Monitoring for Cold Weather Concreting

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Cold Weather Affects on Residential Concrete Foundation Walls

Presented by:
James R. Baty II, Managing Director

Research Results
Phase I, II and III conducted
November, 2002 to July 2003
- Testing Lab Cylinders
- Simulated Field Walls
- Petrographic Investigation

The Research Team
- Research Leader
  Brad Barnes P.E., North Central Engineering, Ltd., Canton, OH
- Suppliers
  Master Builders, Inc., Cleves, OH
  Osborne-Medina Concrete, Medina, OH
  Con-Cure Corporation, St. Louis, MO
  Cremstone Concrete, Minneapolis, MN
- Contractors
  Lacy Concrete Construction, Piqua, OH
  Modern Poured Walls, LaGrange, OH
  Tri-County Excavating Inc., Richfield, OH
  Dependent Foundations, Brighton, MI
  Van Wyks Inc., Waldo, WI
  JC Concrete Inc., Berrien Springs, MI
  Martinson Construction, Washtenaw, IA

A Response to the Market...
2001 – Ohio
Over a dozen projects shut down by inspectors due to "cold weather".
2002 – North Carolina
Contractors are not permitted to place concrete below 50°F.
2001 – Michigan
Contractors routinely and successfully place at sub-freezing temperatures without restrictions.
Policy #099 – Anchorage, Alaska
Concrete strength to reach 1,500psi at 24 hours... submit documentation verifying results
Testing must be provided until concrete reaches 1,500psi when temps fall below 35°F.
Precipice

Need to understand how “cold weather” impacts the residential concrete foundation wall industry.

Existing codes – Protective measures must be taken; Empirical evidence – they may not be necessary or even helpful.

Variations in “local” mixture performance mandates a need for method of validation of in place strengths.

What constitutes cold weather is even debatable. In other words…

The Research Program

Phase I: Laboratory Chiller Cylinders
- 36 mix designs
- 44 maturity curves
- over 650 cylinders cast and tested
- Wide range of mixes from very “lean” to very “rich”
- Two different temperatures, 30°F and 50°F

Phase II: Field Mock-Up Walls
- 6 selected mix designs
- 24-hour blanketed vs. un-blanketed

Phase III: Laboratory Petrographic Studies

Mix Design Variation

<table>
<thead>
<tr>
<th>Qty of Cement (Sacks per CY)</th>
<th>Cement Type</th>
<th>Admixtures</th>
<th>Curing Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>I</td>
<td>None</td>
<td>30°F</td>
</tr>
<tr>
<td>5.5</td>
<td>III</td>
<td>1% Calcium</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>III</td>
<td>2% Calcium</td>
<td></td>
</tr>
<tr>
<td>6.5</td>
<td>III</td>
<td>1% Calcium with MBWR Non-Chloride Accelerator (NCA)</td>
<td>50°F</td>
</tr>
</tbody>
</table>
Research Methodology

- Designed to a “worst-case” scenario for lab cylinders (Phase I) and received “worst-case” scenario for field walls (Phase II).
- Testing represented a significant deviation from standard conditions (no 70° moist cure).
- All 44 lab maturity curves were checked and entered into the maturity testing software.
- All 12 field maturity curves were also checked by maturity.
Type III 5.5-sack mix with 1% CaCl

Compressive Strength of 5 sack mixes with different admixtures

Mix Desc.

Data Set

1 Day 2 Day 3 Day 7 Day 28 Day 180 Day

5-sack Type I 2% CaCl

U (uncov.) 330 560 1040 1740 3410 5530

Cov. (covered) 340 600 1060 1790* 3290* 5765

Matur. (matured) 230 500 810 1450 - -

5.5-sack Type I 2% CaCl

U (uncov.) 410 600 1020 1650 3460 5695

Cov. (covered) 400 590 1000 1815* 3520* 6250

Matur. (matured) 280 580 940 1690 - -

5-sack Type III 1% CaCl

U (uncov.) 500 840 1350 1750 3150 5750

Cov. (covered) 510 870 1470 2035* 3270* 5450

Matur. (matured) 450 1050 1560 2070 - -

5.5-sack Type III 1% CaCl

U (uncov.) 990 1320 1840 2220 4140 5550

Cov. (covered) 990 1370 2110 2710* 4180* 5750

Matur. (matured) 550 1530 2280 2990 - -

6-sack Type III 1% CaCl

U (uncov.) 1400 1870 2500 3030 5250 6500

Cov. (covered) 1550 1970 2620 3360* 4965* 6850

Matur. (matured) 1180 2060 2760 3820 - -

* Average strength of 2 cores taken from the top one foot and center of the same wall panel.
§ Covered with a curing blanket for first 18 hours after it was placed.

Mix 3 Performance

CFA Phase II Study

+48°F +68°F +4°F +24°F +2°F -14°F -17°F -21°F -1°F -4°F +0°F

Stationary Temperature

Top of Wall

Center of Wall

ConCure

6x12 Lab 6x12 Field 4" Core (UB) 4" Core (B) ConCure
Conclusions for Residential Walls

- Concrete temperature not ambient temperature.
- Hydration does not stop at 40°F…strength gain continues well below freezing.
- Maturity prediction can be used to accurately track in-place strengths.
- 500 psi early strength before freezing is reasonable and can be readily achieved.
- Current restrictive codes should be relaxed through new techniques and professional practice.
- Codes should accommodate better quality control and maturity testing.

Conclusions for Residential Contractors

- No single mix answer.
- Selection of a few mix designs supported by maturity testing to confirm local performance.
- Pour earlier in the day – solar gain on concrete mass.
- Type III cements over Type I for performance.
- Economical strength gain from use of calcium chloride.
- Slower strength gain in cold weather – use caution when removing support.