Cold Weather Concrete in Colorado

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If you went camping, hiking, or hunting, would you want to be prepared and protected from the elements?
Or unprepared and unprotected?
CONCRETE FEELS THE SAME WAY!

- Why is it important?
- What are some problems?
- How to prevent and protect?
U.S. FREEZE / THAW ZONE MAP

Annual average number of days temperatures fall below 32 °F (0 °C)

- Less than 30
- 30 to 90
- 91 to 150
- 151 to 210
- More than 210
Why is it Important in Colorado?

- Seasonal weather conditions
- Daily temperature fluctuations
- High/strong winds
- Higher elevations
Define Cold Weather
What is Cold Weather?

**Period of 3 consecutive days**
- Average daily temperature is \(<40^\circ F\)
- Air temperature is not \(\geq 50^\circ F\) for 1/2 of 24 hours

**Placement control**
- Prevent damage from freezing at early stages
- Limit rapid temperature changes
- Provide protection consistent with serviceability of structure
Some EXCITING, Completely TECHNICAL stuff!
Effects on Concrete

- **Slows Cement Hydration**
  - A 10°F drop delays setting approximately 2–2½ hours
    - EXAMPLE – If the set time is 6 hours at 75°F, it will be over 10 hours at 55°F
  - Concrete needs to...
    - (1) Set – Plastic to Solid State
    - (2) Harden – Gains Strength
Effects on Concrete

- Slows Cement Hydration
- Slows Initial Setting Time
  - Concrete should be protected from freezing at an early age – *for the first 48 hours* – until it achieves a compressive strength of at least 500 psi
  - Up to 50% strength reduction can occur if concrete freezes before reaching 500 psi
Effects on Concrete

- Slows Cement Hydration
- Slows Initial Setting Time
- **Slows Overall Strength Gain**
  - Compressive strength development will be delayed up to 60% in cold weather...
  - Meaning, if design strength is **3000 psi** in 7 days @ 75°F (for 4000 psi mix), in cold weather, UNPROTECTED, compressive strength at 7 days could be as low as **1200 psi**.
Effects on Concrete

• Slows Cement Hydration
• Slows Initial Setting Time
• Slows Overall Strength Gain
• Danger of Freezing
  • Water begins to freeze in capillaries of concrete at 28°F (air temperature)
  • Water expands up to 9% of its volume when it freezes, causing cracks in the concrete matrix
    • Use an air-entrained concrete mix
Before Placement

• Materials
  • Use of an accelerator
    • Water reducers?
• Minimize water in the mix
• Heated aggregates and water (NEVER exceed 140°F)
• Mix design
  • Use air entrained concrete
  • Use a type III cement or High-Early (HE) strength cement
  • Use additional 100-200 LB/cy add type I cement
Chemical Accelerators

*Use with caution/understanding*

**Non Chloride (or Corrosive) Accelerators (NCA)**
- Required in reinforced concrete or by spec
- Follow manufacturer’s dosage guide

**Calcium Chloride (CC)**
- Only in non-reinforced concrete
- Can increase potential for corrosion and sulfate attack
- Speeds hydration, which increases heat
Placement Conditions

- Schedule appropriately
- Place concrete at the lowest practical slump
- Remove snow, ice and frost from subgrade & contact surfaces (including reinforcing steel and forms)
- Insulate and/or heat subgrade and contact surfaces
  - Subgrade freezes deeper than the top inch exposed to weather
  - Control temperature of reinforcing and forms
- Use of maturity meters to monitor

*Concrete should NEVER be placed on a frozen subgrade*
Improper use or no use at all...
What’s the temperature of my subgrade?
What’s the temperature of my subgrade?
Pop Quiz!

What is wrong with these placements?
Pop Quiz!

What should be expected after placement?
Pop Quiz!

What other considerations should be made on-site?
Pop Quiz!

What happened to the concrete at placement?
Pop Quiz!

Will there be any long-term affects?
Low Ambient Temperatures
Concrete Slab
Frozen Subgrade
Heat during hydration

Frozen Subgrade
What can happen?
Curing Conditions and Time

- Provide protection immediately after concrete placement
- Don’t allow concrete to freeze when saturated
- External heating source
- If dry heat is used, curing compound should be considered
- Don’t water cure in the winter
Protection

- Cover concrete surfaces with insulated blankets, tarps, or straw covered with plastic sheeting to retain heat generated by hydration process
  - Corners & edges are most susceptible to heat loss
- Enclosures may be needed, depending on ambient and site conditions
On the worst days...
Quality Control and Assurance

- Initial curing of specimens
  - Location
  - Storage
  - Temperature monitoring
- Protection for field cured specimens
  - NOT for acceptance

Where?  How?  Range?
Which specimen(s) likely cured properly?
Which specimen(s) likely cured improperly?
Which specimen(s) likely cured slowly?
Prevention

• Prevent concrete from freezing at an early age (first 24-48 hours)
• Assure concrete reaches strength prior to loading or form removal
• Maintain normal curing conditions
• Limit rapid temperature changes
• Provide protection consistent with the intended serviceability of the structure
It Takes Teamwork

- Plan ahead
- Be prepared
- Be concerned
- Schedule work
- Instruct and inspect

Conversation, not Confrontation!
Bottom Line

• A drop in concrete temperature of 20°F will DOUBLE the setting time.
• Plan, plan, plan

“\textit{I’m sure the contractor will understand}”

\textit{~ No One...EVER!}
Question?

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