Sustainability and How the Industry is Reducing it's Environmental Impact

By Lori Tiefenthaler and Jay Whitt

- Leading the Way to Carbon Neutrality
- Evolution of Sustainability – Developing Expertise
- Products and Technology
- Discussion

SUSTAINABILITY

Why do we collectively care about Sustainability?

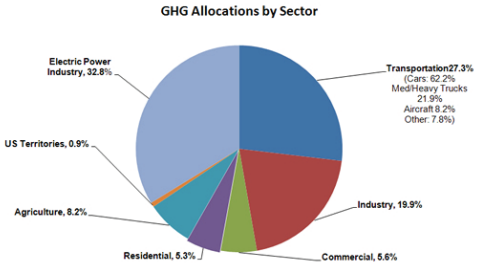
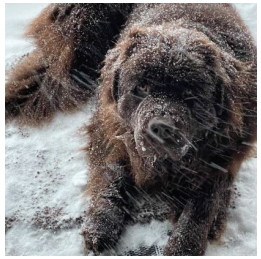


Figure 1. GHG emissions by economic sector in the U.S. (EPA 2013).



Lehigh Hanson is part of the HeidelbergCement Group

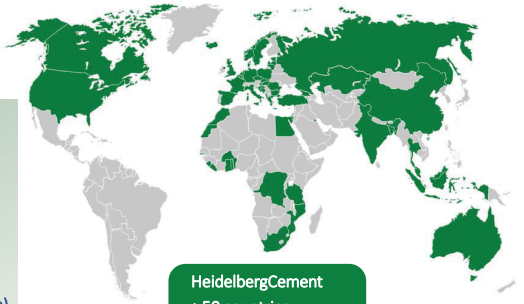
one of the worldwide market leaders in the building materials sector

World leader in the vertical integration

 # 1 worldwide in aggregates:
- 600 production sites for sand, gravel and crushed rock (200+ Lehigh Hanson)

 # 2 worldwide in cement
- 160 cement plants/grinding mills (20+ Lehigh Hanson)

#3 worldwide in ready-mixed concrete
- 1.700 ready mixed concrete plants (200 Lehigh Hanson)



HeidelbergCement
>50 countries
>3,000 locations
>54,000 employees

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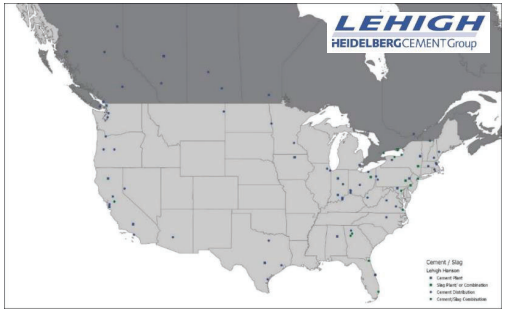
Products and Technology: Developing Sustainable Solutions in Our Markets

Cement's environmental impacts are typically at least 80% of Concrete's carbon footprint



Lehigh Cement: Cement and Slag facilities - including JVs

It is difficult to have same offering in each market; however we strive to serve all of our areas with at least one sustainable cement.

User of recycled materials (Circular Economy):
- Slag
- Fly Ash

Blended Cements – EcoCem
Low-carbon cement types:
- Portland Limestone Cement (IL) - EcoCem*PLC*
- Composite Cements (IT) - EcoCem*PLUS*
- Slag and Portland (IS)
- Fly Ash and Portland (IP)

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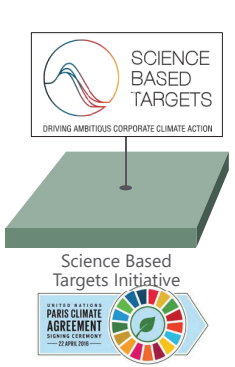
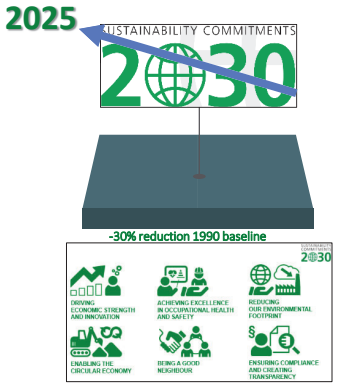
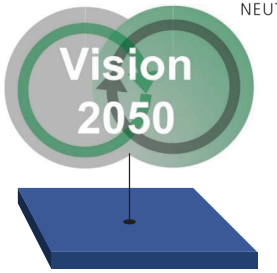
Leading the Way to Carbon Neutrality







Our goal is to realize the vision of carbon-neutral concrete at the latest by 2050

2019 2030 2050

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HeidelbergCement 2030 Commitments

"We are committed to fulfilling our share of the global responsibility ***to keep temperature rise below 2° Celsius****, and we will continue to reduce our impacts on air, land and water."*

Ensuring Compliance and Creating Transparency
"We adhere to international human rights, anti-corruption and labour standards and co-operate pro-actively in an open and transparent manner with all our stakeholders."

Reducing our Environmental Footprint
"We are committed to fulfilling our share of the global responsibility to keep temperature rise below 2°C, and we will continue to reduce our impacts on air, land and water."

Being a Good Neighbour
"We are committed to supporting the social and economic development of our neighbouring communities and ensure transparent communication to all our stakeholders."

Achieving Excellence in Occupational Health and Safety
"We are committed to continuously enhancing the occupational health and safety conditions of our employees, contractors, and third parties."

Enabling the Circular Economy
"We conserve our natural reserves by continuously increasing the use of alternative resources as substitutes for natural raw materials."

Driving Economic Strength and Innovation
"We will ensure sustainable profitability through the effective management of all processes and resources and the continuing innovation of products and services."

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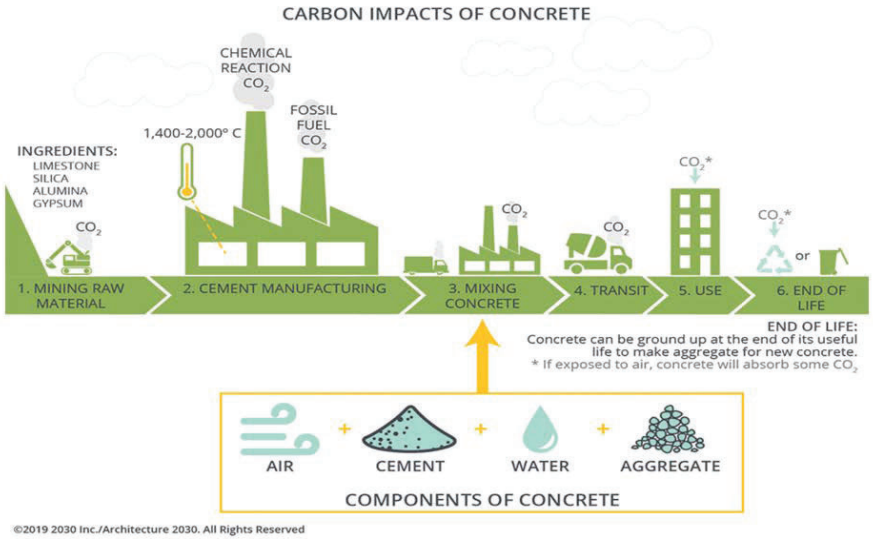
SUSTAINABILITY

Our Industry is developing a roadmap

Carbon Neutrality by 2050…!

- Cement and concrete sector (led by PCA) is developing a roadmap by the end of 2021 to facilitate achieving **carbon neutrality** across the concrete value chain by 2050…

www.cement.org/newsroom

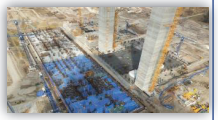


Cement/Concrete Products and Technology: Sustainable Solutions

At least 80% of HeidelbergCement's Research and Development Investments are Sustainability Driven

ALTERNATIVE RAW MATERIALS

- Reduction of clinker content in cement and concrete
- Alternative cementitious systems
- Levers for Lower Carbon Concrete



Use of SCMs: slag cement for basements and massive construction pours

Use of fly ash other recycled fines in cement production

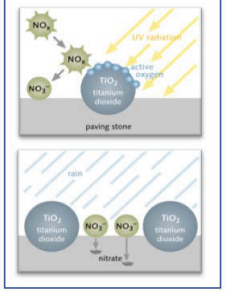
ALTERNATIVE FUELS

Biomass (zero emissions)
- sewage sludge
- Wood, paper, carton
- animal meal, animal fat
- animal bone meal

Other fuels
- waste oil, tires
- RDF

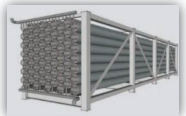
AIR CLEANING

TioCem® reduces NOx in cities



ENERGY STORAGE & TRANSMISSION

Heatcrete® is a special concrete with high thermal conductivity for energy storage.



Powercrete® increases the efficiency of underground power cables with its high thermal conductivity.

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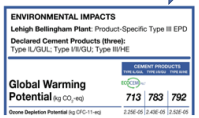
Sustainability Evolution – Developing Expertise

Operational Carbon Emissions

Transparency

Embodied Carbon Emissions



LEED (1998-present)
- Rating system
- Credit driven
- 75% Operational (water/Energy efficiency)
- Materials (10%)

Environmental Product Declaration (2015)
- Product/Plant EPD
- Embodied Carbon Accounting
- Reducing GWP kg of CO2
- Low Carbon Concrete
- Setting Baselines

Global Warming
- Climate Change
- Paris Agreement (2016)
- GHG emissions
- GWP in kg of CO2 eq
- Cement Industry 5-8% global emissions – due to resilience necessity

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TRANSPARENT REPORTING OF ENVIRONMENTAL IMPACTS - EPD

Environmental Product Declaration (EPD)

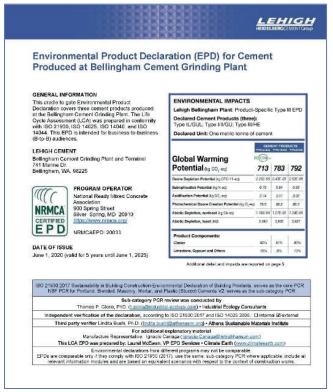
"a transparent, verified report used to communicate the environmental impact (e.g., resource use, energy, emissions) associated with the manufacture or production of construction materials…"

What are the Benefits of EPD's

- Provide verifiable and transparent information on life-cycle environmental impact data for materials or products
- Allow meaningful comparisons of the environmental performance of materials
- Identify areas for environmental performance improvement, encouraging industry efficiency

SUSTAINABLE PAVEMENTS PROGRAM

Source: FHWA https://www.fhwa.dot.gov/pavement/sustainability/hif19087.pdf



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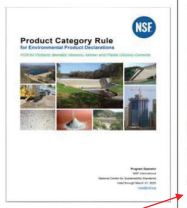
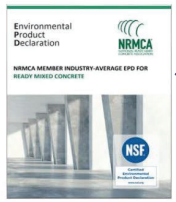
Environmental Product Declarations (EPD) – What's Included to Make Them

Cement PCR | Cement EPD | Concrete PCR | Concrete EPD





Includes 72 mixes; 6 categories; 2500-8000 PSI

2019 <13% GWP than 2014

Updated Cement Industry average in Q1 2021 will have a PLC

PRODUCTION STAGE			CONSTRUCTION STAGE		USE STAGE							END OF LIFE STAGE			
Extraction and upstream production	Transport to Factory	Manufacturing	Transport to site	Installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction / Demolition	Transport	Waste Processing	Disposal of Waste
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4

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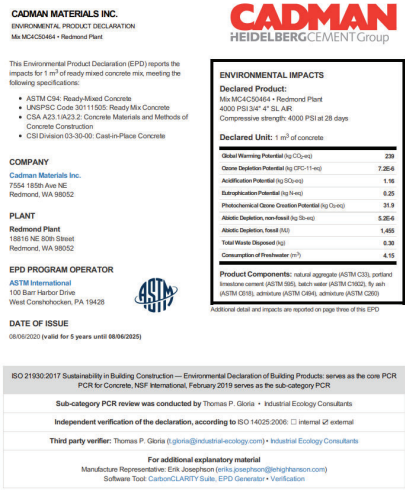
What is on an EPD



CADMAN MATERIALS INC.
ENVIRONMENTAL PRODUCT DECLARATION
Mix MC4C50464 • Redmond Plant

CADMAN HEIDELBERGCEMENT Group

This Environmental Product Declaration (EPD) reports the impacts for 1 m³ of ready mixed concrete mix, meeting the following specifications:

- ASTM C94: Ready-Mixed Concrete
- UNSPSC Code 30111505: Ready Mix Concrete
- CSA A23.1/A23.2: Concrete Materials and Methods of Concrete Construction
- CSI Division 03-30-00: Cast-in-Place Concrete

COMPANY
Cadman Materials Inc.
7554 185th Ave NE
Redmond, WA 98052

PLANT
Redmond Plant
18816 NE 80th Street
Redmond, WA 98052

EPD PROGRAM OPERATOR
ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428

DATE OF ISSUE
08/06/2020 (valid for 5 years until 08/06/2025)

ENVIRONMENTAL IMPACTS

Declared Product:
Mix MC4C50464 • Redmond Plant
4000 PSI 3/4" 4" SL AIR
Compressive strength: 4000 PSI at 28 days

Declared Unit: 1 m³ of concrete

Global Warming Potential (kg CO2-eq)	239
Ozone Depletion Potential (kg CFC-11-eq)	7.2E-6
Acidification Potential (kg SO2-eq)	1.16
Eutrophication Potential (kg N-eq)	0.25
Photochemical Ozone Creation Potential (kg O3-eq)	31.9
Abiotic Depletion, non-fossil (kg Sb-eq)	5.2E-6
Abiotic Depletion, fossil (MJ)	1,455
Total Waste Disposed (kg)	0.30
Consumption of Freshwater (m³)	4.15

Product Components: natural aggregate (ASTM C33), portland limestone cement (ASTM 595), batch water (ASTM C1602), fly ash (ASTM C618), admixture (ASTM C494), admixture (ASTM C260)

Additional detail and impacts are reported on page three of this EPD

ISO 21930:2017 Sustainability in Building Construction — Environmental Declaration of Building Products: serves as the core PCR
PCR for Concrete, NSF International, February 2019 serves as the sub-category PCR

Sub-category PCR review was conducted by Thomas P. Gloria • Industrial Ecology Consultants

Independent verification of the declaration, according to ISO 14025:2006: ☐ internal ☑ external

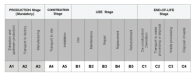
Third party verifier: Thomas P. Gloria (tgloria@industrial-ecology.com) • Industrial Ecology Consultants

For additional explanatory material
Manufacture Representative: Erik Josephson (erika.josephson@lehighhanson.com)
Software Tool: CarbonCLARITY Suite, EPD Generator • Verification

Page 2 of 3

LIFE CYCLE ASSESSMENT

SYSTEM BOUNDARY
This EPD is a cradle-to-gate EPD covering the product stages (A1-A3) only



CUT-OFF
Items excluded from system boundary include: production, manufacture, and construction of manufacturing capital goods and infrastructure; production and manufacture of production equipment, delivery vehicles, and laboratory equipment; personnel-related activities (travel, furniture, and office supplies); and energy and water use related to company management and sales activities that may be located either within the factory site or at another location.

ALLOCATION PROCEDURE
Allocation follows the requirements and guidance of ISO 14044:2006, Clause 4.3.4.
The product category rules for this EPD recognize fly ash, silica fume and slag as waste products recovered materials and thus the environmental impacts allocated to these materials are limited to the treatment and transportation required to use as a concrete material input.

LIFE CYCLE INVENTORY (LCI)
This EPD was calculated using manufacturer specific cement data that represents 100% of the total cement used in this mix.

PRIMARY SOURCES OF LCI DATA

- **Admixture (air-entraining)** EPCA EPD, Europe 2015
- **Admixture (chemical)** USLCI: "Soap, at plant" 2007
- **Aggregate (natural)** US-EI (2016): "Gravel, round, at mine/US", 2001
- **Cleaning Chemicals:** Ecoinvent 3.4: 50% Citric acid and 50% Phosphoric acid, industrial grade, without water, in 70% solution state, market for/GLO, 2017
- **Diesel:** USLCI: "Diesel, combusted in industrial equipment/NREL/US", 2007
- **Electricity (WECC):** Ecoinvent 3.4: " Electricity, medium voltage, market for, cut-off", 2015
- **Fly ash:** byproduct of coal combustion; no upstream manufacturing impacts
- **Natural gas:** USLCI: "Natural gas, combusted in industrial boiler/NREL/US", 2007
- **Non-Hazardous Solid Waste:** US-EI (2016): Disposal, municipal solid waste, 2008
- **Oils, Lubricants and Greases:** Ecoinvent 3.4: Lubricating oil, GLO, market for, cut-off, 2011
- **Portland Limestone Cement:** Supplier specific primary data, 2020
- **Ship transport:** USLCI: "Transport, ocean freighter, average fuel mix/NREL/US", 2007
- **Truck transport:** USLCI "Transport, combination truck, short-haul, diesel powered/RNA", 2010

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Products and Technology: Using Portland Limestone Cement (PLC or Type IL)

ECOCEM® PLC

EcoCem®*PLC* is a blended portland cement with up to 15% limestone and as much as 10% less embodied carbon.

Benefits of Using Type IL

Concrete Producers	Contractors/Customers	Public
Reduced Energy impact from cement	Improved Consistency and workability	Fewer CO2 Emissions
Lower Global Warming Potential (GWP)	> Durability	More Durable Concrete with SCMs
Better Chemical Control	Particle packing optimized	Cleaner Air
Synergies with SCMs	Lower Carbon Concrete	Concrete has Lifetime CO2 Uptake

Link: www.concretejustgotgreener.com

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Advantages of PLC

What does PLC do for me?

- The primary advantage is that it allows for a reduction in CO2, typically up to 10%
- PLC is a simple, straight forward switch in your operation; essentially "plug n play"
  - Pull OPC powder out of your mix, and replace it with PLC
- PLC provides you an opportunity to "**Go Green**" and increase your sustainability without spending money on capital investments for specialized systems at your ready mixed concrete plants

https://www.greenercement.com/

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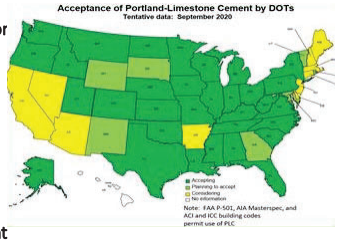
PLC or Type IL: Current Status

- Lehigh Cement - Seattle market reaching 100% conversion to PLC
- Department of Transportation in 32+ States have now approved the use of PLC or Type IL cement.
  - ✓ IDOT 2013-14
  - ✓ FAA
  - ✓ US Army Corps of Engineers
- Many Cities and Counties are adopting PLC into their local specifications
- Engineers and Architects have begun adding ASTM C 595 to their specifications
- PLC is being used on many high profile projects, where reducing carbon footprint is part of their goal
- Performance concrete rather than specified concrete is bringing additional value to the owner and contractor
- Combining PLC with recycled products is leading the way in sustainable design.



Accepting
Planning to accept
Considering

https://www.greenercement.com/

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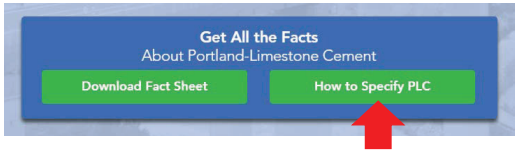
Portland Cement Association: https://www.greenercement.com/

Links to PLC fact sheets, Research Reports and for the Architects, Engineers and Specifiers, there is a link to “How to Specify PLC”.



To understand how PLC works, we need to look at how it’s made.

- What is a PLC?
  - Type IL blended cement in ASTM C595/AASHTO M240
    - Allowed 5% to 15% limestone by mass
  - Typically made from the **same clinker** as C150 cement; PLC just has ~6% more limestone.
  - Designed for equivalent performance.

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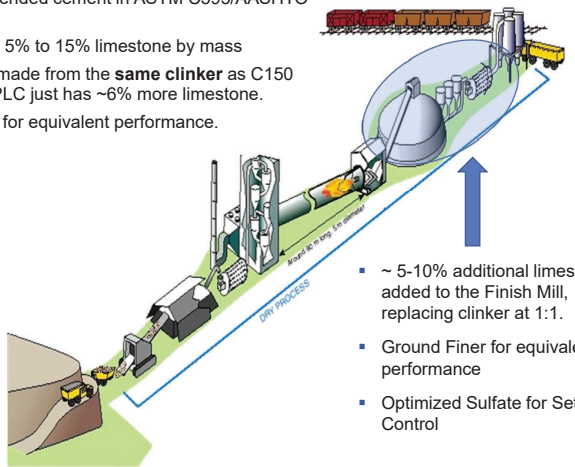
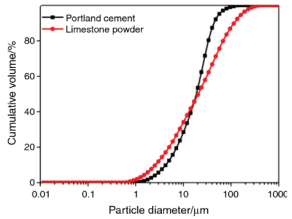
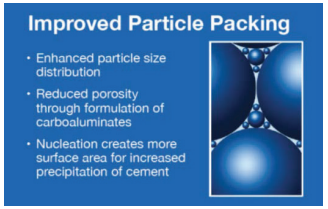


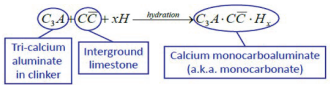
- ~ 5-10% additional limestone added to the Finish Mill, replacing clinker at 1:1.
- Ground Finer for equivalent performance
- Optimized Sulfate for Set Control

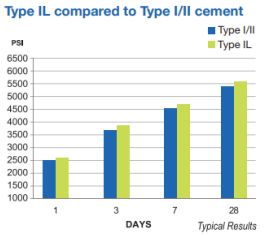
Keys to PLC Performance



The LS occupies the finest part of the cement Particle Size Distribution (PSD) spectrum



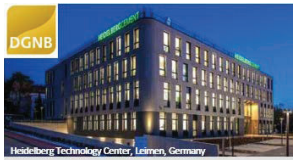




Products and Technology:
Re-Carbonation Ready - Embodied Carbon Emission Reduction Accounting Soon

RE-Carbonation benefits quantifiable through EPDs

- HeidelberCement: significant carbonation R & D
- HeidlbergCement Research Labs:

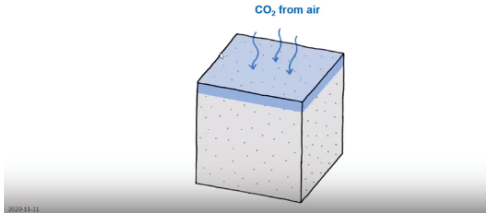


EPD Calculations a concrete product (EN 16757, Annex BB)

The CO_2 uptake in kg for each application during t years can be calculated as:

$$CO_2 \text{ uptake} = (\Sigma(k_i \times DOC_i \times A_i))\ (V(t)/1000) \times U_{tcc} \times C$$

CO_2 uptake = f(concrete properties),(geometry),(time),(Cement parameters)



Global Cement and Concrete Association good source on this topic

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SUSTAINABILITY

Sustainable Concrete Pavements – Whole Life Carbon Accounting

Life Cycle Assessment (LCA) – Use-phase impacts are often dominant (energy, CO_2 etc.)

- Pavement Vehicle Interaction (PVI) – roughness, texture and **deflection** (stiffness)
  - Useful tool for agencies to reduce GHG emission. Increasing the stiffness using 10% resurfacing in the network per year → 18% reduction of GHG emissions from the pavement network, or 440 Mt CO_2eq, over a 50-years. *(AzariJafari et al.)*
- Albedo – Mitigating Urban Heat Island and Climate Change
  - Reflective pavements could lower air temperatures by more than 2.5°F, and offset CO2 equivalent of 4 million cars per year
- Carbon Uptake – can offset 5.4% of GHG emissions associated with clinker production!
  - 5.8 Million metric tons CO_2 can be sequestered by US pavement network (*AzariJafari et al.*)

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PORTLAND LIMESTONE CEMENT PROJECTS

Lehigh Project and Case Studies using EcoCem*PLC™*

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PLC PROJECTS

First Iowa DOT PLC Pavement Project - 2013

Concrete was a Ternary Mixture:

- Iowa DOT QMC Mix Design
- Type IL(10) Cement and 20% Class C Fly Ash
- 19,270 yd^3 Concrete
- 4,274 Tons Type IL(10) Cement

Pavement:

- 10 ½ inch Doweled Pavement
- 4 Miles, 2 East Bound Lanes w/ Turn Lanes
- Placed in 12 days: May 24-June 19, 2013

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PLC PROJECTS

Central Iowa Expo Center: Boone IA

Concrete Mix Information:
- Iowa DOT QMC Mix Design
- Type IL(10) and 20% Class C Fly Ash
- 2,536 yd^3 Concrete
- 553 Tons Type IL(10) Cement

Pavement:
- 6 inch Plain Pavement
- 19 Mile Haul from Concrete Plant!
- Placed: June 21-28, 2013

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PLC PROJECTS

Lehigh Plant – Leeds, Alabama

2009-10 Creek Relocation
– 26,800 CY
- Soil Stabilization, Creek Lining, Tunnel Under Plant

2010 New Cement Silo – 5,100 CY
- Slip Formed – 5100 CY (40% Slag)
- Intricate Structural Design

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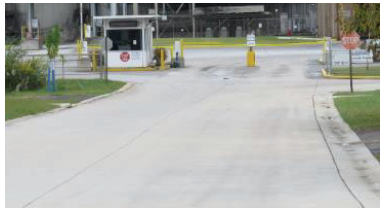
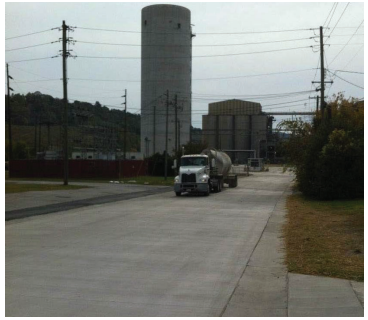
PLC PROJECTS

City of Leeds, AL Streets



2013 & 15 Streets – 500 CY (20% F-ash)
City of Leeds Paving – 400 CY



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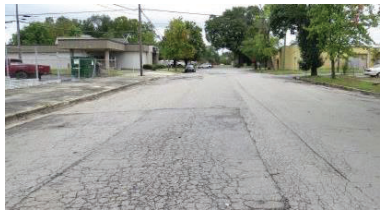
PLC PROJECTS

City of Leeds, AL Streets



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PLC PROJECTS

Indiana First PLC Pavement Project - Patching

Project: completed Sept. 2020
Project location: I-65 Columbus, IN

Comments from the project:

Plastic properties of the concrete were very consistent and stable

Expected project duration was 5-6 Saturdays; due to the performance of the PLC concrete, the project was completed in 3 Saturdays.

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PLC PROJECTS

Indiana First PLC Pavement Project - Patching

Project: completed Sept. 2020
Project location: I-65 Columbus, IN

Patch Concrete: 284 Cubic Yards
Concrete Patch Mix design - typically patching mix
Replaced ordinary cement with PLC (like for like)

Specs: 625psi flex in 3days (typically 550psi)

Concrete Test Results:
425 flex psi spec to open to traffic; with maturity, this was attained in 12-15 hrs.
The 3d flex spec was 625 psi; the average for the project was 730 psi in 3 days.

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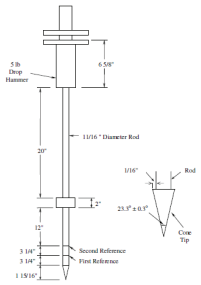
PLC PROJECTS

Indiana First PLC Pavement Project - Patching

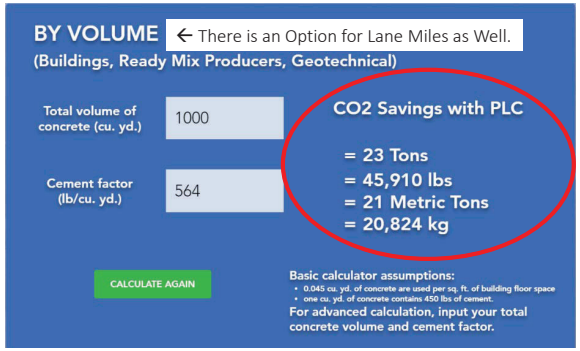
Flowable fill: 68 yards
First time DOT was using a higher performance flowable mixture
Flowable Fill: 8 hour DCP blow count (typically a 3 day spec – 30 blows). New mix met in ~2.5 hrs

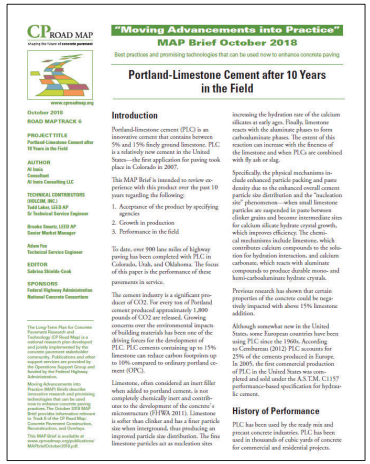


Resources for You

Portland Cement Association: https://www.greenercement.com/

The Site Contains a CO2 Calculator – How much CO2 can you save by using PLC on a project?





A Green Cement | PLC | Portland Limestone Cement

3,823 views • Oct 7, 2020 — 321 — 4

Tyler Ley
60.6K subscribers

The concrete industry has made great strides to create green cements. They do this by adding limestone during the final grinding. These cements are called Portland-Limestone Cements or PLCs. These cements have lower carbon footprints but similar performance to traditional portland cements. This video is sponsored by the Portland Cement Association to promote its new website www.greenercement.com.

[A Green Cement | PLC | Portland Limestone Cement - YouTube]

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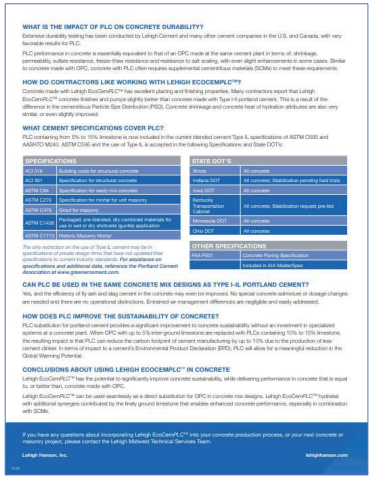

PORTLAND LIMESTONE CEMENT RESOURCES

Specifying PLC

WHAT CEMENT SPECIFICATIONS COVER PLC?

PLC containing from 5% to 15% limestone is now included in the current blended cement Type IL specifications of ASTM C595 and AASHTO M240. ASTM C595 and the use of Type IL is accepted in the following Specifications and State DOT's:

SPECIFICATIONS	
ACI 318	Building code for structural concrete
ACI 301	Specification for structural concrete
ASTM C94	Specification for ready mix concrete
ASTM C270	Specification for mortar for unit masonry
ASTM C476	Grout for masonry
ASTM C1436	Packaged, pre-blended, dry combined materials for use in wet or dry shotcrete (gunite) application
ASTM C1713	Historic Masonry Mortar

STATE DOT'S	
Illinois	All concrete
Indiana DOT	All concrete; Stabilization pending field trials
Iowa DOT	All concrete
Kentucky Transportation Cabinet	All concrete; Stabilization request pre-bid
Minnesota DOT	All concrete
Ohio DOT	All concrete

OTHER SPECIFICATIONS	
FAA P501	Concrete Paving Specification
	Included in AIA MasterSpec

The only restriction on the use of Type IL cement may be in specifications of private design firms that have not updated their specifications to current industry standards. ***For assistance on specifications and additional data, reference the Portland Cement Association at www.greenercement.com.***

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CONSTRUCTION SUSTAINABILITY RESOURCES

Increase Your Knowledge

Resources for Information and Learning on Concrete Sustainability and Transparency

https://www.fhwa.dot.gov/pavement/sustainability/
Greenercement.com – Portland Limestone Cement
CSHubMIT – YouTube – MIT Concrete Sustainability Hub Public Videos
Home | Concrete Sustainability Hub (mit.edu) – Website with research Briefs
https://www.fhwa.dot.gov/pavement/sustainability/hif19087.pdf
https://buildwithstrength.com/education/ - National Ready Mix Concrete Association Educations – On demand videos

carbonleadershipforum.org – Carbon Leadership Forum
buildingtransparency.org – CLF's tool for viewing EPDs
gccassociation.org – Global Cement and Concrete Association
nrmca.org/association-resources/sustainability/epd-program - NRMCA
Home - Build With Strength : A Coalition of the National Ready Mixed Concrete Association
linkedin.com/groups/1807540/ - Women in Concrete Alliance
https://www.linkedin.com/company/lehigh-hanson/mycompany/ Lehigh Hanson Linked In - #knowledgeIsStrength
Environmental Product Declarations (EPDs) - Lehigh Hanson, Inc. - Lehigh Hanson and Industry Wide EPDs

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Thank You!

MATERIAL TO BUILD OUR FUTURE

Questions?

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