Extending the Season for Concrete Construction and Repair

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NESMEA
Northeastern States Materials Engineers’ Association
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Winter Concreting (review)

Current Practice

- Not changed since the 1930s
- Thaw substrate
- Pre-heat materials
- Use insulation and heated enclosures

1990s

- Demonstrated antifreeze admixtures
Problem

• No acceptance standard for antifreeze admixtures.
  * Tort Liability
  * Market Size
  * Inertia

• No single commercial admixture significantly lowers the freezing point of fresh concrete.

Solution

• Combine Off-the Shelf Admixtures
  – Already Meet Standards
  – Familiar & Available
  – No Limit on the # of Admixtures
POOLED-FUND STUDY
October 2000 – October 2003
(ID, MI, MT, NH, NY, PA, UT, VT, WI, WY)

FHWA TPF 5-(003)

Objective: develop concrete that can fully cure at below freezing temperatures

Product: tools to design, mix, place, and cure concrete in below-freezing weather
How Normal Concrete Performs

![Graph showing the strength of concrete over time at different temperatures. The x-axis represents age (days), and the y-axis represents MPa. The graph includes curves for room temperature, 40°C, 5°C, and -5°C, with all cured at room temperature.](image)
How Antifreeze Admixtures Work

Combine admixtures to:

- Depress the freezing point
- Accelerate the hydration rate of cement

“Antifreeze Concrete”
Admixtures do not reduce concrete’s freeze-thaw durability
ANTIFREEZE ADMIXTURES:
Cut Time & Cost

-5°C Capability
• 1/3 less cost
• Extends the season

In-place Cost $/m³

Summer
Antifreeze
Winter

60 Days
120 Days
Year Round

ANTIFREEZE ADMIXTURES:
Cut Time & Cost

-5°C Capability
• 1/3 less cost
• Extends the season
### Field Tested

**FHWA Study**

<table>
<thead>
<tr>
<th>Location</th>
<th>Date</th>
<th>Work Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Littleton, NH</td>
<td>10 Dec ’01</td>
<td>Bridge Curbing</td>
</tr>
<tr>
<td>Rhinelander, WI</td>
<td>27 Feb ’02</td>
<td>Pavement</td>
</tr>
<tr>
<td>North Woodstock, NH</td>
<td>12 Dec ’02</td>
<td>Footing</td>
</tr>
<tr>
<td>West Lebanon, NH</td>
<td>18 Dec ’02</td>
<td>Bridge Curbing</td>
</tr>
<tr>
<td>Concord, NH</td>
<td>14 Feb ’03</td>
<td>Sidewalk</td>
</tr>
</tbody>
</table>

**Others**

<table>
<thead>
<tr>
<th>Location</th>
<th>Date</th>
<th>Work Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York, NY</td>
<td>18 Feb ’04</td>
<td>Streets &amp; Sidewalks</td>
</tr>
<tr>
<td>Grand Forks AFB, ND</td>
<td>23 Feb ’04</td>
<td>Airfield slab</td>
</tr>
</tbody>
</table>
CASE STUDY

Bridge Curbing, W. Lebanon, NH
18 December 2002

-15°C

10 a.m.

32m L x 46cm W x 38cm D
Preconstruction Trial Batches

Adjustments Needed:

- Workability
  * Cements Vary Widely
  * Batching Plant Setups Differ

- Zero in on freezing point
  * Agg. Moisture Varies

- Optimize Batch Sequence
  * All at mixing plant
  * Some at plant, rest at job
  * All at job

FP = -4.3°C
FP = -4.7°C
FP = -5.1°C
### Ready-Mix Plant

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
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<tbody>
<tr>
<td>Cement</td>
<td>392 kg/m³</td>
</tr>
<tr>
<td>Aggregate</td>
<td>1083 kg/m³</td>
</tr>
<tr>
<td>Sand</td>
<td>804 kg/m³</td>
</tr>
<tr>
<td>AEA</td>
<td>77 ml/m³</td>
</tr>
<tr>
<td>Type A</td>
<td>584 ml/100kg</td>
</tr>
<tr>
<td>Cor. Inh.</td>
<td>30 L/m³</td>
</tr>
<tr>
<td>Type E</td>
<td>5.87 L/100kg</td>
</tr>
<tr>
<td>Type E dosed but not mixed until truck arrived at jobsite</td>
<td></td>
</tr>
<tr>
<td>W/C</td>
<td>0.37</td>
</tr>
</tbody>
</table>

| Air Content | 8.0%            |
| Slump       | 200mm           |

#### BATCHING

- **First Load**
  - 9:45 – 10:15 A.M.
  - 3.5 m³

- **Second Load**
  - 10:40 – 10:10 A.M.
  - 3.5 m³
PLACING & FINISHING

Traffic Control

10:15 A.M –12°C
CURING

... but for how long?
Maturity
Fast-Track
Measuring the Freezing Point

• Quality Assurance

• Back-calculate water/cement Ratio (Critical to Strength)

Is it good concrete?
Actual Performance

Maturity Curve

Strength Development Curve

7 Days
Cost Comparison
Trues Brook, West Lebanon, NH
18 Dec ‘02

Erect Shelter:  96 mhr
Dismantle:    36 mhr
βHeat Shelter: 364 gal LP
Materials:    48 ea – 2x4x8
              120 m – 1x8 pine
              120 m – strapping
              2 rolls – poly

Heat = $748.47

βAdmixture #1 = $58.69/m³
βAdmixture #2 = $3.52/m³
βAdmixture #3 = $52.34/m³

Admixtures = $700.64

… a chemical substitute for heat. 
... developed an antifreeze technology that produces concrete that can fully cure while its internal temperature is below freezing, and that is as strong and durable as normal concrete cured during the summer.
What We Still Don’t Know

*Phase I – Establishing the Technology*
“… demonstrated the practicality of antifreeze admixtures”

*Phase II – Determining Engineering Parameters*

- Enhanced Durability
- Thermal Safety
- Quality Assurance Tools
- Other Cements
Phase II: Enhanced Freeze-Thaw Durability

**Objective:** The freeze-thaw durability of concrete seems to improve whenever high doses of chemical admixtures are used. This needs to be investigated.
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