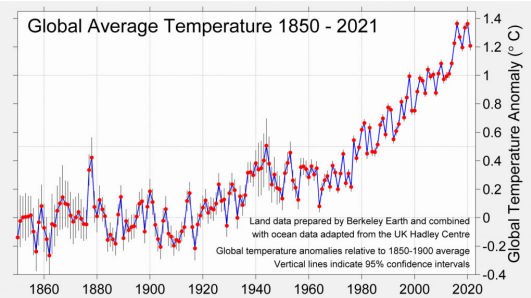
Type 1L Cements

IOWA STATE UNIVERSITY
Institute for Transportation

National Concrete Pavement Technology Center
Tech Center

Why change?

- It is getting hotter
- Federal Government is pressing to reduce carbon impact
  - At construction
  - Over pavement life



Berkeley Earth

Warmer air is melting the top of the Greenland Ice Sheet

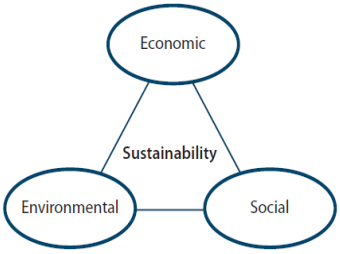
Accelerating melt of ice sheets now 'unmistakable'

By Jonathan Amos
BBC Science Correspondent
1 day ago | Science & Environment

BBC

Sustainability?

- Economics still rule
- Learning about social impacts
- Carbon
  - 30 billion tons of concrete is used each year worldwide
  - ~¼ ton CO_2 per person per year



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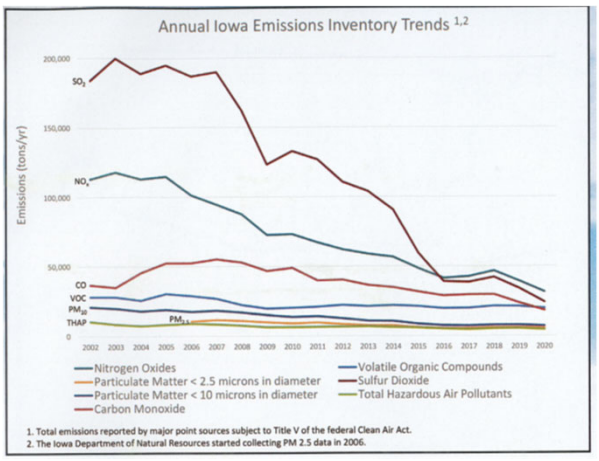
Who Me?

- Change is hard – but possible



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Iowa DNR

How?

- What can we do to reduce impact?
  - Use less concrete
  - Use less binder in the concrete
  - Use less clinker in the binder
  - Reduce construction impacts
  - Reduce user impacts

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Use Less Concrete in the Structure

- Avoid replacing it
  - Longer lasting
  - Use existing equity of older pavements (overlays)
- More efficient designs
  - Beware of rules of thumb, and cut-and-paste
  - ME-Design procedure
  - PavementDesigner.org
  - Appropriate construction systems

PavementDesigner.org

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Use Less Binder in the Concrete

- Many specifications call for more than needed

	Conventional	Optimized
Cement	400	351
SCM 1	170	150
SCM 2	0	0
Coarse Agg	457	662
Fine Agg	1171	1303
Intermediate 1	1167	954
Intermediate 2	244	254
Water	228	200
Air	7.0	7.0
Total	3837	3874
Cementitious	570	501
vp/vv	208	180
w/cm	0.40	0.40
% SCM 1	30	30

	Conventional	Optimized
Slump	2.0	2.0
HRWRA	2.0	2.3
Air content	6.8	7.0
Box	1 - 0	1 - 0
Initial set	6:27	6:12
Strength at 7	3,340	3,650

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Use Less Cement in the Binder

- Supplementary cementitious materials
  - Enhance performance
  - Increase longevity
  - Reduce disposal headaches
- Other SCMs
  - Recycled Ground Glass, ASTM C1866
  - Locally processed waste products ASTM C 1709
- Ternary combinations
- Harvested fly ash

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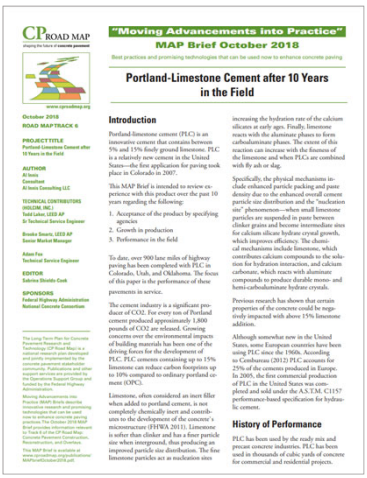
Use Less Cement in the Binder

- Portland Limestone Cements (ASTM C 595)
  - Up to 15% ground limestone
  - Similar performance
  - Becoming the norm



CP ROAD MAP

"Moving Advancements into Practice"

MAP Brief October 2018

Best practices and promising technologies that can be used now to enhance concrete paving

Portland-Limestone Cement after 10 Years in the Field

www.cproadmap.org

October 2018

ROAD MAP TRACK 6

PROJECT TITLE
Portland-Limestone Cement after 10 Years in the Field

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The Long-Term Plan for Concrete Pavement Research and Technology–CP Road Map–is a national research plan developed collaboratively by the U.S. concrete pavement stakeholder community. Publications and other deliverables are developed by the Operations Support Group and funded by the Federal Highway Administration.

Moving Advancements into Practice (MAP) Briefs highlight innovative research and promising technologies that can be used now to enhance concrete paving practices. The October 2018 MAP Brief is relevant to Track 6 of the CP Road Map: Concrete Pavement Construction, Reconstruction, and Overlays.

This MAP Brief is available at www.cproadmap.org/publications/MAPbriefOctober2018.pdf.

Introduction

Portland-limestone cement (PLC) is an innovative cement that contains between 5% and 15% finely ground limestone. PLC is a relatively new cement in the United States—the first application for paving took place in Colorado in 2007.

This MAP Brief is intended to review experience with this product over the past 10 years regarding the following:

1. Acceptance of the product by specifying agencies
2. Growth in production
3. Performance in the field

To date, over 900 lane miles of highway paving has been completed with PLC in Colorado, Utah, and Oklahoma. The focus of this paper is the performance of these pavements in service.

The cement industry is a significant producer of CO_2. For every ton of Portland cement produced approximately 1,800 pounds of CO_2 are released. Growing concerns over the environmental impacts of building materials has been one of the driving forces for the development of PLC. PLC cements containing up to 15% limestone can reduce carbon footprints up to 10% compared to ordinary portland cement (OPC).

Limestone, often considered an inert filler when added to portland cement, is not completely chemically inert and contributes to the development of the concrete's microstructure (FHWA 2011). Limestone is softer than clinker and has a finer particle size when interground, thus producing an improved particle size distribution. The fine limestone particles act as nucleation sites increasing the hydration rate of the calcium silicates at early ages. Finally, limestone reacts with the aluminate phases to form carboaluminate phases. The extent of this reaction can increase with the fineness of the limestone and when PLCs are combined with fly ash or slag.

Specifically, the physical mechanisms include enhanced particle packing and paste density due to the enhanced overall cement particle size distribution and the "nucleation site" phenomenon—where small limestone particles are suspended in paste between clinker grains and become intermediate sites for calcium silicate hydrate crystal growth, which improves efficiency. The chemical mechanisms include limestone, which contributes calcium compounds to the solution for hydration interaction, and calcium carbonate, which reacts with aluminate compounds to produce durable mono- and hemi-carboaluminate hydrate crystals.

Previous research has shown that certain properties of the concrete could be negatively impacted with above 15% limestone addition.

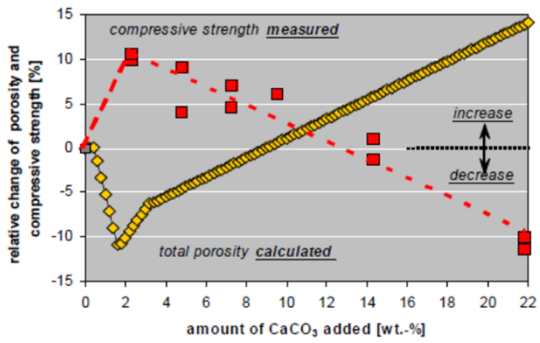
Although somewhat new in the United States, some European countries have been using PLC since the 1960s. According to Cembureau (2012) PLC accounts for 25% of the cements produced in Europe. In 2005, the first commercial production of PLC in the United States was completed and sold under the A3.T.M. C1157 performance-based specification for hydraulic cement.

History of Performance

PLC has been used by the ready mix and precast concrete industries. PLC has been used in thousands of cubic yards of concrete for commercial and residential projects.

Portland Limestone Cements

- Why 15% limit?

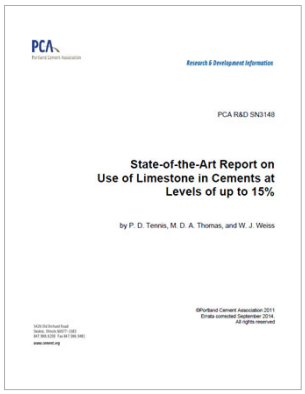


Matschei

Portland Limestone Cements

- Effects

Workability	Increase or decrease No significant effect on admixtures
Bleeding	Decreases with increasing fineness Generally of no concern
Setting time (initial, final)	May vary
Heat of hydration	Slight increase at early ages (up to 48 hours) But less significant at later ages
Compressive strength	May vary
Scaling and freeze-thaw resistance	Use same techniques as with PC concrete mixes: Proper air-void systems, curing, higher strengths
Sulfate resistance	Use same techniques as with PC concrete mixes: Low w/cm, min. strength, and MS or HS designations


PCA

Research & Development Information

PCA R&D SN3148

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

Portland Limestone Cements

- Potential impacts on carbon
  - 100 MT cement produced in the USA 2021
  - Means about ~6 MT less CO_2 is possible
- Context
  - USA Carbon emissions ~4,700 MT
  - Cement contribution ~ 41 MT
  - So ~15% reduction possible today…

What's the catch?

- One for one will not work in all cases
- Trial batches and proportion adjustments are necessary
- Practices may have to be adjusted
  - Setting time
  - Bleed
  - Strength development
- "Works fine when I add 10% more"!

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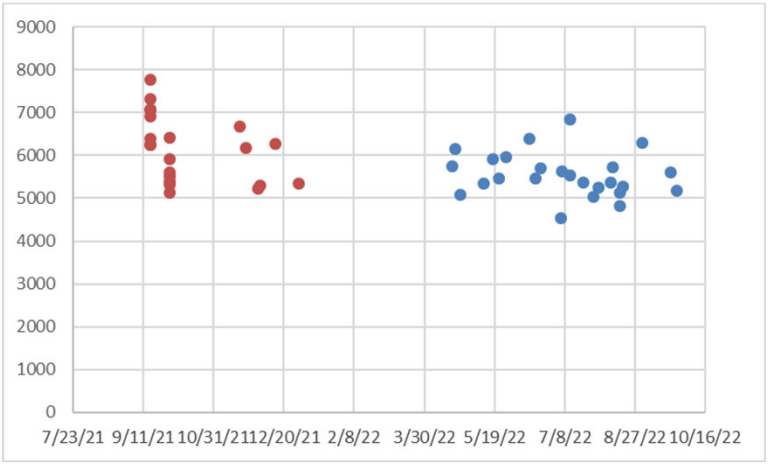
Compressive strength



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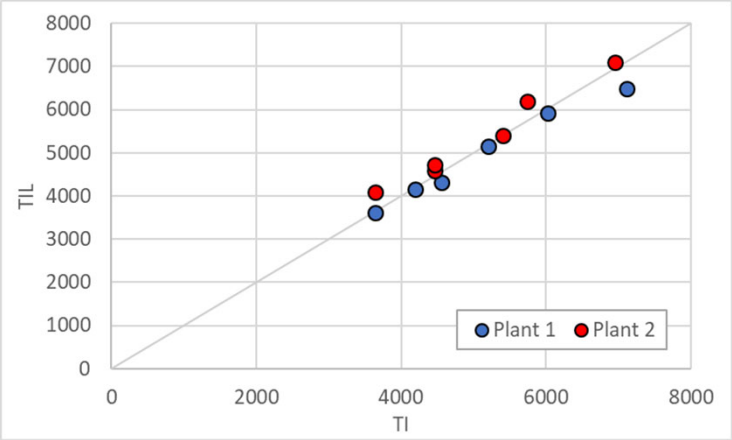
Compressive strength



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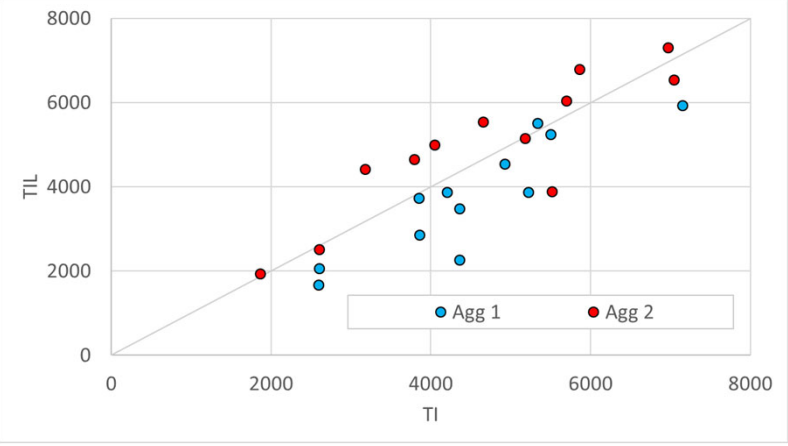
Compressive strength



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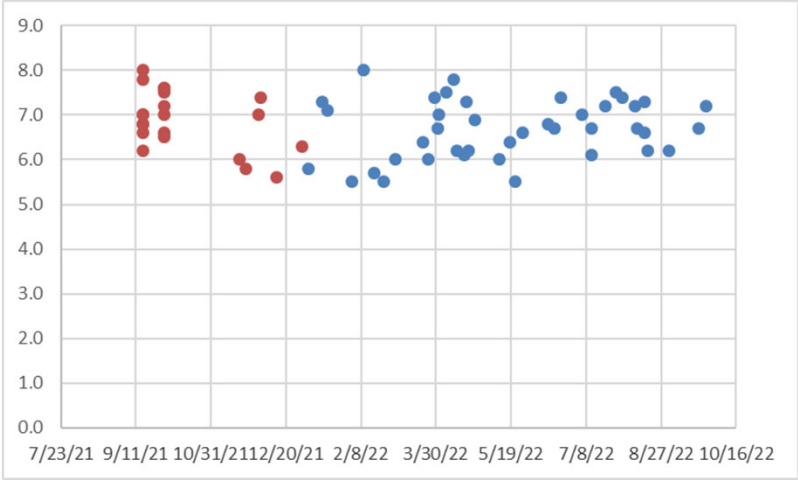
Air content



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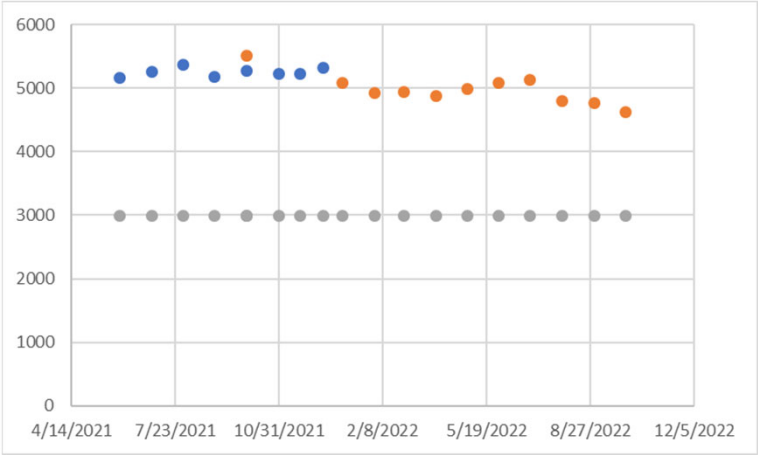
Mill Cert Mortar Cubes



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Experience

- Oklahoma 2012
  - PLC with 15% Class C Ash
  - 5,300 psi @28 days
- Reportedly doing well

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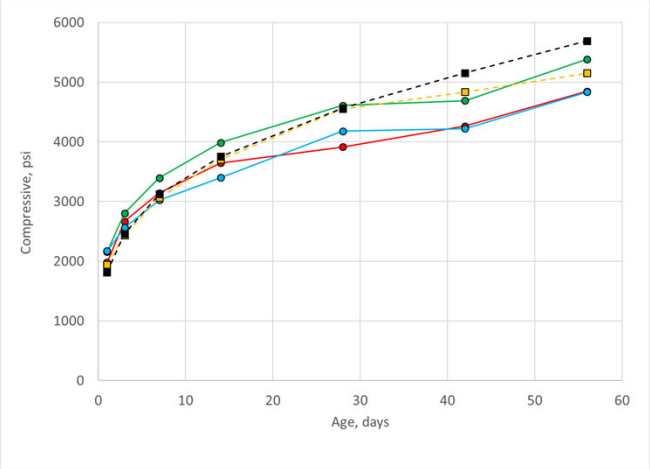
Experience

- MNDOT Test sections were good – PLC + 30 fly ash



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Where next

- Talk to your supplier
- Specify the properties you need
- Do those trial batches
  - Call if you need help
  - Stay away from the cliff edge
- More changes may be coming