Portland-Limestone Cement (PLC)
Nicolas Marks

As you are all aware, there’s a lot of talk around the climate impact and sustainability of building materials, specifically cement and concrete.

CO2 problem?

CO2 opportunity!

Paving the Way to Zero Emissions From Cement
Can the World’s Most Polluting Heavy Industries Decarbonize?

Climate change: The massive CO2 emitter you may not know about

PCA members have committed to the goal of reaching carbon neutrality throughout the cement-concrete-construction value chain by 2050.

Roadmap to Carbon Neutrality (cement.org)
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8.1 Million Metric Tons of CO2 would have been saved if the US used 100% Portland-Limestone Cement in 2019

Statement taken from greenercement.com (PCA); Image from Cement Association of Canada contemporary promotion

THIS IS LIKE TAKING 1,753,776 CARS OFF ROADS ANNUALLY...

-or-
37,572 Homes’ Energy Use for the Year

-or-
The Carbon Sequestered by 10,601,334 Acres of US Forests for 1 year

Source: greenercement.com, which provides a link to the USEPA Greenhouse equivalence calculator Slide taken from Cement Association of Canada contemporary promotion
U.S. Standards

Cementitious Materials and Concrete Standards

C150 portland cement – up to 5% limestone, Type I or II most common
C595 blended cement – 5% to 15% limestone, Types IL and IT. Also pozzolan and slag blended cements, Type IP and IS
C1157 hydraulic cement – can contain limestone in varying amounts. Types GU, HE, MS, HS, MH, LH
C94 ready-mixed concrete – equal recognition of C150, C595, and C1157 and equal handling of SCMs

Long Track Record

Blended limestone cements

History of good performance, even at higher limestone contents than the U.S.
Europeans introduced in the late 1960s
Canada has used them since the late 2000s
U.S. standards in place since 2012 (even earlier as C1157 performance cements)
Market share for blended cements grows as users gain comfort working with them
History of Limestone in Cement

- 1983 CSA A5 allows up to 5% limestone in Portland cement
- 2004 ASTM C 150 allows 5% in Types I-V
- 2006 CSA A3001 allows 5% in other Types than GU
- 2007 AASHTO M85 allows 5% in Types I-V
- 2008 CSA A3001 includes PLC containing 5%-15% limestone
- 2012 ASTM C595/AASHTO M 240 include PLC

DOT Acceptance of Portland-Limestone Cements

How do I specify Portland-Limestone Cements?

Specifying PLC for use in concrete is not complicated, it only requires one change to project specifications:

ASTM C150 Type I/II Portland Cement
How do I specify Portland-Limestone Cements?

Specifying PLC for use in concrete is not complicated, it only requires one change to project specifications:

- ASTM C150 Type I/II Portland Cement
- ASTM C595 Type IL

How do I specify Portland-Limestone Cements?

Specifying PLC for use in concrete is not complicated, it only requires one change to project specifications:

- ASTM C150 Type I/II Portland Cement
- ASTM C595 Type IL

If concrete requires special properties, such as sulfate resistance, a qualifier can be added to the IL designation:

<table>
<thead>
<tr>
<th>Cement type</th>
<th>OPC C150</th>
<th>PLC C595</th>
</tr>
</thead>
<tbody>
<tr>
<td>General use</td>
<td>I</td>
<td>IL</td>
</tr>
<tr>
<td>moderate sulfate resistance*</td>
<td>I (LSH)</td>
<td>I (LSH)</td>
</tr>
<tr>
<td>moderate heat of hydration</td>
<td>I (FHR)</td>
<td>I (FHR)</td>
</tr>
<tr>
<td>high sulfate resistance</td>
<td>V (LSH)</td>
<td>I (LSH)</td>
</tr>
<tr>
<td>low heat of hydration</td>
<td>F</td>
<td>I (UH)</td>
</tr>
</tbody>
</table>

What is PLC?

A greener cement option

A blended cement with additional limestone content, optimized for performance

The easiest way to reduce your carbon footprint by about 10%

Suitable for buildings, bridges, pavements, geotechnical applications

Availability continually increases

Mix Designs with PLC

Proportioning, batching, and mixing

PLC replaces ordinary portland cement at 1:1 ratio

PLC allows for the same dosages of fly ash or other pozzolans, slag cement

As with any new material, some testing is warranted to confirm effect fresh and hardened properties

Air content, slump, bleed potential, setting time, compressive strength

Some producers report no adjustments are needed, others tweak proportions or adjust admixture dosages
### Mix Designs with PLC

Typical effects on fresh and hardened properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workability</td>
<td>Increase or decrease depending on admixtures</td>
</tr>
<tr>
<td>Bleeding</td>
<td>Decrease with increasing limestone fineness</td>
</tr>
<tr>
<td>Setting time (initial, final)</td>
<td>Can be slight decrease with increasing limestone fineness</td>
</tr>
<tr>
<td>Heat of hydration</td>
<td>Slight increase at early ages (up to 48 hours)</td>
</tr>
<tr>
<td>Compressive strength</td>
<td>Can increase slightly</td>
</tr>
<tr>
<td>Scaling and freeze-thaw resistance</td>
<td>Use same techniques as with OPC concrete mixes: Proper air-void systems, curing, higher strengths</td>
</tr>
<tr>
<td>Sulfate resistance</td>
<td>Use same techniques as with OPC concrete mixes:</td>
</tr>
</tbody>
</table>

### Working with PLC Mixes

Normal operations for:
- Placing
- Finishing
- Curing

As fineness increases, may see:
- Slightly less bleed water
- Slightly shorter setting times
- Slightly higher water demand

Virtually the same handling and performance as OPC

### Performance of PLC Concrete

Field Trials: Pavement slab after one winter

<table>
<thead>
<tr>
<th>Mix</th>
<th>Field Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLC + 25% SCM</td>
<td></td>
</tr>
<tr>
<td>PLC + 50% SCM</td>
<td></td>
</tr>
<tr>
<td>PC + 25% SCM</td>
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</table>

### How Limestone Works

- Particle packing
  - Improved particle size distribution
- Nucleation
  - Surfaces for precipitation
- Chemical reactions
  - Only a small amount, but...
Green America Recycling Expansion Project

April 22, 2021

Hannibal Type I-II
Hannibal Type I-II

Summary

- A Portland cement with additional limestone content, optimized for performance
- Compared to C150 cements, PLC reduces carbon footprint of concrete by about 10%
- Portland cements are easily replaced by Portland-Limestone Cements (1:1)
- Complimentary to the use of supplementary cementitious materials
- Suitable for buildings, bridges, pavements, geotechnical applications

More info

Calculator for CO2 savings
Benefits of PLC
Spec language
Case studies
FAQs
Contact an expert
THANK YOU!!!

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