the environment to which it is exposed
  - Frost resistance
  - Permeability
  - Sulfate resistance
  - Alkali-silica reaction
  - Abrasion resistance
Resistance to Freezing and Thawing

The most potentially destructive weathering factor is freezing and thawing while the concrete is wet, particularly in the presence of deicing chemicals. Deterioration is caused by the freezing of water and subsequent expansion in the paste, the aggregate particles, or both.
Concrete Permeability

- The ease with which fluids can penetrate concrete
- *All durability damage is governed by permeability*
  - Use low w/cm
  - Use SCMs
  - Cure
  - Minimize cracking
RELATIONSHIP BETWEEN WATER-CEMENT RATIO AND PERMEABILITY

Figure 20.1 Influence of w/c ratio on the permeability of: (a) cement paste [from T. C. Powers, L. E. Copeland, J. C. Hayes, and H. M. Mann, Journal of the American Concrete Institute, Vol. 51, No. 3, 1954, pp. 285–298]; (b) concrete [adapted from Concrete Manual, 8th ed., U.S. Bureau of Reclamation, Denver, Colo., 1975].

"concrete" by Sidney Mindess and J. Francis Young
Curing Compound

• Curing compound is applied to all exposed surfaces of fresh concrete to maintain moisture.

• Adequate moisture allows strength development and has a strong influence on durability.

• Curing should be applied as soon as practical after finishing to achieve these goals.
CIP – 11 Curing in-Place Concrete

• Spraying with a Hudson sprayer needs to follow manufacture coverage specifications.

• Curb and gutter specifications use a white pigmented cure for easy identification of placement.
100 Years Old!!!
Cold Weather Concrete

- Mn/DOT Concrete Office Web Site
- PCA
Common Finishing Tools

• Bull Float and Handle(s)
• Darby
• Float (Magnesium, Resin, or Wood)
• Fresno (Steel Trowel with Handle(s))
• Edger
• Jointer
• Steel Trowels
• Rubber Float
Common Hand-finishing tools
Finishing Concrete
(First Pass/Highway Pavement Finish)

- Bull Floating
- Darbying
- Edging
  (Edge for Subsequent Finishing Passes)
- Jointing
  (Tool Joints Required for Subsequent Finishing Passes)
- Highway Straight Edge
- Time Lapse/Bleeding
- Texture
Bull Floating
Darby
Edging
Time Lapse/Bleeding
Broomed Finish
When **NOT** to use Steel Trowel

- On air entrained concrete
- On any concrete that will be exposed to weather, freezing and thawing.
- (Exterior concrete is not intended to have a sealed surface)
This is not the finish we are looking for on exterior concrete.
Concrete In Practice

CIP 11-C

WHAT is Curing?

Curing is the maintaining of an adequate moist and temperature in concrete at early ages for developing the strength that was designed. Curing begins immediately after placement and continues until the concrete has developed the desired strength.

Without an adequate supply of moisture, the cement in concrete cannot undergo normal hydration, which may result in the concrete becoming weaker than expected. The ability of concrete to absorb and retain moisture is temperature-sensitive. Generally, a concrete pavement should be kept moist for at least 28 days after it is placed and cured. Sufficient curing should be maintained through the time it takes for the concrete to harden and develop its strength.

Wet concrete surfaces can benefit from wet curing, which helps to maintain the moisture content of the concrete. Wet curing is achieved by applying water to the concrete surface after it has hardened. The water helps to slow the rate of evaporation and prevent the concrete from drying too quickly. Wet curing is also important for preventing plastic shrinkage and cracking in concrete.

Wet Curing

- Reduces drying shrinkage and cracking
- Reduces temperature fluctuations
- Improves concrete strength and durability
- Reduces the risk of surface cracks

Why Curing?

- Prevents surface cracking
- Enhances concrete strength
- Improves concrete durability
- Reduces the risk of surface cracks

CIP 12 - Hot Weather Concreting

WHAT is Hot Weather?

Hot weather may be defined as any period of high temperature at which special precautions need to be taken to ensure proper handling, placing, finishing, and curing of concrete. Hot weather conditions can include high temperatures, low relative humidity, and high solar radiation, which can occur at any time, especially in arid or tropical climates. Hot weather conditions can produce a rapid rate of evaporation of moisture from the surface of the concrete and accelerate setting time, among other problems. Generally, high relative humidity tends to reduce the effects of high temperature.

WHY Consider Hot Weather?

It is important that hot weather be taken into account when planning concrete projects. The potential effects on fresh concrete can be significant, including:

- Increased water demand
- Slower setting times
- Reduced concrete strength
- Increased water maintenance
- Increased labor costs

HOW to Conserve Water

1. Reduce the amount of water used in the concrete mix.
2. Use water-conserving equipment.
3. Monitor the water usage and adjust the mix as necessary.

Curing is also important in hot weather conditions, as it helps to maintain the moisture content of the concrete. Wet curing is achieved by applying water to the concrete surface after it has hardened. The water helps to slow the rate of evaporation and prevent the concrete from drying too quickly. Wet curing is also important for preventing plastic shrinkage and cracking in concrete.

Effect of temperature on water requirement of concrete (Ref. 1)

Effect of temperature on concrete setting time (Ref. 2)
Final Thoughts

• Quality mix design
• Quality curing
• Quality contractors
Mn/DOT Specs

- ‘Highway’ specs not residential specs
A Little Math

• Typical Mn/DOT C&G mix
  – 280 lb water (16.6% by volume)
  – 1.5 ft^3 air (5.5%)
  – 500 lb cement (9.4%)
  – 90 lb fly ash (2.0%)
  – 1190 lb sand (26.7%)
  – 1800 lb rock (39.8%)
  – (100.0%)
A Little Math

• Typical Mn/DOT C&G mix
  – 3.5% deleterious material, by weight, allowed by spec in the rock
  – $1800 \times 0.035 = 63\#$/cy of deleterious material
A Little Math

- 12” x 12” x ½” section = 0.0015 CY
- 63# x 0.00154 = 0.097# = 1.6 oz
- If a ½” diameter rock weighs 0.2 oz that is 8 pop-outs / sf or
- 72 pop-outs per SY