

The logo for the Portland Cement Association (PCA) features the letters 'PCA' in a bold, white, sans-serif font. A white swoosh underline is positioned beneath the 'A', and a registered trademark symbol (®) is located to the right of the swoosh.

**PCA**®

*Since 1916*

**America's Cement Manufacturers™**

**Portland Cement Association**

**Portland-Limestone Cements  
PLC, Type II**

**Paul D. Tennis, Ph.D., FACI, FASTM**

# CO2 and Sustainability

## We can't ignore this

Increased pressure to reduce our environmental impact from many groups: designers, regulators, even the public

CO2 footprint of cement production

US – ~ 1.25%

Worldwide – 5% to 8%

Concrete is so essential to the way we live, that our industry must do its part to address climate issues

**CALIFORNIA'S  
CEMENT INDUSTRY**  
FAILING THE CLIMATE CHALLENGE



**Guardian concrete week**

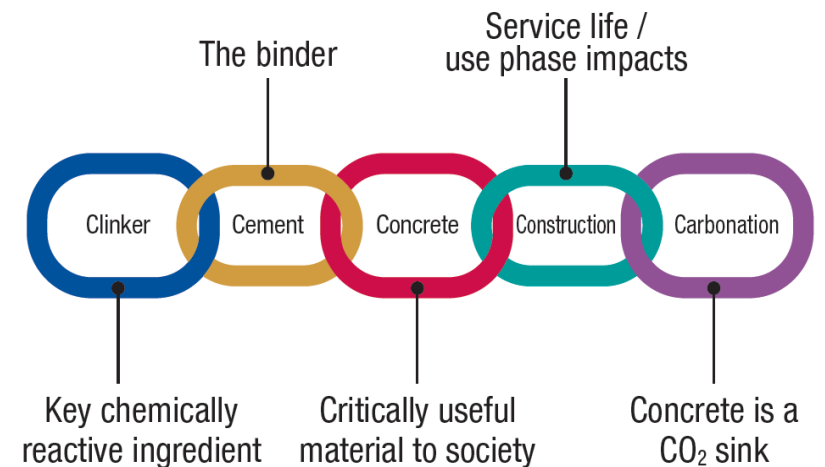
**Concrete: the most  
destructive material on  
Earth**

# PCA Roadmap to Carbon Neutrality

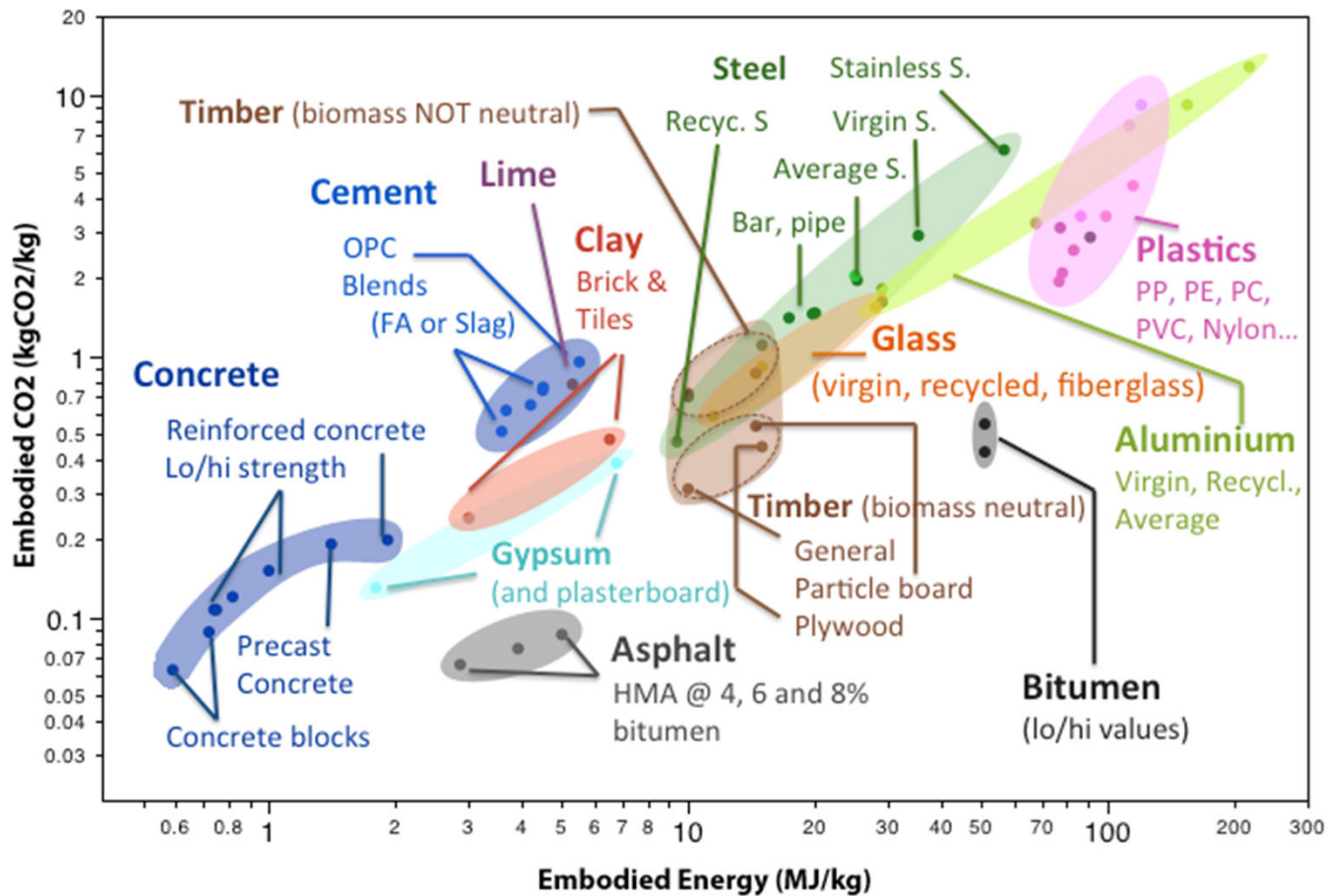
## CO2 and Sustainability

Blended cements like PLC can help make concrete as more sustainable

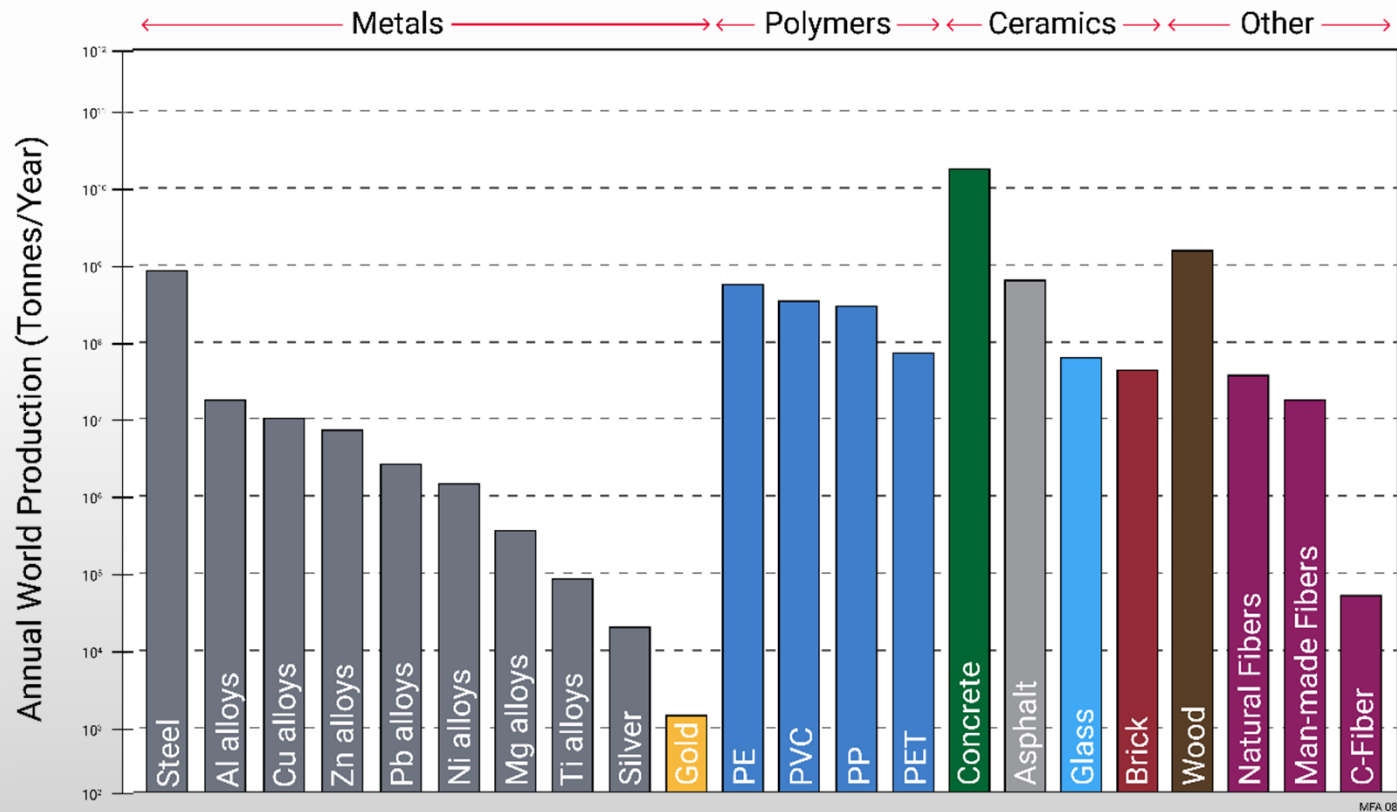
[Roadmap executive summary](#)



# Concrete /S Environmentally Friendly



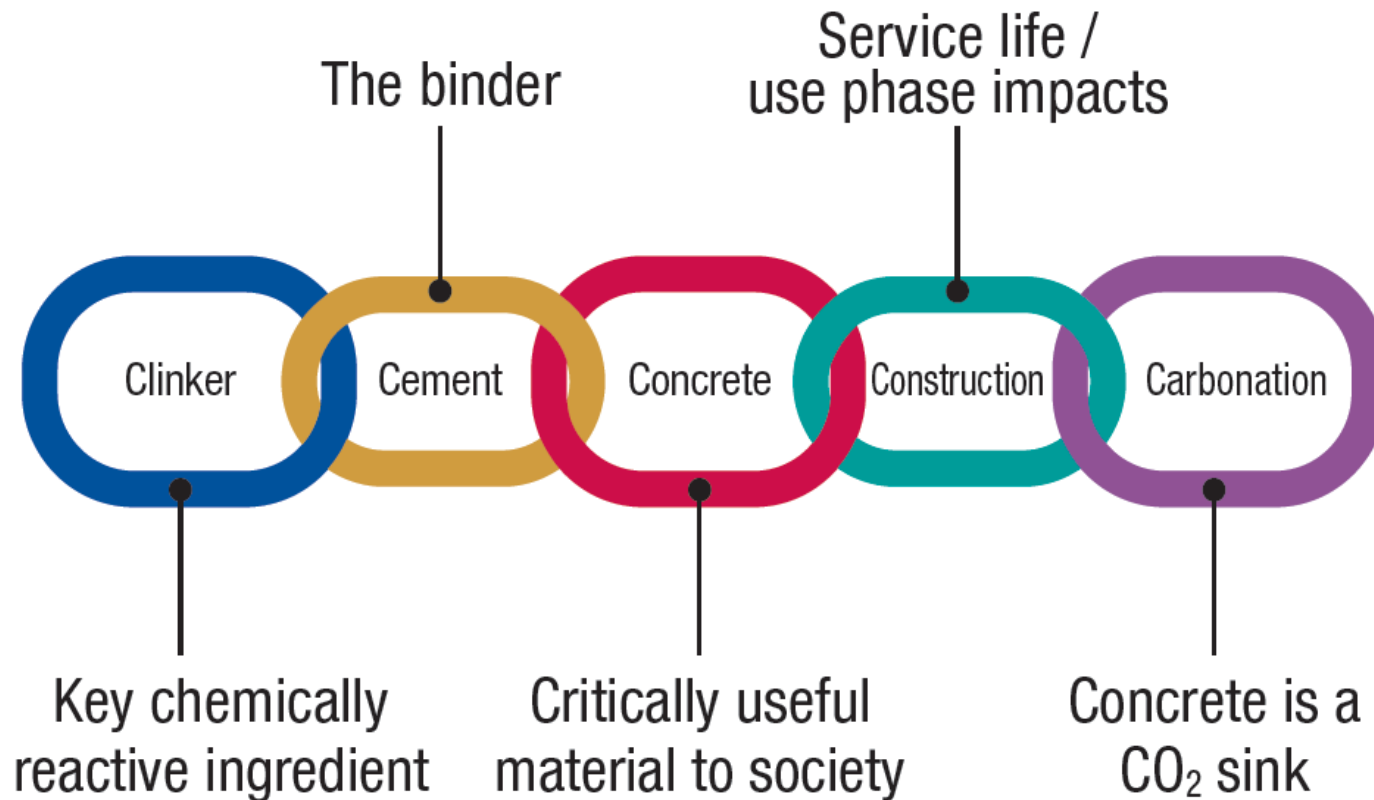
# Concrete is *the* most widely used material



Log Scale: Each step is a 10x increase

MFA 08

# Concrete Value Chain



# What is PLC?

## A Greener Cement Option

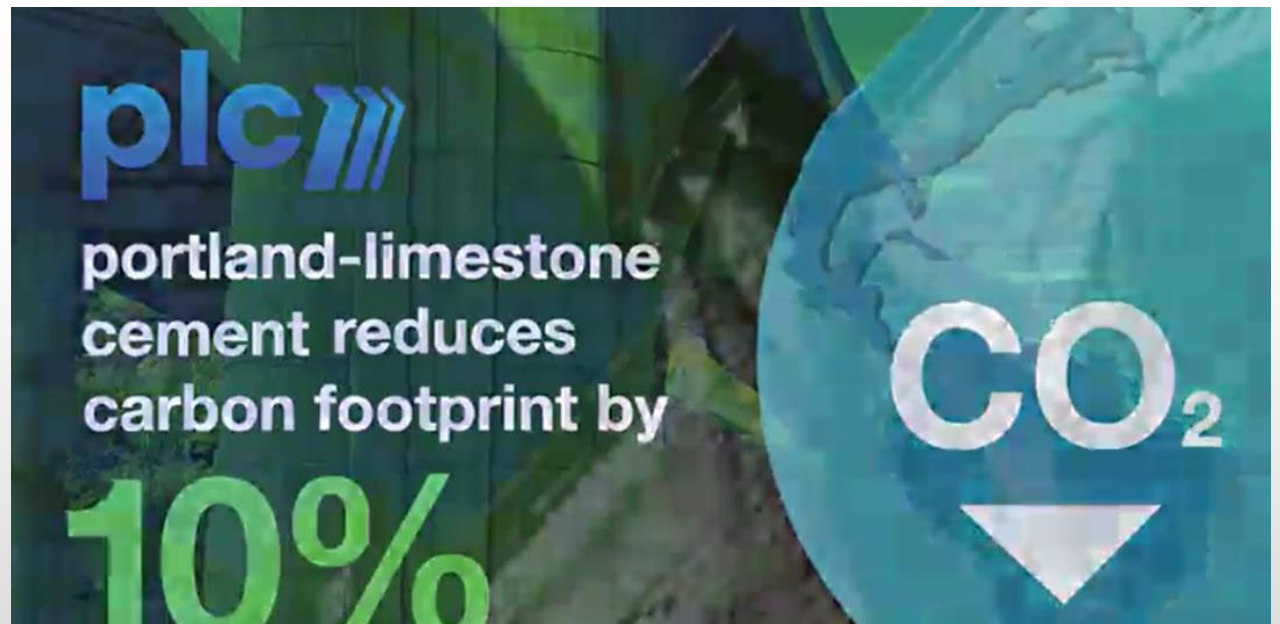
### A Key Lever in the Roadmap to Carbon Neutrality

A blended cement with additional limestone content, optimized for performance

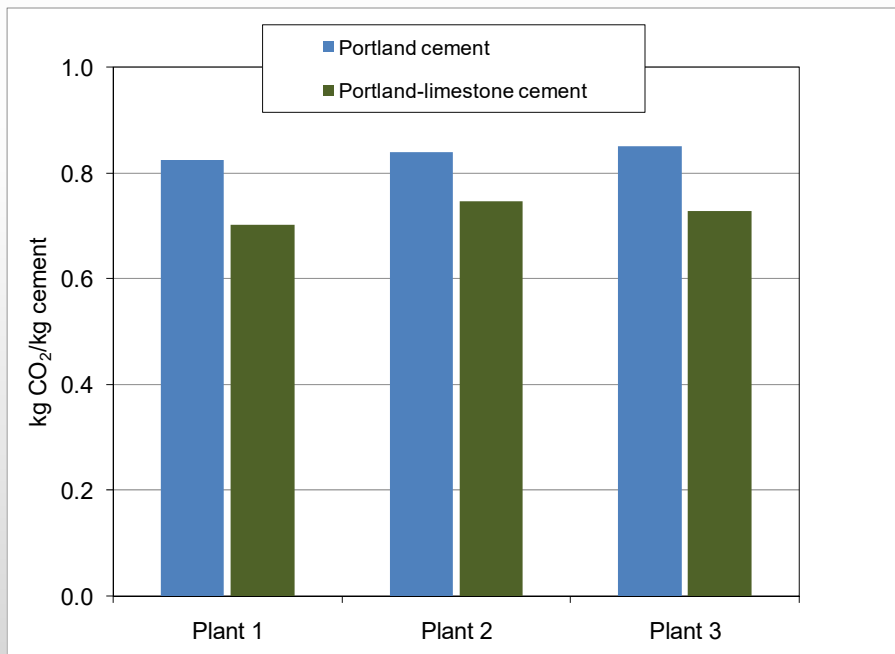
The easiest way to reduce your carbon footprint by up to 10%

Suitable for buildings, bridges, pavements, geotechnical applications

Readily available throughout the U.S. and Canada



# PLC Environmental Benefits

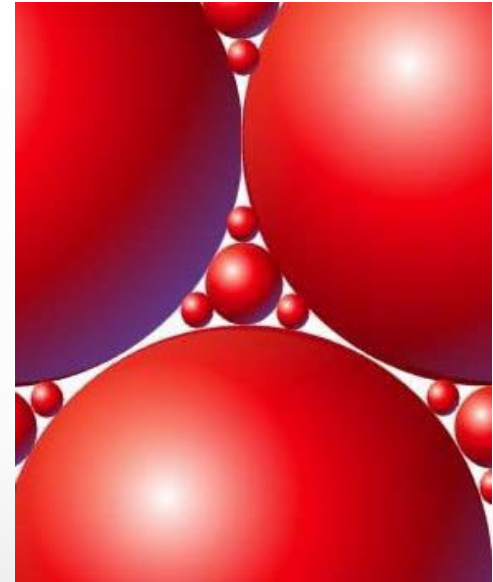


- Recent US IW EPDs
  - Portland cement dropped about 11% from 2016 to 2021
  - PLC about 8.2% lower than portland cement in 2021



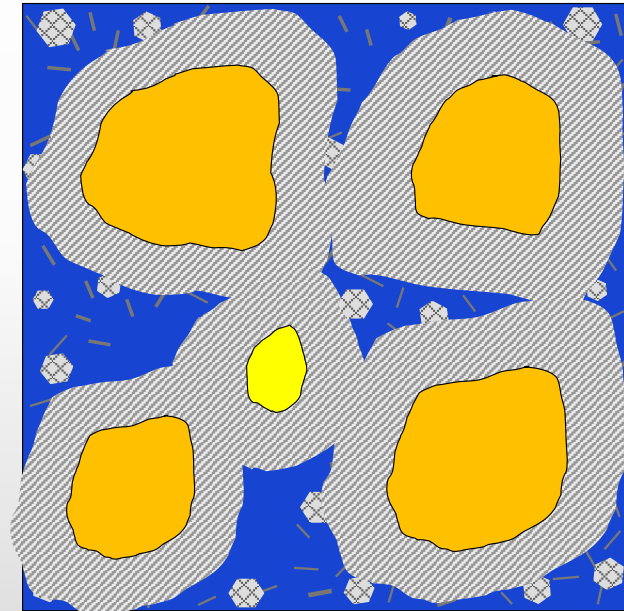
# How Limestone Works

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



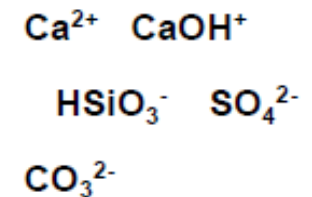
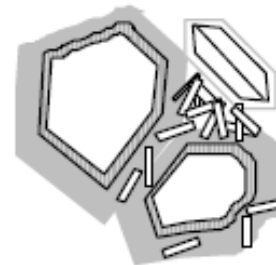
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# Long Track Record

## Portland-Limestone Cements

History of good performance, even at higher limestone contents than the U.S.

Introduced to Europe 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



# Performance of PLC Concrete

## A look at hardened properties

### Strength

OPC to PLC comparisons

With and without SCMs

### Durability

Scaling

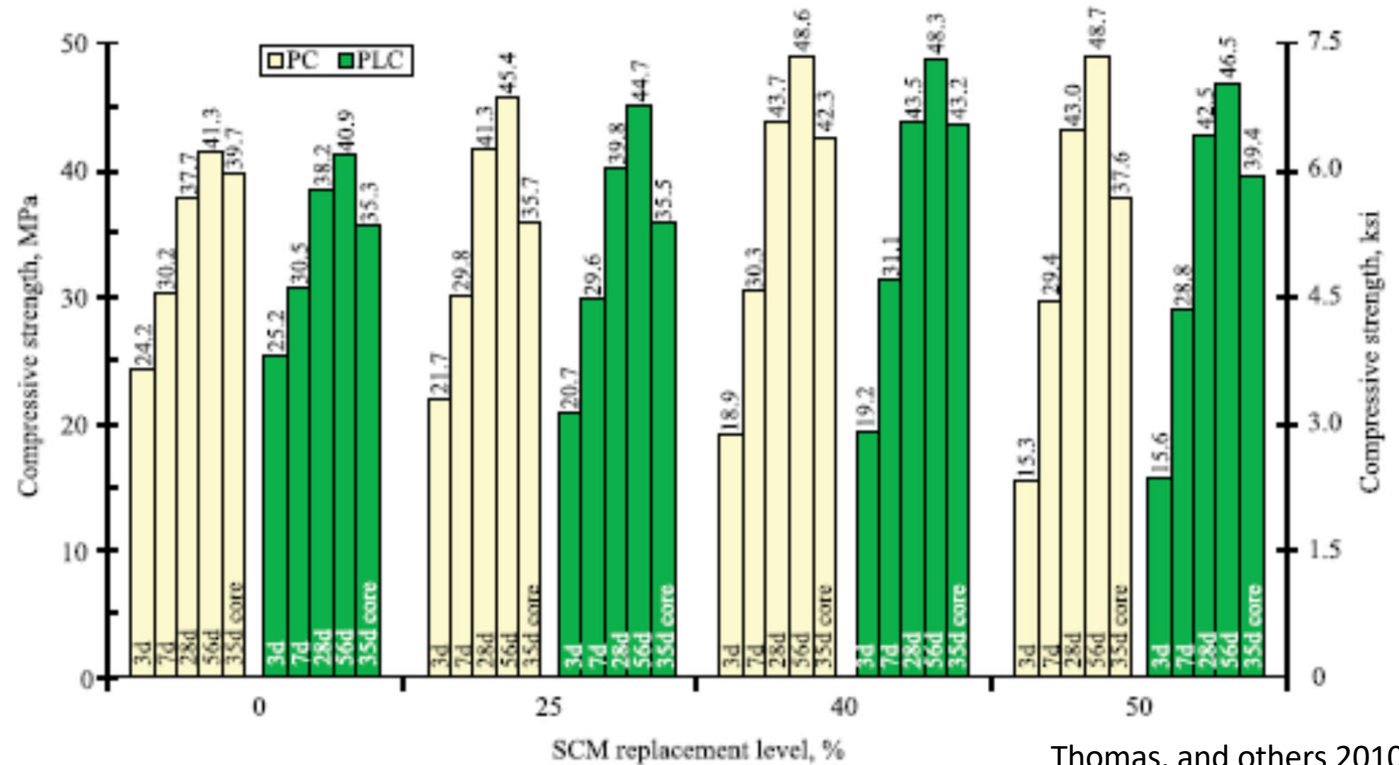
Freeze-thaw resistance

Chloride permeability

ASR resistance

Sulfate resistance

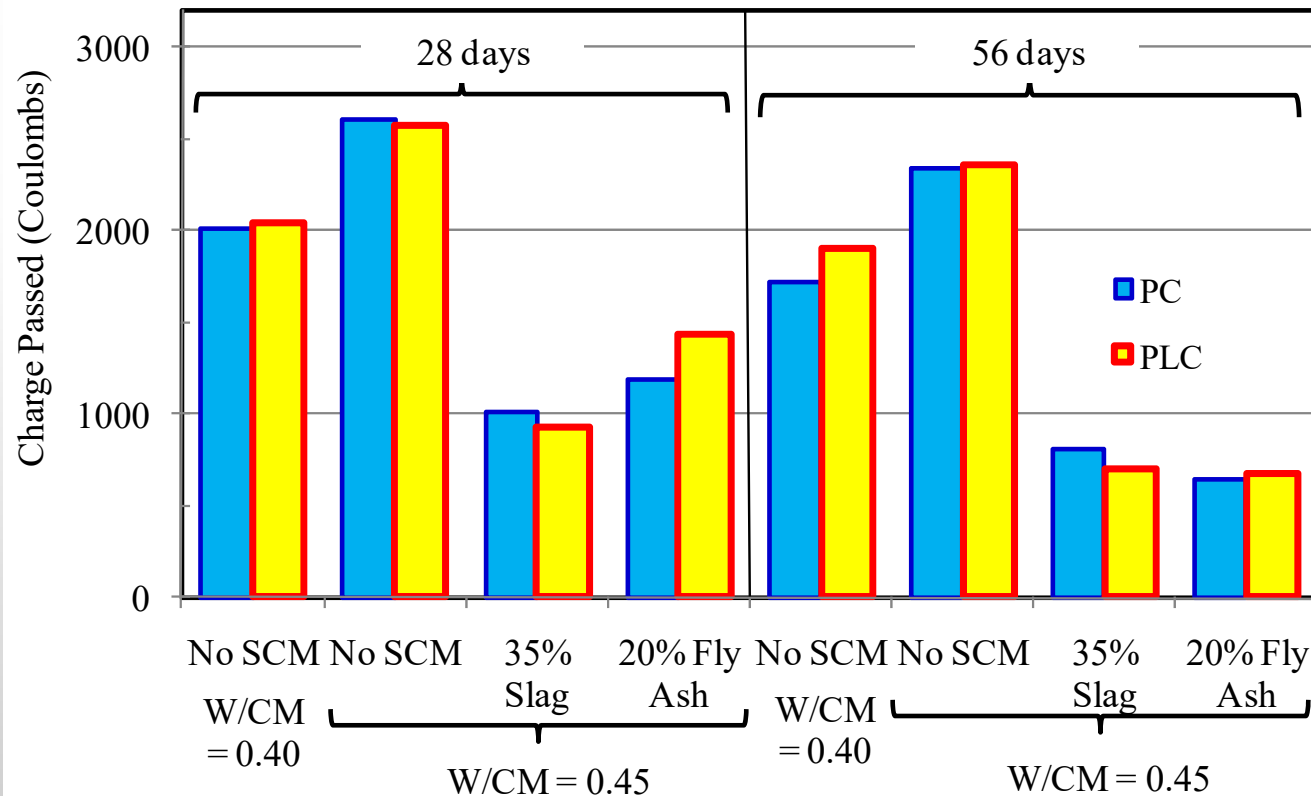
Field trial results



Thomas, and others 2010

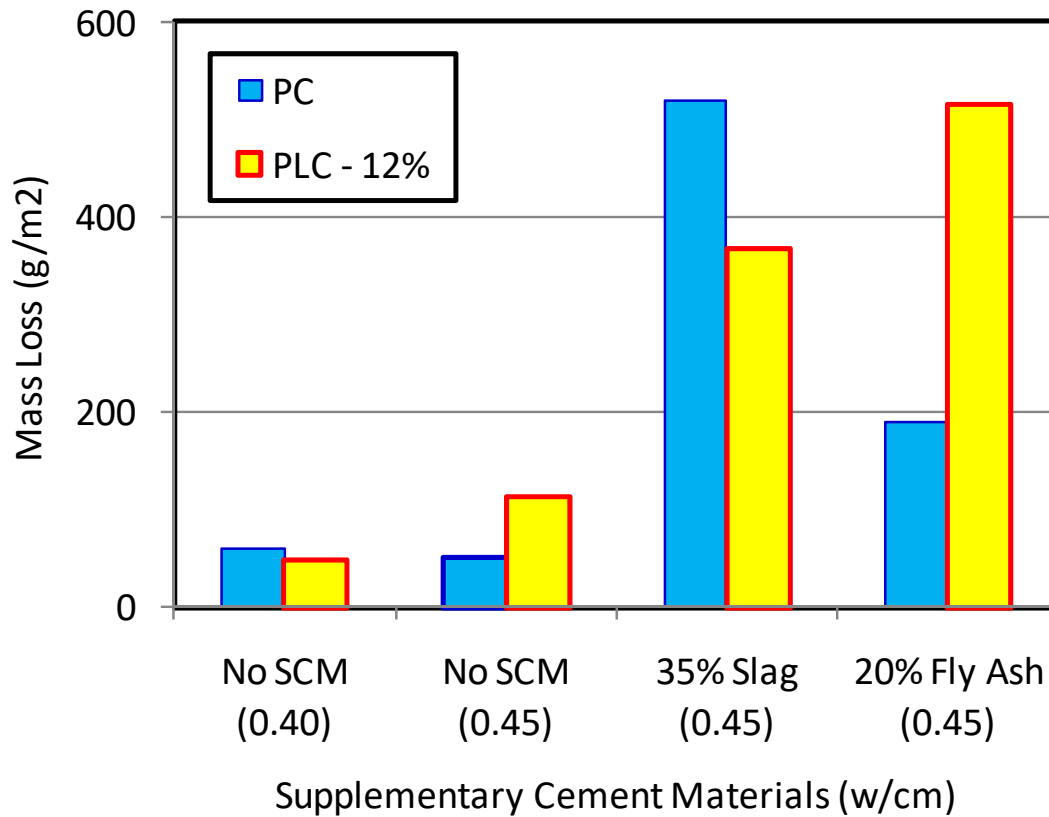
# Performance of PLC Concrete

“Permeability” T 277/C1202



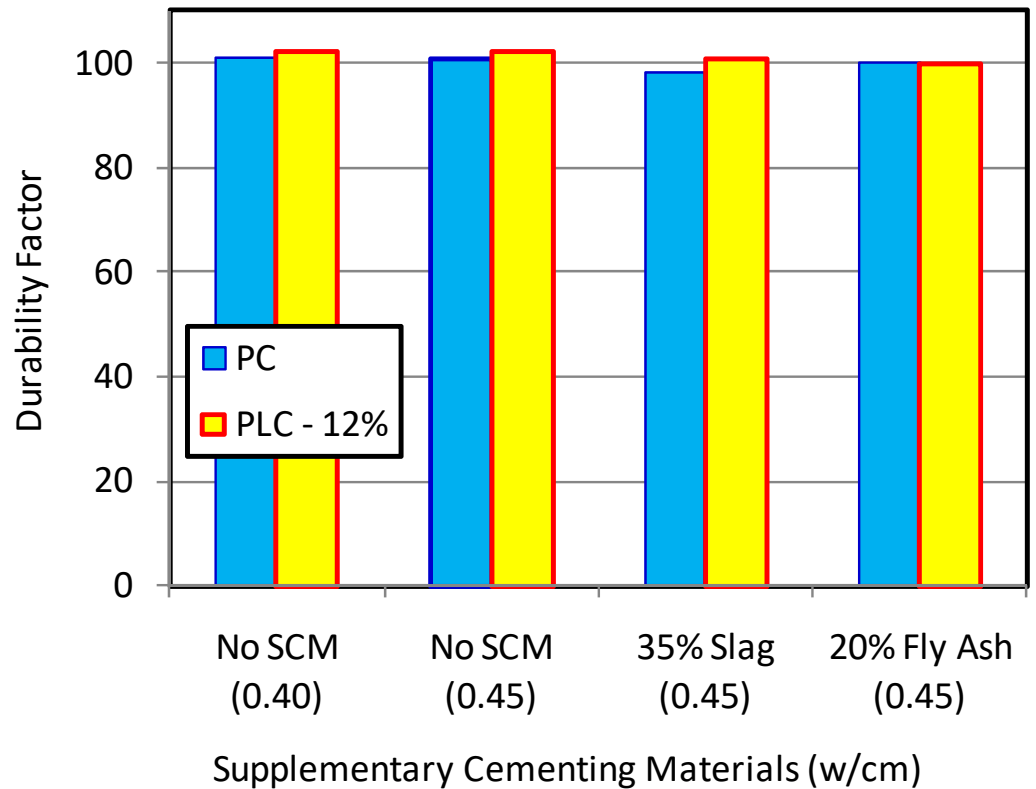
# Performance of PLC Concrete

Scaling resistance (ASTM C672)



# Performance of PLC Concrete

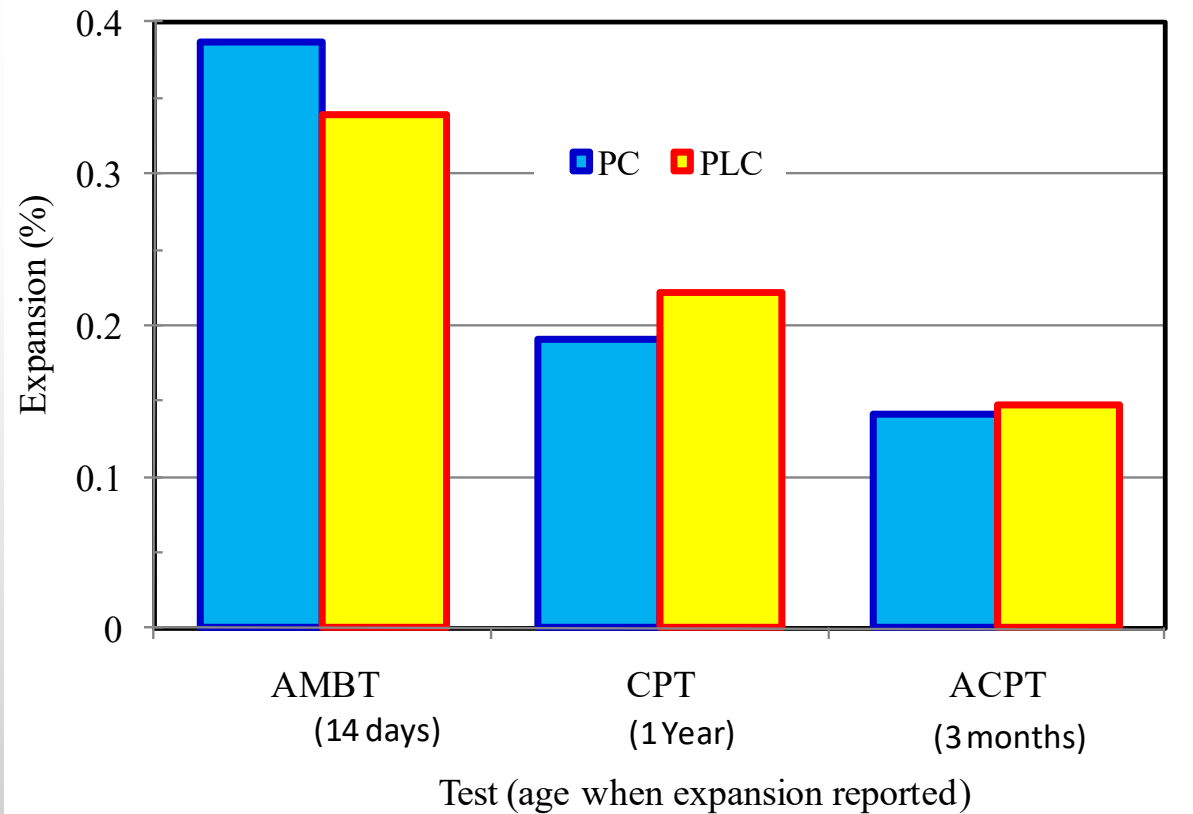
Freeze-Thaw Resistance (ASTM C666)





# Performance of PLC Concrete

ASR resistance



# 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:

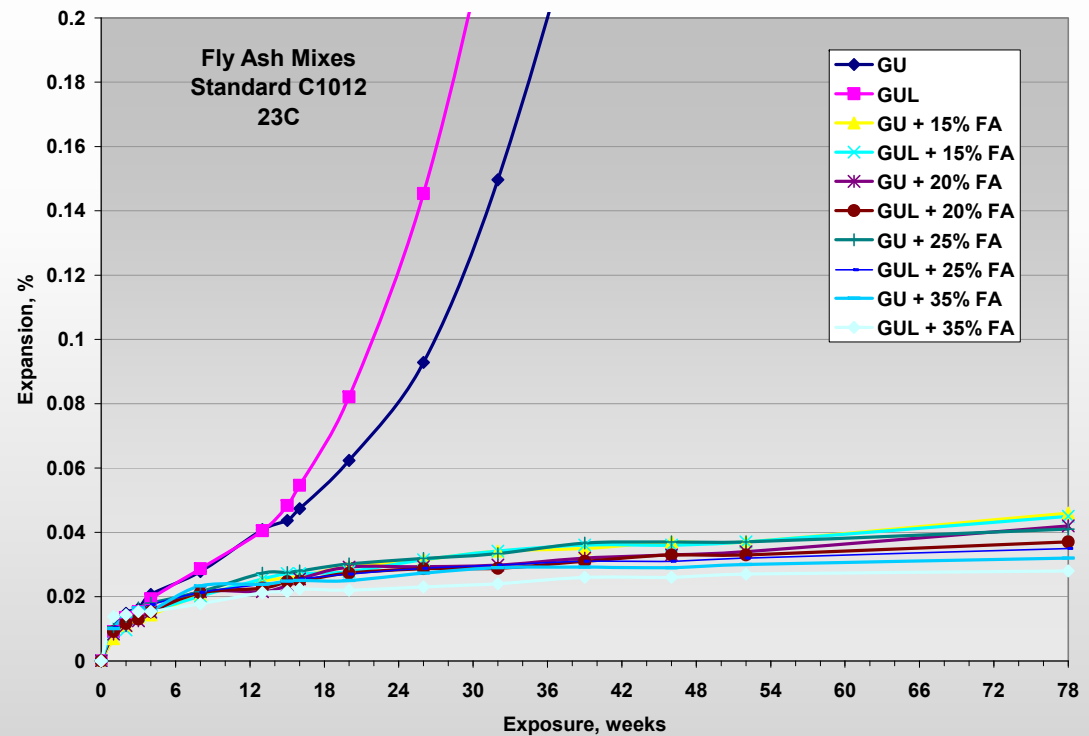
Type IL(MS)

Type IL(HS)

Type IT(MS)

Type IT(HS)

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



# Report on Properties

- Summary in PCA Report SN3148 at [www.cement.org](http://www.cement.org)
- Strength
- Scaling
- Freeze-thaw resistance
- Chloride permeability
- ASR resistance
- Sulfate resistance

**State-of-the-Art Report on  
Use of Limestone in Cements at  
Levels of up to 15%**

by P. D. Tennis, M. D. A. Thomas, and W. J. Weiss

# PLC Acceptance

ACI 318 Building Code

ACI 301 Structural Concrete Spec

ICC Building Codes (by reference to ACI codes)

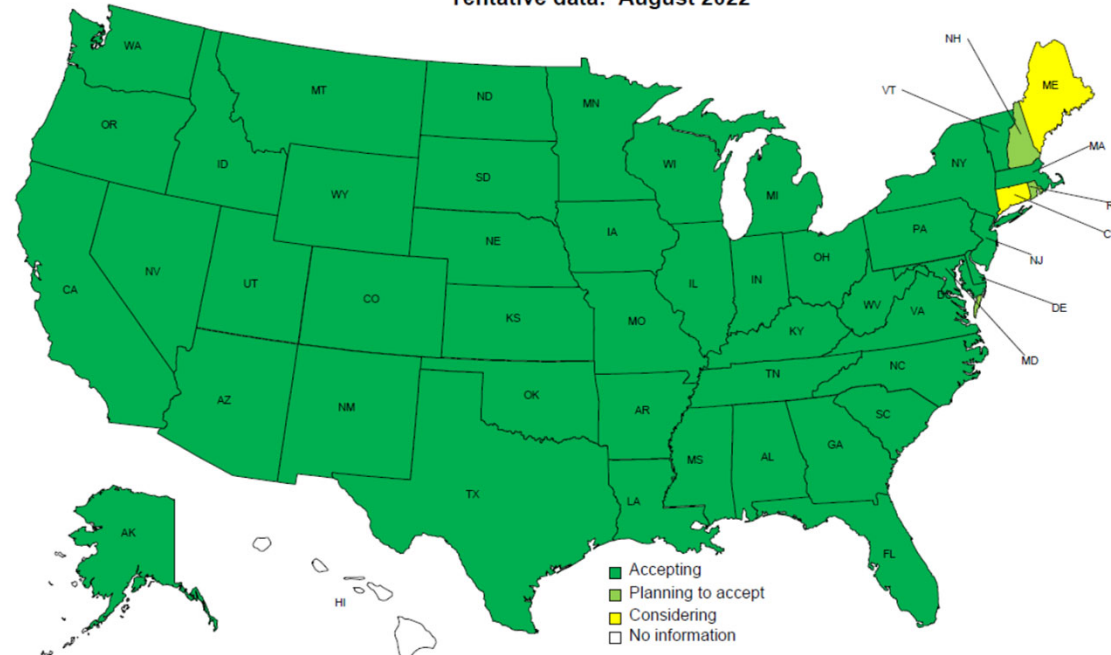
AIA MasterSpec

UFGS 03 30 00 Cast-in-Place Concrete

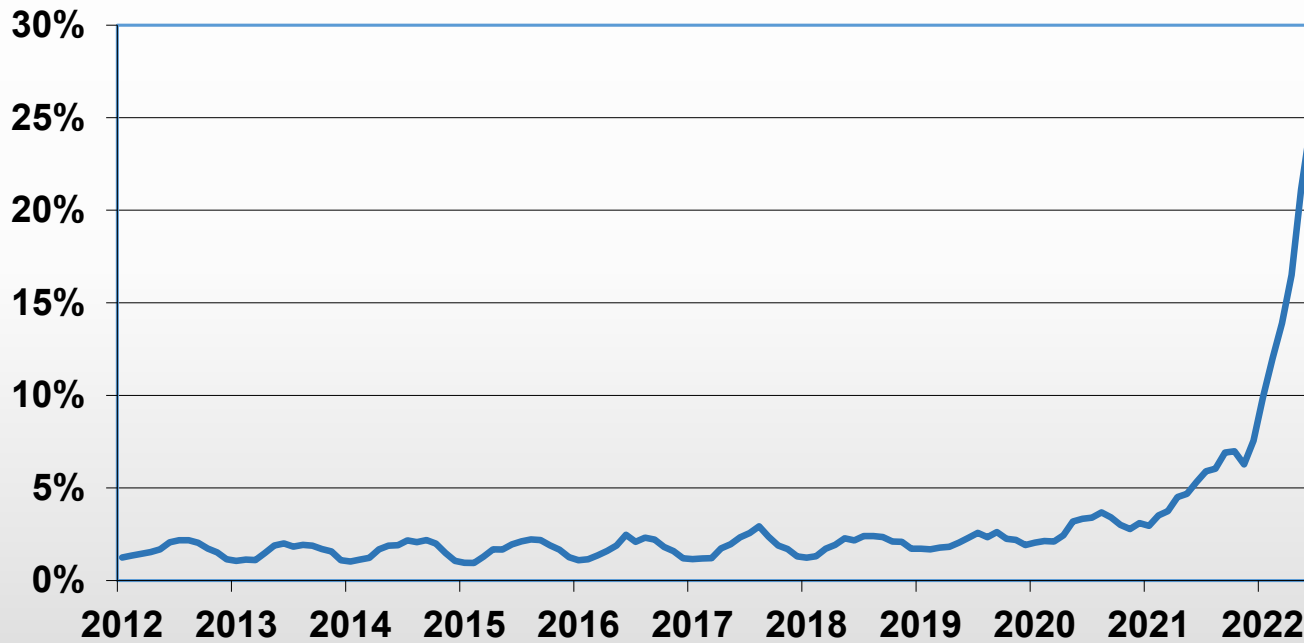
FAA P-501

45 State DOTs

**State DOT Acceptance of Portland-Limestone Cement**  
Tentative data: August 2022



# PLC Acceptance

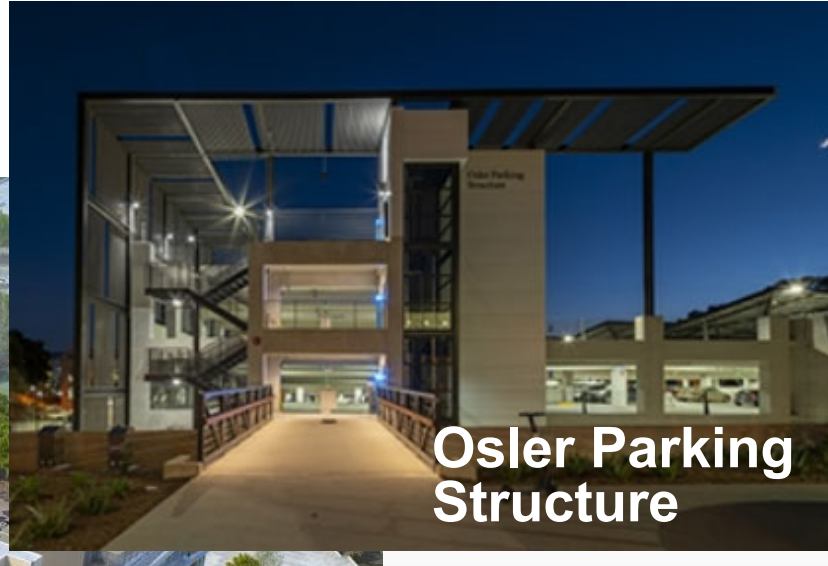
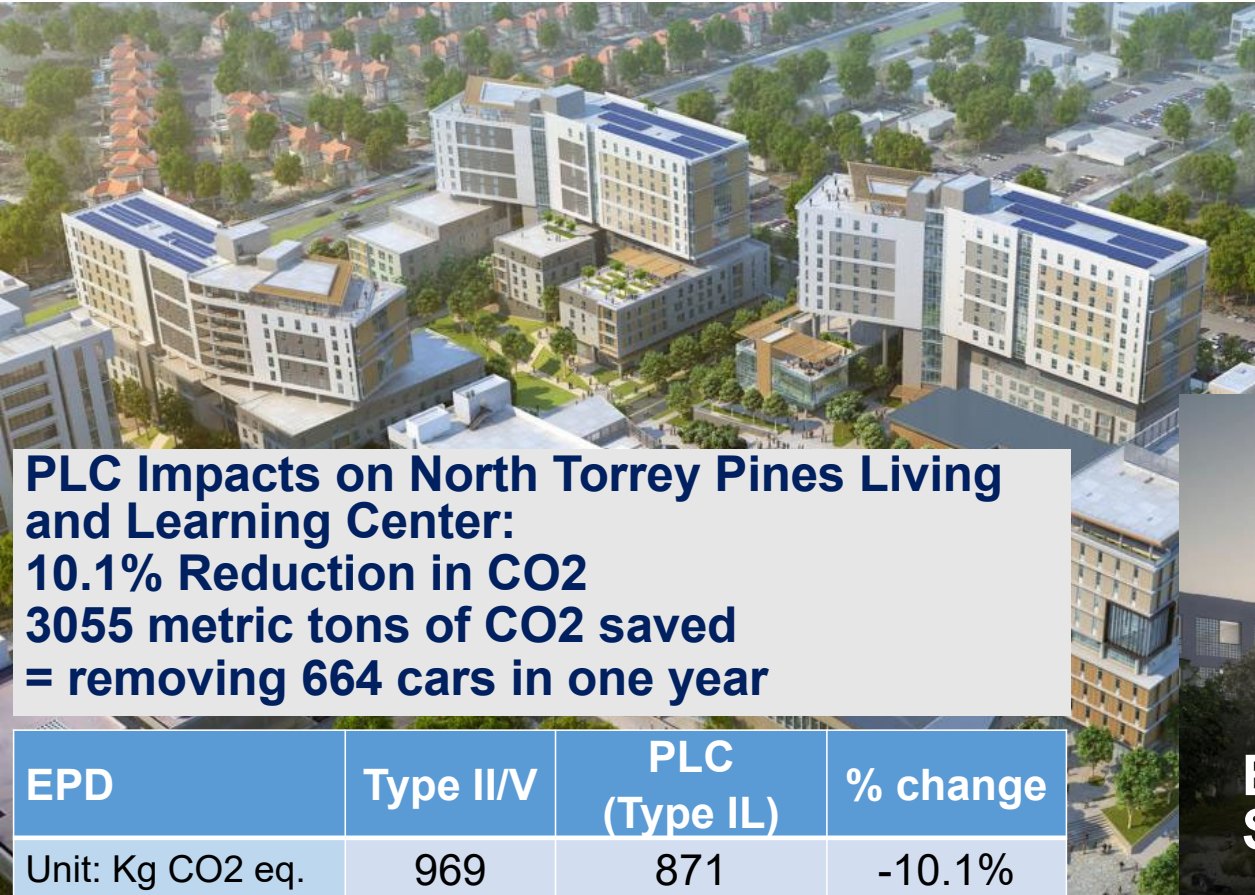


*Blended cement as a percentage of total cement (US data from USGS)*

# PLC Acceptance



# UCSD Project Examples



**Osler Parking Structure**



**Biological and Physical Science Building**

**PLC Impacts on North Torrey Pines Living and Learning Center:**  
**10.1% Reduction in CO2**  
**3055 metric tons of CO2 saved**  
**= removing 664 cars in one year**

EPD	Type II/V	PLC (Type IL)	% change
Unit: Kg CO2 eq.	969	871	-10.1%

# CO<sub>2</sub> Savings in Vancouver, BC with PLC



Image: Nicolas Blachette

Telus Garden Development  
- 1300 tons CO<sub>2</sub>



Image: HDR / CEI

Teck Acute Care Center  
- 1040 tons CO<sub>2</sub>



Image: Chris Dikeakos Architects

Solo District; Burnaby  
- 2750 tons CO<sub>2</sub>



Image: Westbank

Vancouver House  
-> 654 tons CO<sub>2</sub>



Image: theexchangebuilding.ca

The Exchange Building  
77% PLC + high strength



Trump International Hotel & Tower  
- 2750 tons CO<sub>2</sub>



The Mark -  
1730 tons CO<sub>2</sub>



Wall Centre False Creek  
- 1226 tons CO<sub>2</sub>



# greenercement.com

## PLC CO2 savings calculator

[Home](#)   [Why PLC](#)   [CO2 Calculator](#)   [Resources](#)

### BY LANE MILES

Length (miles)	<input style="width: 90%;" type="text" value="10"/>	<h3 style="margin-top: 0;">Direct and Immediate* CO2 Savings with PLC</h3> <p style="margin-top: 10px;"> <b>= 559 Tons</b>  <b>= 1,117,639 lbs</b>  <b>= 507 Metric Tons</b>  <b>= 506,953 kg</b> </p>
Width (ft)	<input style="width: 90%;" type="text" value="20"/>	
Thickness (in)	<input style="width: 90%;" type="text" value="8"/>	
Cement Factor (lb/ cu. yd.)	<input style="width: 90%;" type="text" value="564"/>	

CALCULATE AGAIN

\* Embodied CO2 savings are based on 2021 EPDs for portland cement vs. portland-limestone cement. There may be additional life-cycle CO2 savings realized, depending on what it is compared to

**Basic calculator assumptions:**

- pavement is 12 ft wide by 9.5 in. thick made with concrete having 550 lb of cement per cubic yard

For advanced calculation, input your total concrete length, width, thickness, and cement


### Equivalency Results [How are they calculated?](#)

The sum of the greenhouse gas emissions you entered above is of Carbon Dioxide Equivalent. This is equivalent to:

**Greenhouse gas emissions from**

i

110




Passenger vehicles driven for one year

-or-

i

1,274,483




Miles driven by an average passenger vehicle

**CO<sub>2</sub> emissions from**

i

57,063




gallons of gasoline consumed

-or-

i

49,815

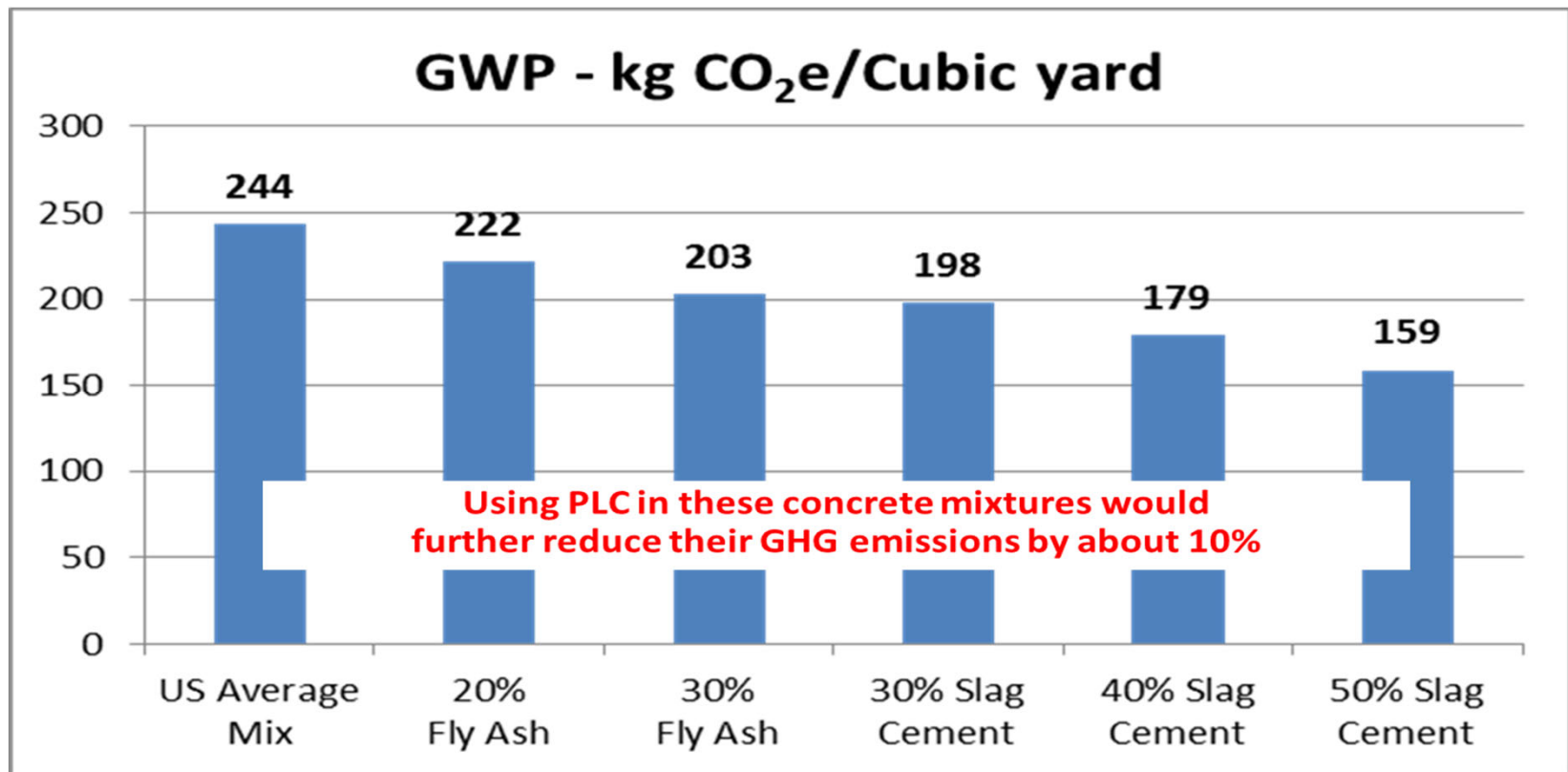


gallons of diesel consumed

Since 1916

America's Cement Manufacturers™

# Lowering Carbon Footprint of Mixes



3000 psi concrete mixes with various SCM contents

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**[ptennis@cement.org](mailto:ptennis@cement.org)**