Type IL Cements and Adjustments to the Construction Process

Matt Sheehan, PE
Concrete & Construction Consultants, LLC (3CON)

Iowa Better Concrete Conference
November 9, 2023
Introduction & Affiliations

► Construction or Service Issues
  ▪ Materials
  ▪ Flatwork
  ▪ Structural
  ▪ Mass concrete
  ▪ Moisture

► ACI Committees
Overview

► Type IL cement
► Implementation
► Experiences
► Adjustments
Type IL – Overview

- Ordinary Portland Cement (OPC)
  - ASTM C150 – Portland Cement
  - Type I/II (Type III, IV, V)
  - Limestone: 0 to 5 percent

- Portland Limestone Cement (PLC)
  - ASTM C595 – Blended Cements
  - Type IL (Type IP, IS)
  - Limestone: >5 to 15
Type IL – Local Markets

- Indiana – March 2021 First Type IL SOG
- Supply of Type I/II – Jan to Mar 2022
- Iowa – 2023
- Varies in United States
- Canada – 2008
Type IL – Why?

CONCRETE’S ‘Cobra’ Effect

The unintended consequences of ‘simple solutions’ in reducing embodied carbon in concrete
Concrete’s “Cobra” Effect

- Cement & concrete responsible for 8% of global carbon emissions
- Industry Goal: Carbon Neutral by 2050
- Environmental Product Declarations (EPDs) embodied carbon
- Concrete Paving Industry Sustainability
Concrete’s “Cobra” Effect

► Current approaches to reduce
  - SCMs (fly ash, slag, limestone, kaolin, etc.)
  - Designs (thinner slabs, strength, timber walls, etc.)

► Type IL cement

► Quality curing to develop alternative mixes
  - Wet curing, curing compounds, curing “aids”
  - Nanosilicate internal curing
Embodied Carbon Energy

Comparison of embodied energy of construction materials per ton of product [9]
Cement Production

Industry – Sustainability

The value chain

1. Clinker: Key chemically reactive ingredient
2. Cement: The binder
3. Concrete: Critically useful material to society
4. Construction: Service life / use phase impacts
5. Carbonation: Concrete is a CO₂ sink

Data source: BS EN 15978:2011

Life Cycle Stages of Building Materials - Types of Embodied Carbon
Overview

► Type IL cement
► Implementation
► Experience
► Adjustments
Type IL – Manufacturing

CaCO₃ → CaO + CO₂
1:1 Replacement & Performance

The same durable, resilient concrete you depend on just got better.

Now you can reduce the carbon footprint of your structure with one simple change.

That easy change will have a big, sustainable impact. Swapping out ordinary portland cement (OPC) for portland-limestone cement (PLC) 10% reduces CO2 by roughly 10%. And because PLC works with other supplementary cementing materials, you can still use fly ash or slag to reduce the carbon footprint of your concrete even further.

Ready mix producers know materials in their market and work with many of them. If a material changes, some testing is warranted until they understand how it works with other ingredients in the mix.

A switch to PLC (Type IL) is handled the same way as a switch to any other new material, with an investigation of fresh mixture...
# Material Certification Report

**Brand:** Holcim
**Material:** Blended Cement
**Type:** IL (8)
**Test Period:** 1-Apr-2023 to 30-Apr-2023
**Certification:**
This cement meets the specifications of ASTM C695 and AASHTO M240 for Type IL cement.

### General Information

**Supplier:** Holcim (US) Inc.
**Source Location:** St. Genevieve Plant, 8700 West Byn Mkr Ave, Chicago, IL 60631
**Address:** 2642 US Highway 61, Bloomfield, MO 63337
**Contact:** [Ben Kist](mailto:ben.kist@holcim.com) / (636) 524-8197

The following is based on average test data during the test period. The data is typical of product shipped from this source; individual shipments may vary.

### Test Data on ASTM Standard Requirements

#### Chemical

<table>
<thead>
<tr>
<th>Item</th>
<th>Limit</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂ (%)</td>
<td>17.9</td>
<td>17.9</td>
</tr>
<tr>
<td>Al₂O₃ (%)</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Fe₂O₃ (%)</td>
<td>2.9</td>
<td>2.9</td>
</tr>
<tr>
<td>CaO (%)</td>
<td>60.2</td>
<td>60.2</td>
</tr>
<tr>
<td>MgO (%)</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>SO₃ (%)*</td>
<td>3.0 max</td>
<td>3.5</td>
</tr>
<tr>
<td>Loss on ignition (%)</td>
<td>10.0 max</td>
<td>9.0</td>
</tr>
<tr>
<td>Na₂O (%)</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td>K₂O (%)</td>
<td>0.85</td>
<td>0.85</td>
</tr>
<tr>
<td>CO₂ (%)</td>
<td>5.1</td>
<td>5.1</td>
</tr>
<tr>
<td>Limestone (%)</td>
<td>15.0 max</td>
<td>15.0</td>
</tr>
<tr>
<td>CaCO₃ in limestone (%)</td>
<td>70 min</td>
<td>70 min</td>
</tr>
<tr>
<td>Inorganic process addition (%)</td>
<td>5.0 max</td>
<td>5.0 max</td>
</tr>
</tbody>
</table>

**Mortar Bar Expansion (in %):**

<table>
<thead>
<tr>
<th>Item</th>
<th>Limit</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortar Bar Expansion (in %)</td>
<td>0.02</td>
<td>0.02</td>
</tr>
</tbody>
</table>

#### Physical

<table>
<thead>
<tr>
<th>Item</th>
<th>Limit</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blaine Fineness (m²/kg)</td>
<td>435</td>
<td>435</td>
</tr>
<tr>
<td>Blaine Fineness (μm)</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Blaine Fineness (μm)</td>
<td>0.45 μm (No. 400)</td>
<td>0.45 μm</td>
</tr>
<tr>
<td>Residue (μm)</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Residue (μm)</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Residue (μm)</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Residue (μm)</td>
<td>0.5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

### Optional Requirements

#### Chemical

<table>
<thead>
<tr>
<th>Item</th>
<th>Limit</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equiv. Alkalies (%)</td>
<td>≤ 0.66</td>
<td>0.66</td>
</tr>
</tbody>
</table>

#### Additional Data

<table>
<thead>
<tr>
<th>Type</th>
<th>Limestone</th>
<th>Inorganic Processing Addition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount (%)</td>
<td>11.9</td>
<td>0.0</td>
</tr>
<tr>
<td>SiO₂ (%)</td>
<td>3.8</td>
<td>3.8</td>
</tr>
<tr>
<td>Al₂O₃ (%)</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>Fe₂O₃ (%)</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>CaO (%)</td>
<td>50.9</td>
<td>50.9</td>
</tr>
<tr>
<td>SO₃ (%)</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

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**Notes:**

1. Values in the Limit/Result columns mean Not Applicable.
2. It is permissible to exceed the specification limits provided that ASTM C11030 Mortar Bar Expansion does not exceed 0.02% at 14 days.

This data must have been reported on a previous certification.

December 15, 2022
St. Marys Cement
Charlevoix Cement Plant
16000 Bells Bay Road
Charlevoix, MI 49719
Tel: (231) 347-1362 - Fax: (231) 347-6292

Benjamin Kist, Quality Manager
Type IL – vs. Type I/II Mixes

- 517 lbs./yd$^3$ Type I/II (2.2% Limestone)
  - 11 lbs./yd$^3$ Limestone
  - 506 lbs./yd$^3$ Cement

- 517 lbs./yd$^3$ Type IL (11.9% Limestone)
  - 62 lbs./yd$^3$ Limestone
  - 455 lbs./yd$^3$ Cement
Type IL – Implementation

► 1:1 Replacement
  ▪ Differences/compared to Type I/II
  ▪ Cement shipments timing/availability
  ▪ Trial batches and testing
  ▪ Submittals
  ▪ % Limestone/manufacturing variability

► Strength
Overview

► Type IL cement
► Implementation
► Experiences
► Adjustments
Type IL – Performance/Experience

► Feedback
  ▪ Contractors
  ▪ Concrete suppliers
  ▪ ACI meetings
  ▪ World of Concrete
  ▪ ASCC survey

► Variability + OPC differences

► Depends on location
Type IL – Performance/Experience

- **Strength development**
- **Finishing / Workability**
  - Water demand varies / admixtures
  - Bleeding characteristics vary / unpredictable
  - Setting time (finishing / sawcutting)
  - Cold weather placements / admixtures
  - Delaminations / surface scaling
- **Shrinkage & curling**
- **Surface durability or wear resistance**
- **Aesthetics (Color and uniformity)**
Type IL – ASCC Survey

ACI-ASCC Concrete Floor and Slab Construction Survey on Type IL Portland-Limestone Cement Concrete

ACI 302 and ASCC are collaborating to survey ACI members on their use and experiences with Type IL Portland-limestone cement concrete. Currently, Type IL cement (ASTM C595) is available in about 40% of the United States and in less than a year is likely to be about 80% of the market. The responses will be used to evaluate the current state-of-the-art for Type IL cement concrete to provide feedback to the concrete industry.
Type IL – ASCC Survey

173 Respondents
Type IL – ASCC Survey

Experience problems with Type IL?

<table>
<thead>
<tr>
<th>Profession</th>
<th>Occur at the Same Frequency</th>
<th>Occur at a Lower Frequency</th>
<th>Occur at a Greater Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner</td>
<td>20%</td>
<td>0%</td>
<td>80%</td>
</tr>
<tr>
<td>Architect/Engineer</td>
<td>47%</td>
<td>0%</td>
<td>53%</td>
</tr>
<tr>
<td>Testing Agency</td>
<td>40%</td>
<td>0%</td>
<td>60%</td>
</tr>
<tr>
<td>CM/GC</td>
<td>40%</td>
<td>0%</td>
<td>60%</td>
</tr>
<tr>
<td>Concrete Contractor</td>
<td>26%</td>
<td>2%</td>
<td>72%</td>
</tr>
<tr>
<td>Ready Mix Producer</td>
<td>60%</td>
<td>2%</td>
<td>38%</td>
</tr>
<tr>
<td>Admixture Supplier</td>
<td>11%</td>
<td>0%</td>
<td>89%</td>
</tr>
<tr>
<td>Cement Producer</td>
<td>86%</td>
<td>0%</td>
<td>14%</td>
</tr>
<tr>
<td>Other</td>
<td>30%</td>
<td>0%</td>
<td>70%</td>
</tr>
</tbody>
</table>
Type IL – ASCC Survey

Experience the following w/Type IL?

- Decrease:
  - Water Demand
  - Set Times
  - Bleed Water
  - Crusting
  - Air Content
  - Changes in Finishing
  - Difficulty Pumping
  - EvaporationReducers
  - Difficulty in Dry Shakes

- Increase:
  - Difficulty in Dry Shakes
Type IL – ASCC Survey

Type IL strength vs. OPC?
Type IL – Performance/Experience

 ► Strength development

 ► Finishing / Workability
   - Water demand varies / admixtures
   - Bleeding characteristics vary / unpredictable
   - Setting time (finishing / sawcutting)
   - Cold weather placements / admixtures
   - Delaminations / surface scaling

 ► Shrinkage & curling

 ► Surface durability or wear resistance (Curing)

 ► Aesthetics (Color and uniformity)
Overview

- Type IL cement
- Implementation
- Experience
- Adjustments
Type IL – Strength/Grinding

- Type I/II Blaine Fineness ~ 390 to 420 m²/kg
- Particle Size Distribution (PSD)

Example PSD (differential volume) compared, Type I/II with and without 10% added LS vs. mill-ground 10% LS Type GU

Particle size analyses of individual materials performed using a Beckman Coulter LS 13 320 laser diffraction PSA
Type IL – Blaine Fineness/PSD

- Type IL higher Blaine?
- +100 m²/kg?
- Particle Size Distribution
- Depends on % limestone
- 20% more grinding time
- Production
- Strength – Monitor/TBD
Type IL – Strength Adjustments

- Trial batches and testing
- Historical performance data
- Source / changing sources
- Production variability
  - Materials generally
  - % Limestone
  - Grinding – Blaine fineness or PSD
  - More cement?
- QA/QC Testing (ASTM C31)
Type IL – Scaling
Type IL – Finishing/Processes
Type IL – Finishing/Processes
Type IL – Finishing Adjustments

- Experience based skills / processes
  - Bleeding
  - Setting
  - Timing
  - Variability / different

- Source / changing sources or production
  - % Limestone
  - Grinding – Blaine fineness or PSD

- Field bleeding and setting tests
Type IL – Cold Weather Adjustments

ACI PRC-306 Guide to Cold Weather Concreting

- Manage placement temperatures/conditions
- Heated mix water
- Heated aggregates
- Increase cement / decrease SCMs
- Curing and protection period length
- Accelerating admixture dosages
OPC – Curing Processes

Source: Gomaco
OPC – SOG Curing/Appearance
Type IL – Curing Options/Risk

- Full development of strength and durability characteristics
- Placement & protection conditions
- Common approaches
  - Wet cure (ASTM C171)
  - Membrane forming (ASTM C309)
  - Cure & seal (ASTM C1315)
  - Tilt-up bond breakers
  - Silicate-based “curing aids”
Type IL – SOG Curing/Appearance
Type IL – Curing Adjustments

► Strength and durability characteristics more susceptible?

► Processes: More robust methods for certain applications + longer?
  - Curing/protection environment
  - % Limestone
  - SCM
  - Functional + Aesthetics
Type IL – Adjustments

► Re-evaluate practices and processes

► Strength
  ▪ Trial batches and testing
  ▪ Historical performance data

► Finishing
  ▪ Field bleeding and setting tests
  ▪ Timing varies significantly (cold weather)

► Curing
  ▪ Full strength and durability potential
Questions?

Matt Sheehan, PE
MSheehan@three-con.com
847-636-9135