Improving Sustainability with Portland Limestone Cement
2-4-2022
What is portland limestone cement (PLC)?

- Blend of portland cement and 5-15% limestone
- Meets ASTM C595 – Type IL
- Benefits:
  - Reduced GWP
  - Same performance as portland cement
    - Strength
    - Durability
  - Replacement levels with SCM’s
  - MS = Moderate sulfate resistance (Type II)
  - HS = High sulfate resistance (Type V)
What does Green mean?
Paper vs. Polyfoam Attributes

Paper takes about 100 years to break down versus 300 plus for polyfoam.

Production cost is 2.5 times higher for paper cup.

Embodied Energy:
- Paper: 0.55 MJ/cup
- Polystyrene: 0.20 MJ/cup

Chlorine, sodium chlorate, and sulfuric acid production 10 to 40 times higher for paper cup by mass.

300 times more wastewater produced by paper cup production than polyfoam production.

Paper cup results in 1.3-1.8 more emissions than polyfoam cup (including CO₂)

WHAT DOES GREEN MEAN(T)?
For Canada and US by 2050

• 1.5°C Metric
• 100% Clean Energy Economy
• Net Zero Emission Basis

Strategy: Canada’s carbon tax

• $20/MT in 2019
• $50/MT in 2022
• Announced $170/MT by 2030

Strategy: US

• Sustainability plan expected in near future
• Discussed cutting all electrical emissions by 2035
How might this affect us?

2005 Sources of CO₂

- Fossil Fuel Combustion: 5,751.2 TgCO₂ Eq.
- Non-Energy Use of Fuels
- **Cement Manufacture**
- Iron and Steel Production
- Natural Gas Systems

Source: epa.gov
Question – Which one is more nutritious?
Last Question – Which one is more nutritious?
Subd. 3. **Implementation.** (a) By January 1, 2019, the commissioner shall establish and publish a maximum acceptable global warming potential for each category of eligible materials in accordance with both of the following requirements:

(1) the commissioner shall set the maximum acceptable global warming potential at the industry average of facility-specific global warming potential emissions for that material. The department shall determine the industry average by consulting nationally or internationally recognized databases of environmental product declaration.
Portland-Limestone Cements

- Type IL
  - A “binary” blended cement (portland cement + limestone)
  - Between 5% and 15% limestone content
How does PLC fit in?

PLC Environmental Benefits – About 10% Better

- Plant 1
- Plant 2
- Plant 3

kg CO₂/kg cement

- Portland cement
- Portland-limestone cement

Schmidt 1992
Transparency: EPDs for 3,000 psi Concrete

Replacing OPC with PLC would offer a further reduction of about 10% for each mix.
Where does CO₂ come from?

Clinker Production: Two Major Sources
- Pyro Processing – 40-50%
- Calcination (conversion of CaCO₃ to CaO) – 50-60%

On average in the US, 922 KG of CO₂ equivalent is produced for every 1000 KG of portland cement. Source: 2021 PCA Industry Average
What is the finished cement production process?

ASTM C150 portland cement

Clinker  Gypsum  Limestone

Supplementary Cementitious Materials (SCMs)

ASTM C595 Blended Cement & ASTM C1157 Performance Cements
- Reduction in clinker factor and GWP
- Current US average clinker factor ~0.90
How?
Performance of PLC Concrete

- **Strength**
  - OPC to PLC comparisons
  - With SCMs
- **Durability**
  - Scaling
  - Freeze-thaw resistance
  - Chloride permeability
  - ASR resistance
  - Sulfate resistance
  - Field trial results
Performance: Strength

Graphs showing the strength of concrete at 1 day and 7 days with different proportions of SCM (No SCM, 35% Slag, 20% Fly Ash) and comparison with PC and PLC-12%.
Performance: Strength

Strength at 28 days

Strength at 56 days

Compressive Strength (MPa)

Compressive Strength (psi)

No SCM  35% Slag  20% Fly Ash

No SCM  35% Slag  20% Fly Ash

Thomas and Hooton 2010
Performance: “Permeability” T277/C1202

![Bar chart showing permeability over 28 and 56 days for different cement mixtures.](image)

- **Charge Passed (Coulombs)**
- **28 days**
  - No SCM, W/CM = 0.40
  - No SCM, W/CM = 0.45
  - 35% Slag, W/CM = 0.40
  - 35% Slag, W/CM = 0.45
  - 20% Fly Ash, W/CM = 0.40
  - 20% Fly Ash, W/CM = 0.45

- **56 days**
  - No SCM, W/CM = 0.40
  - No SCM, W/CM = 0.45
  - 35% Slag, W/CM = 0.40
  - 35% Slag, W/CM = 0.45
  - 20% Fly Ash, W/CM = 0.40
  - 20% Fly Ash, W/CM = 0.45

Legend:
- PC
- PLC

Thomas et al. 2010
Freeze-Thaw Resistance (ASTM C666)
Why are you really here?

Working with PLC Mixes

- PLC replaces OPC 1:1
- Mix adjustments:
  - No change to SCM dosage
  - Admixture dosage may require minor adjustments
- Normal operations for:
  - Batching
  - Mixing
  - Placing
  - Finishing
  - Curing
- Virtually the same handling and performance as OPC
Acceptance
DOT Acceptance of Type IL Cement

Source: Portland Cement Association, April 2020
Where is it accepted?

American Concrete Institute

Federal Aviation Administration

US Army Corps of Engineers®

INTERNATIONAL CODE COUNCIL®

ASTM INTERNATIONAL

MasterSpec®

a product of The American Institute of Architects
4.1.2.3 *Concrete materials*—The information for concrete materials in 4.1.2.3(a) through 4.1.2.3(g), along with evidence demonstrating compliance with 4.2.1.

4.1.2.3(a) For cementitious materials: types, manufacturing locations, shipping locations, and certificates showing compliance with ASTM C150/C150M, ASTM C595/ C595M, ASTM C618, ASTM C989/C989M, ASTM CI157/ C1157M, or ASTM C1240.
What is our ask? *Allowance*

**Update** Project Specifications to match industry standards
- ACI 318 – 2019
- ACI 301 – 2020
- AIA MasterSpec
- IBC/IRC

**Allow** blended cements
- ASTM C595 Specification for Blended Cements
- ASTM C1157 Specification for Blended Cements

**Allow** SCMs
- ASTM C618 Fly Ash, Natural Pozzolans
- ASTM C989 Slag Cement
- ASTM C1240 Silica Fume
Where can I look for more information?

OneCem Type IL is a **Portland limestone cement (PLC)**. For more information on the industry-wide PLC movement visit [www.greenercement.com](http://www.greenercement.com)

- Case Studies
- US Fact Sheet
- How to specify

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**Portland-Limestone Cement U.S. Fact Sheet**

A lower carbon cement that has already reduced CO2 emissions in the U.S. by more than 325,000 metric tons is available now, which is equivalent to the carbon stored in over 400,000 acres of forest for a year. And that's just the beginning.
Durability of Portland Limestone Cement Concrete

Testing mixtures for an infrastructure project

by Neal S. Berke, Ali N. Inceefe, Allan Kramer, and Oscar R. Antommattei
Questions?

Joseph Clendenen, PE, LEED AP
Technical Service Engineer | Holcim
Midwest US Region
joseph.clendenen@lafargeholcim.com

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