About the Presenter

Jamie Farny is the Director, Building Marketing for Portland Cement Association. He promotes the use of cement-based materials for buildings and other applications by focusing on sustainability, resilience, energy efficiency, durability, and other key benefits.

He assisted with development of PCA’s new campaign to raise awareness of portland-limestone cements (PLCs) for improved sustainability of concrete construction.

As a voting member of numerous committees of ACI, ASTM, and The Masonry Society, he works to develop technical guides, codes, and standards related to materials, design, and construction using cement, concrete, and masonry.

He holds a B.S. degree in Civil Engineering from the Illinois Institute of Technology.
PLC and Paving
A decade of experience for sustainable concrete pavements

American Jobs Plan

Modernize highways, roads, and bridges

Transportation needs continue to grow

Jobs Plan prioritizes resilient infrastructure and recognizes sustainable building materials (such as PLC)

Jobs Plan increase for research investments & tax incentives for emerging technologies aligns with industry’s efforts to drive down its carbon intensity

Administration has tied infrastructure program to investing in industry & solutions that:

  Help US/economy recover from the pandemic
  Look for ways to build more sustainably

New $$? Sustainable construction: PLC concrete
A focus on cement and concrete

CO2 Footprint of Construction

CO2 problem?
CO2 opportunity!

Whether you are hearing about this from your customers or not, you will soon

PLC is proven technology

PLC can help position concrete pavements as more sustainable

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

Readily available throughout the U.S. and Canada
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

U.S. Standards

Cementitious Materials and Concrete Standards
ASTM/AASHTO

C150/M 85 portland cement – up to 5% limestone, Type I or II most common

C595/M 240 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/M 157 ready-mixed concrete – equal recognition of C150, C595, and C1157 and equal handling of SCMs
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</td>
</tr>
<tr>
<td></td>
<td>No significant effect on admixtures</td>
</tr>
<tr>
<td>Bleeding</td>
<td>Decreases with increasing limestone fineness</td>
</tr>
<tr>
<td></td>
<td>Generally of no concern</td>
</tr>
<tr>
<td>Setting time (initial, final)</td>
<td>Can be slight decrease w/increasing limestone fineness</td>
</tr>
<tr>
<td></td>
<td>Not a concern even up to 15% limestone</td>
</tr>
<tr>
<td>Heat of hydration</td>
<td>Slight increase at early ages (up to 48 hours)</td>
</tr>
<tr>
<td></td>
<td>But less significant at later ages</td>
</tr>
<tr>
<td>Compressive strength</td>
<td>Can increase slightly</td>
</tr>
<tr>
<td></td>
<td>Both early-age and long-term strengths</td>
</tr>
<tr>
<td>Scaling and freeze-thaw resistance</td>
<td>Use same techniques as with OPC concrete mixes:</td>
</tr>
<tr>
<td></td>
<td>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>
<tr>
<td></td>
<td>Low w/c (or w/cm) and MS or HS designations</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

A look at hardened properties

**Strength**
- OPC to PLC comparisons
- With and without SCMs

**Durability**
- Scaling
- Freeze-thaw resistance
- Chloride permeability
- ASR resistance
- Sulfate resistance
- Field trial results
Performance of PLC Concrete

Early age strength development with and without SCMs

Later age strength development with and without SCMs

Thomas and Hooton 2010
Performance of PLC Concrete

"Permeability" T277/C1202

Charge Passed (Coulombs)

<table>
<thead>
<tr>
<th></th>
<th>28 days</th>
<th>56 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No SCM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W/CM = 0.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35% Slag</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W/CM = 0.45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20% Fly Ash</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W/CM = 0.45</td>
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</table>

Thomas and Hooton 2010

Performance of PLC Concrete

Chloride profiles for cores immersed in NaCl solution

Chloride (% by mass of concrete)

PC - 0% SCM
PC - 25% SCM
PC - 50% SCM
PLC - 0% SCM
PLC - 25% SCM
PLC - 50% SCM

Blair and Delagrave 2012
Performance of PLC Concrete

Scaling resistance (ASTM C672)

Mass Loss (g/m²)

Supplementary Cementing Materials (w/cm)

Thomas et al. 2010

Performance of PLC Concrete

Freeze-Thaw Resistance (ASTM C666)

Durability Factor

Supplementary Cementing Materials (w/cm)

Thomas et al. 2010
Performance of PLC Concrete

Field Trials: Pavement slab after one winter

![Image of pavement slab after one winter]

<table>
<thead>
<tr>
<th>Test (age when expansion reported)</th>
<th>PC + 25% SCM</th>
<th>PLC + 25% SCM</th>
<th>PC + 50% SCM</th>
<th>PLC + 50% SCM</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMBT (14 days)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPT (1 Year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>ACPT (3 months)</td>
<td></td>
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</tbody>
</table>

ASR resistance

Graph showing expansion (%)

Test (age when expansion reported)

Thomas et al. 2010
PLC for Special Properties

Cement modifiers

- Sulfate resistance – MS, HS
- Sulfate-containing soils
- Sulfate-containing groundwaters
- Heat of hydration – LH, MH
- Not generally required

<table>
<thead>
<tr>
<th>Cement type</th>
<th>OPC C150 (M 85)</th>
<th>PLC C595 (M 240)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General use</td>
<td>I</td>
<td>IL</td>
</tr>
<tr>
<td>moderate sulfate resistance</td>
<td>II, II(MS)</td>
<td>IL(MS)</td>
</tr>
<tr>
<td>moderate heat of hydration</td>
<td>II(MH)</td>
<td>IL(MH)</td>
</tr>
<tr>
<td>high sulfate resistance</td>
<td>V</td>
<td>IL(HS)</td>
</tr>
<tr>
<td>low heat of hydration</td>
<td>IV</td>
<td>IL(LH)</td>
</tr>
</tbody>
</table>

PLC and Sulfate Resistance

Same approach as for other blended cements

- Use additional SCMs and low w/cm
- Use moderate- or high-sulfate resistant types:
  - Type IL(MS)
  - Type IL(HS)
  - Type IT(MS)
  - Type IT(HS)

Performance confirmed by numerous research studies and decades of field exposures on real-world installations

![Graph showing Fly Ash Mixes Standard C1012 23C](image-url)
PLC and Heat of Hydration

Temperature control for pavements

Warm weather
Not necessary
Mass placements uncommon for pavements (less than 3 ft (1 m) thick)

Cold weather
Not appropriate
Similar to OPC, may need set accelerators or blankets to maintain fresh concrete temperature as placed

Procuring PLC Concrete

Basics of specifying and ordering

A simple revision to specifications: 1:1 replacement of OPC with PLC
Same suppliers for your ready mix
Same delivery and placing equipment
Specifying PLC Concrete

Parallel standards for Type IL

ASTM and AASHTO specifications

Adoption varies by state

ASTM C595 Type IL cement instead of ASTM C150 Type I portland cement

Or AASHTO M 240 Type IL cement instead of M 85 Type I portland cement

greenercement.com

A new resource

Calculator for CO2 savings

Benefits of PLC

Spec language

Case studies

FAQs

Contact an expert

Informative videos

Mobile friendly
Greener Roads for Right Now!

“Excellent durability and improved sustainability”

Proven technology
Easy to implement
Sustainable, resilient pavements

These states were some early adopters of PLC concrete pavements – more than a decade ago:

- Colorado
- Utah
- Oklahoma

One Colorado Example

US HWY 287 Near Lamar

Built in 2008 – more than a decade of service
Carries heavy trucking & commerce, US - Mexico
Summertime construction – hot and dry (100°F)

- 7 miles paving and shoulder widening
- PLC (10%L), 20% Class F fly ash
- 695 psi average 28-day flexural strength
- Contractor received quality incentive from CDOT
ACPA Activities

Portland-Limestone Cements for Pavement Applications

ACPA Position Paper May 2020

PCA worked with ACPA to address PLCs for paving

“ACPA supports and encourages PLCs for economic and environmental benefits”

FHWA encourages DOT’s use of PLCs for more sustainable concrete pavements

Point users toward greenercement.com

ACPA reports lots of interest in this

greenercement.com

PLC partners

Working with many industry groups to raise awareness and educate about PLC

In addition, PCA is creating a roadmap to carbon neutrality by 2050:

5C’s: clinker, cement, concrete, construction, and carbonation

PLC is a key component of the roadmap, and as already shown, it’s a market-ready, proven, and effective way to reduce your CO2 by about 10%

Asking for PLC is a change you can make today
PLC for Paving Applications

NCC Spring 2021 Webinars