Cementitious Materials for the Precast Industry – Where are We Headed Next?

Larry Rowland, Heidelberg Materials

2/5/2026

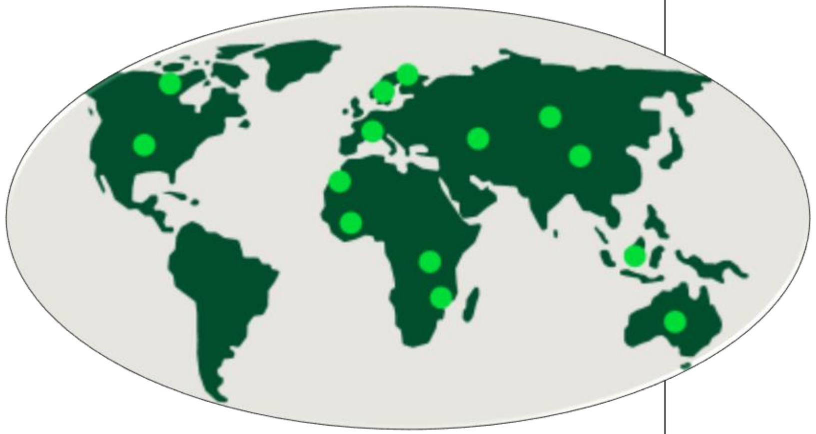
Heidelberg Materials

Speaker Background and Experience

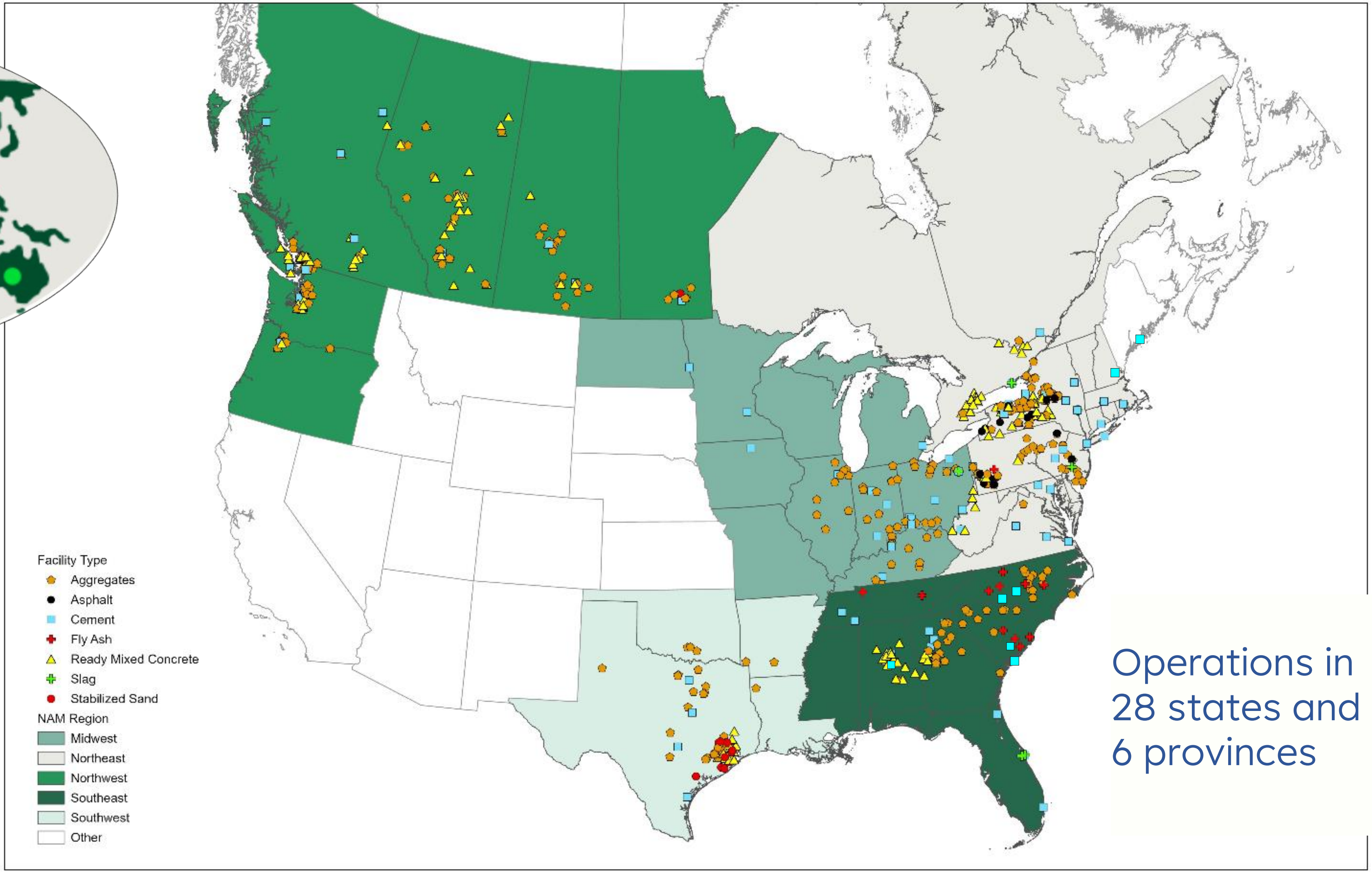
Larry Rowland

- Sustainability Market Manager for Heidelberg Materials, North America
- Has 30-yrs supplying precasters and a recognized expert on Cement and Concrete Sustainability
- An American Concrete Institute (ACI) Fellow and recipient of the ACI Concrete Sustainability Award
- Rowland has been a USGBC, LEED® Accredited Professional since 2004
- Regularly presents to Concrete Materials Industry Professionals, Architects, Engineers, Students and Green Building Practitioners on the topic of low carbon concrete

Heidelberg Materials' National and Global Perspective

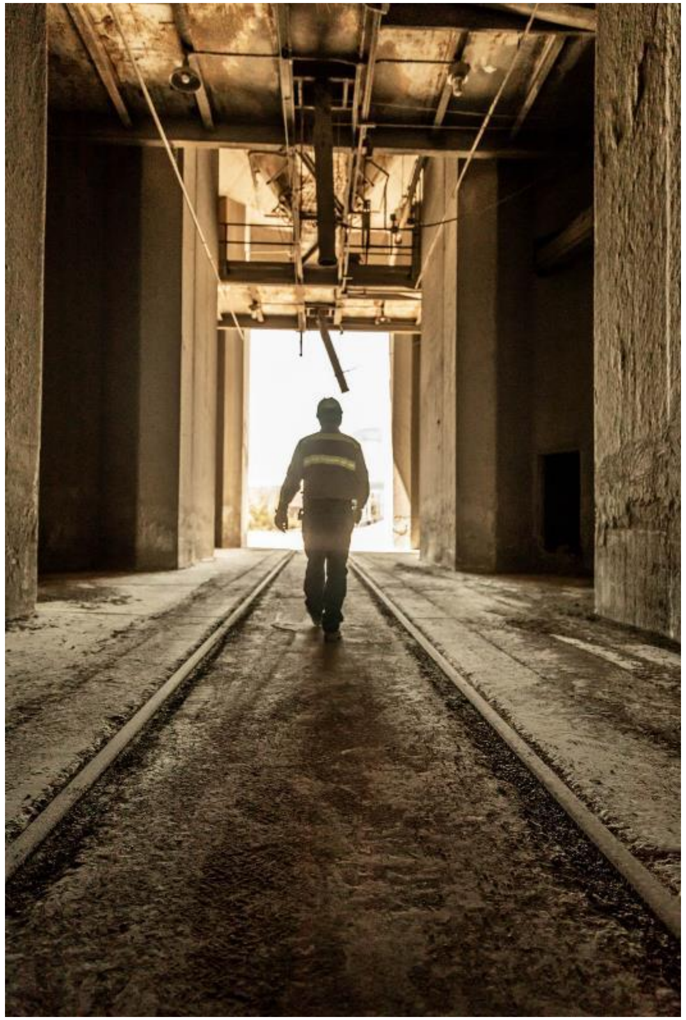


- Cementitious Materials
  - Portland / PLC / Masonry
  - Slag Cement
  - Coal Ash aka Fly Ash
- Aggregate as noted
- Ready Mix, in limited markets



Operations in 28 states and 6 provinces

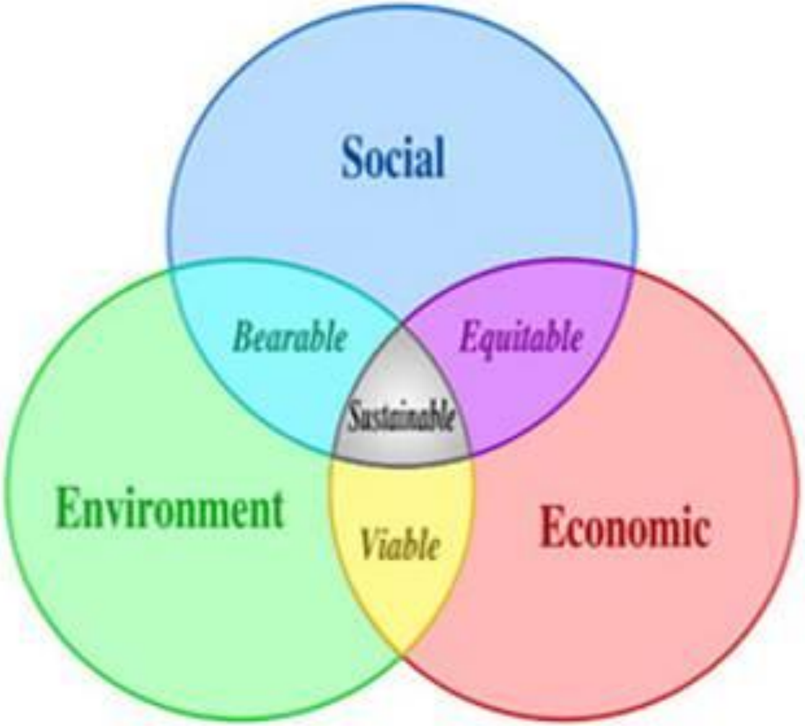
Where We Are Headed Next – National/Global Trends



National/Global Trend – Sustainability In Practice

The Triple-Bottom-Line

- Social
- Environmental
- Economic



… Sustainability is in the Overlap

What Makes a Material More or Less Sustainable?

Sustainable Constituents

LCA Production Stage A1

Low Embodied CO_2 / Energy

LCA Production Stage A3

Durable and Resilient

LCA Use Stage B1 – B5

Long Service Life, Easily Recycled

LCA Use Stages B and C, End of Life Stages

Precast Concrete is Resilient a Key Benefit to Promote

CONCRETE SUSTAINABILITY By Larry Rowland and Jeff Sieg

Why You Should Care About Resilience

Concrete is the most widely used man-made construction material in the world. It is versatile, economical, durable, recyclable, environmentally responsible and most importantly, it is resilient. Resilience is where the promise of sustainability and the real world meet. And while "resilience" may seem to be just the latest buzzword among green building enthusiasts and building designers, the concept of resilience is something we all need to care about.

It's not green if it's not resilient. As society has embraced sustainable design, more and more owners and end users are questioning trade-offs made in the name of being green. This theme was clearly displayed when the cover story of the December 2014 issue of *Building Operating Management* posed the question: Are Green Buildings Fire Safe? The article pointed out that as the design industry embraced new materials that delivered benefits such as rapidly renewable content, important safety and durability considerations were sometimes

40 Concrete Contractor | August/September 2015 | www.forconstructionpros.com/concrete

What do you want your project made of?

- Will it burn? Does it give passive resistance to fire?
- Is it power/pressurized water dependent?
- Will it rot or be eaten by insects or mold?
- Will it blow away?

Concrete is …

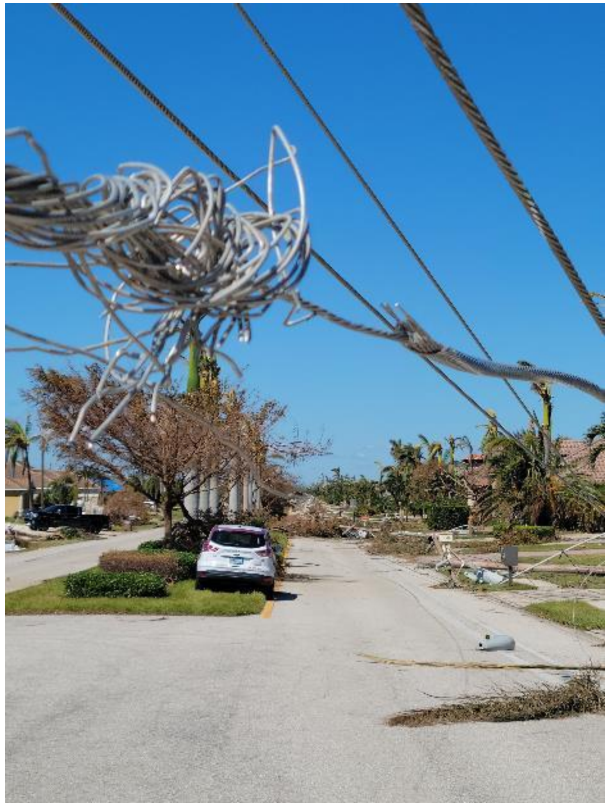
Naturally Resilient & Sustainable, Significant safety advantages for…

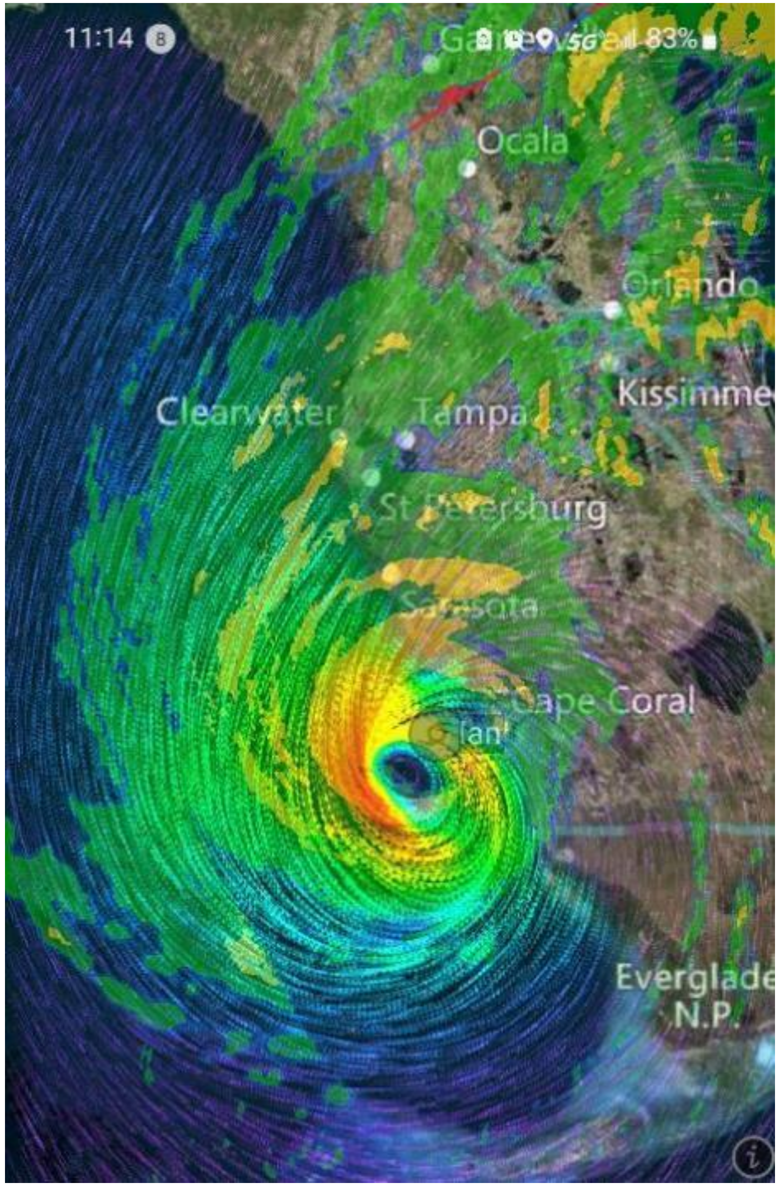
- Hurricane & Tornado
- Floods
- Mayhem

Resilience Matters

Lessons learned from Ian & others

- What's your building made of ?
- Will it keep your family safe?
- Will it blow away?
- Will debris come through your wall?
- Will critical infrastructure survive?





Resilience Matters

Lessons learned from Ian… & others

- What's your building made of ?
- Will it keep your family safe?
- Will it blow away?
- Will debris come through your wall?
- Will critical infrastructure survive?

The stakes couldn't be higher!

- ~ 40% increase in building construction
- To add 2.6 trillion ft² (241 billion m²) new floor area by 2060 ~ the size of Great Brittan
- Will it be safe… or just cheap?

National/Global Trends – Embodied Energy and CO_2 Matters

What we can all agree on…

- Human activity impacts the environment, and there are a lot of us…
- Fossil fuel, and process emissions, impact air quality & produce Green House Gases
  - Examples: burning coal to produce electrical energy, and marking cement clinker from limestone

"We do not inherit the earth from our ancestors; we borrow it from our children"
Wendell Berry

What the evidence and science tells us…

- Green House Gas emissions are driving climate change
- Climate change will increase the need for resilience and is driving policy decisions
- Concerns about embodied carbon has changed the way we do business

Concrete Industry’s Response to Climate Change Concerns

Projections on the effects of global warming increasing from 1.5 °C to 2 °C

- 14% → 37% of the global population will be exposed to extreme heat at least every 5 years
- 100% → 170% increase in flooding risks
- 70% → 99% further decline of coral reefs
- 8% → 16% of natural plant habitat lost




Concrete is More Than 50% of Everything We Make[1]

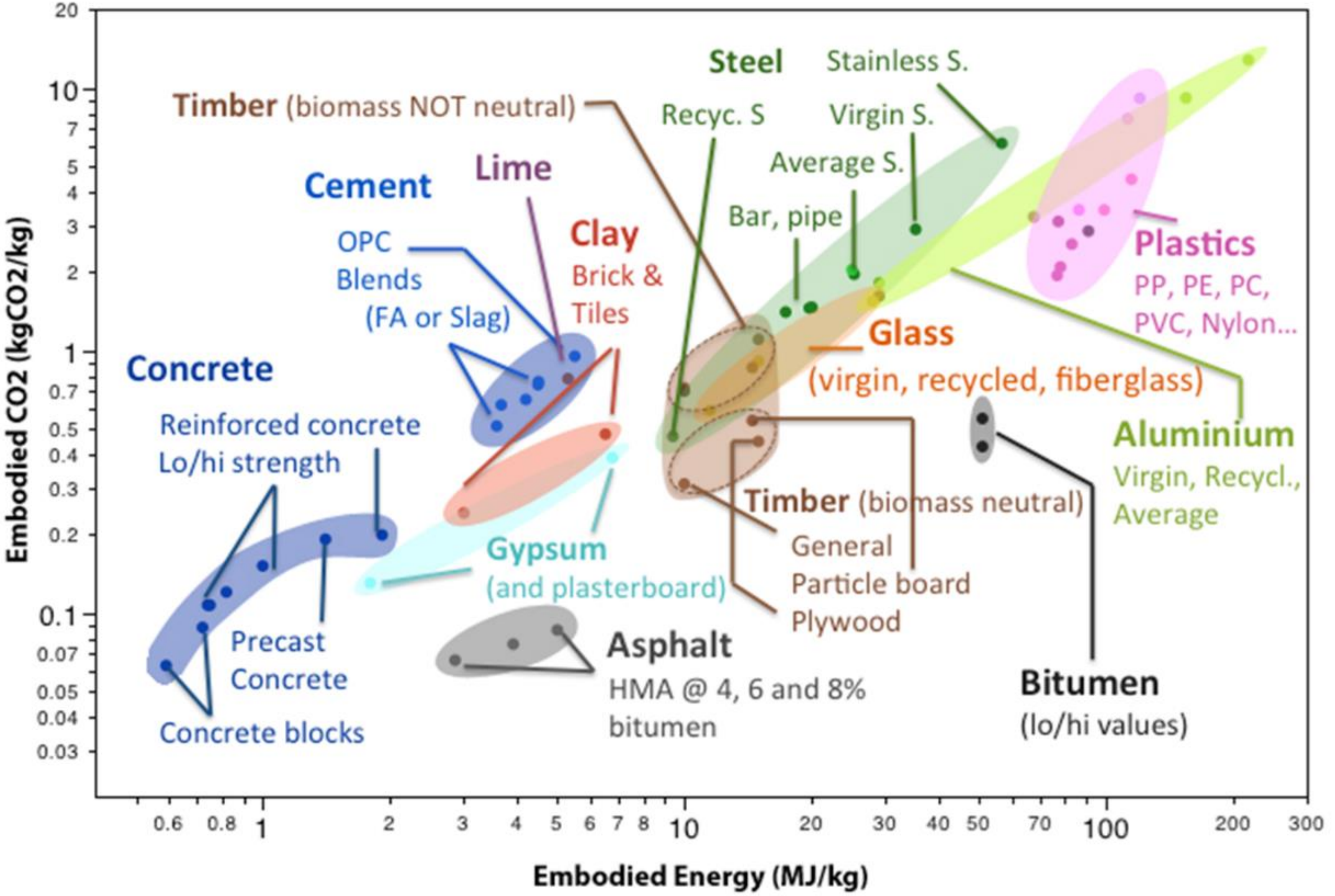
Most widely produced solid material on earth

- Concrete delivers…
  - Economy
  - Strength & Durability
  - Versatility
  - Resilience
- Because concrete is practically synonymous the term construction it….
  - Is responsible for 7% – 8% of global manmade CO_2 emissions
  - It can be argued this is a relatively small CO_2 investment for more than 50% of the stuff we make but, we are working to lower these #s

Photo Credit, Rasmus Hjortshoj

[1]Rencontre du Conseil d'Etat avec la Présidence de l'EFL EPFL Fribourg, https://www.concrete.org/portals/0/files/pdf/webinars/ws_S23_KarenScrivener.pdf

Comparative CO_2 Emissions from Cement



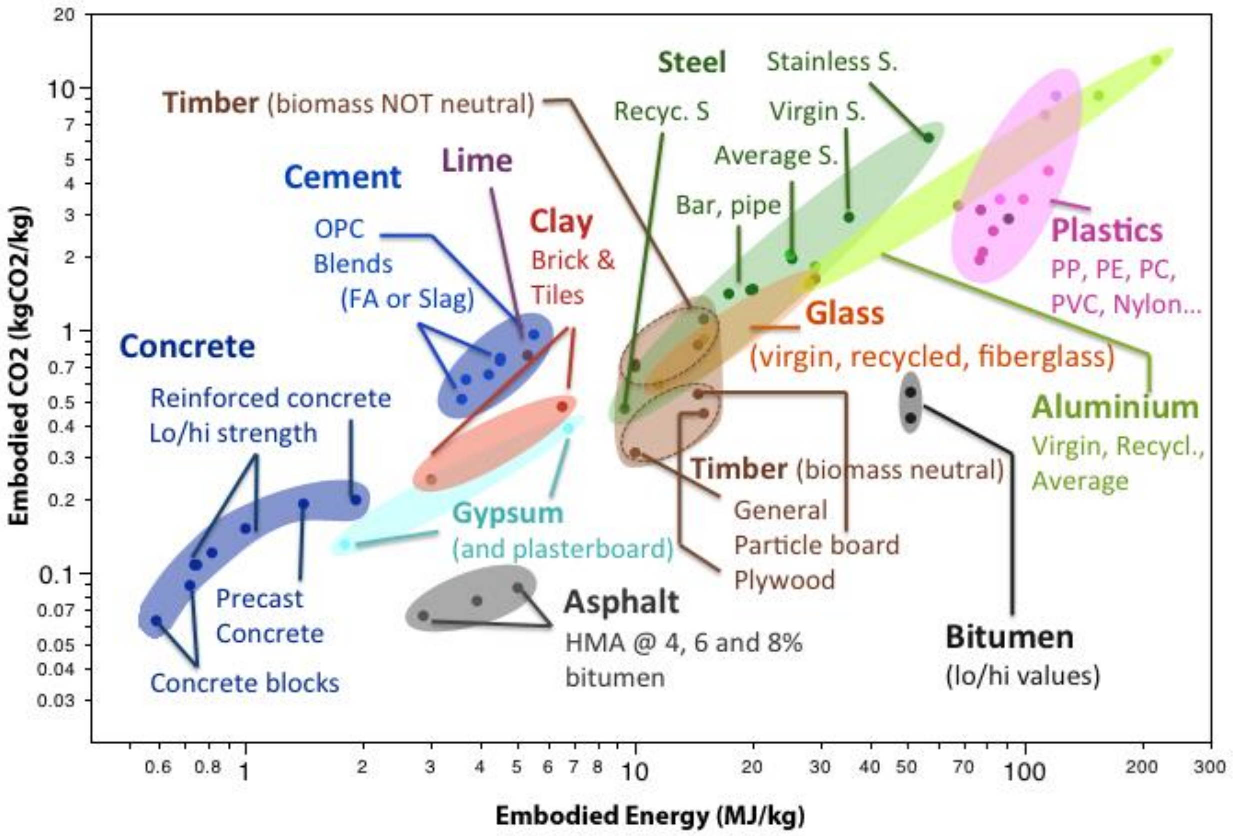
Precast Concrete is a very sustainable material with low environmental impacts.

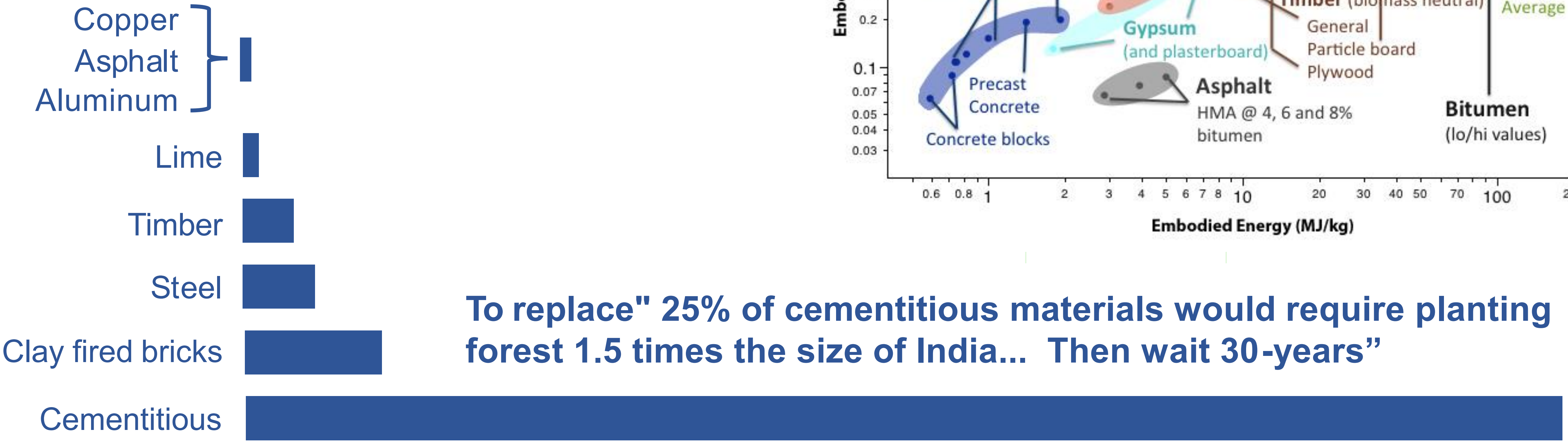
Reference: **Cement and carbon emissions** by Laurent Barcelo, John Kline, Gunther Walenta, Ellis Gartner, Materials and Structures, June 2014, Volume 47, Issue 6, pp 1055-1065
DOI 10.1617/s11527-013-0114-5

Global CO_2 from Concrete

"Cementitious materials make up > 50% of everything we produce."

"It is only for this reason they account for 8% of CO2 annually."





To replace" 25% of cementitious materials would require planting forest 1.5 times the size of India... Then wait 30-years"

Slide adapted from LC3 presentation 3.31.2023 by Prof. Karen Scrivener

Concrete is Our Business, and the Foundation of Our Society, How Can We Make it More Sustainable?

“ That which is measured improves. That which is measured and reported improves exponentially ”

Karl Pearson

Whole Building LCA Stages

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
x	x	x	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

X = Included in Cradle to Gate

MND = Module Not Declared

A material's GWP is determined by completing a Life Cycle Assessment (LCA)

- As required by the North American PCR (Product Category Rule) for Portland cement GWPs are for...
- Cradle to Gate - accounting for all the inputs in a LCA Production Stage (Modules A1 to A3)
- Findings from LCAs are best summarized in a Type III EPD

Product Category Rules

Life Cycle Assessments level the playing field for “like” materials

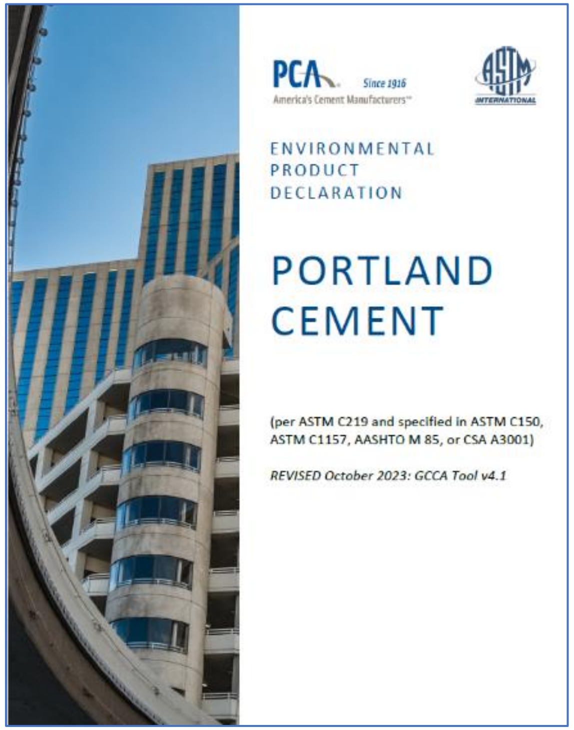
Product Category Rules (PCRs) set baseline requirements for doing LCA studies and reporting impacts via an EPD

- PCRs define what is measured and reported
- Set scope, and framework of what LCA data to report on EPDs
- They are “Product” specific
- Individual PCRs for…
    - Newly published Cement PCR valid through July 2030
    - Precast Concrete valid through April 30, 2026 (to be Extended)

EPDs Provide Transparency & GWPs (embodied CO_2)

Having a way to compare environmental impact is crucial. GWPs are a good indicator

EPDs make an accounting, furthering the transparency of environmental claims



PCA Since 1916
America's Cement Manufacturers™

ASTM INTERNATIONAL

ENVIRONMENTAL PRODUCT DECLARATION
PORTLAND CEMENT

Life cycle assessment results

The cradle-to-gate (A1 to A3) EPD results for producing one metric ton of portland cement are presented in Table 4.

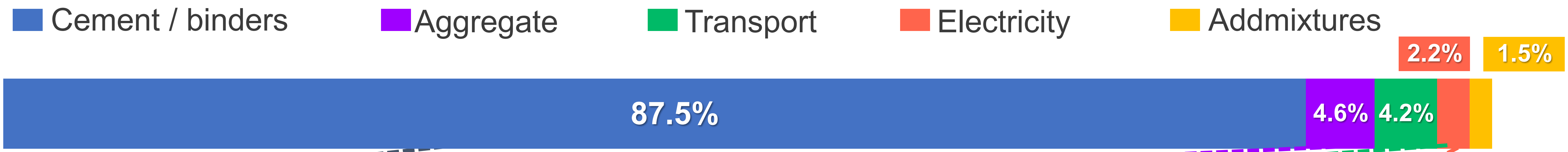
Table 4. Production stage EPD results for portland cements.

Impact category and inventory indicators	Unit	Portland Cements 1 metric ton
Global warming potential, GWP 100, IPCC 2013	kg CO_2 eq	919

Industry Average GWP* for Portland Cement
919

* GWP = kg CO_2 equiv. / M. ton

Precast – Embodied CO_2 by Component & Activity



- Use SCMS vs. Cement
- Incorporate limestone and SCMs in Blended Cements
- Use alternate fuels

- Aggregate is local, and very low energy and GWP building material.
- Often overlooked CO_2 success factor

- Work with suppliers to minimize empty back-hauls
- Ask them to document CO_2 emissions

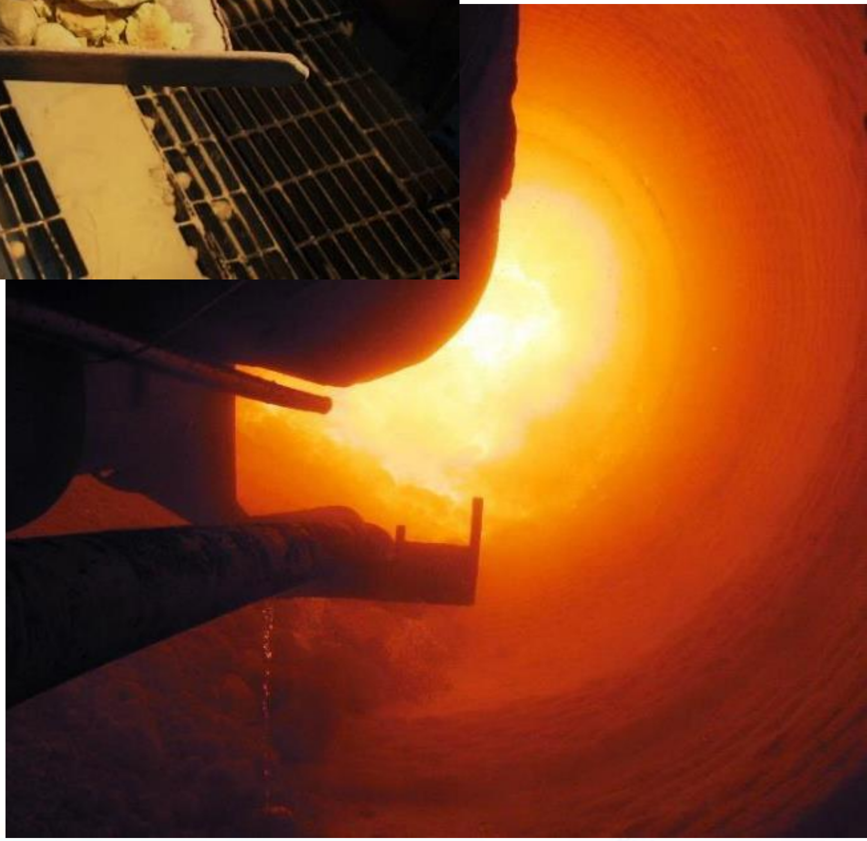
- Dependent on power mix from the grid
- Renewable energy credits are usable benefit today

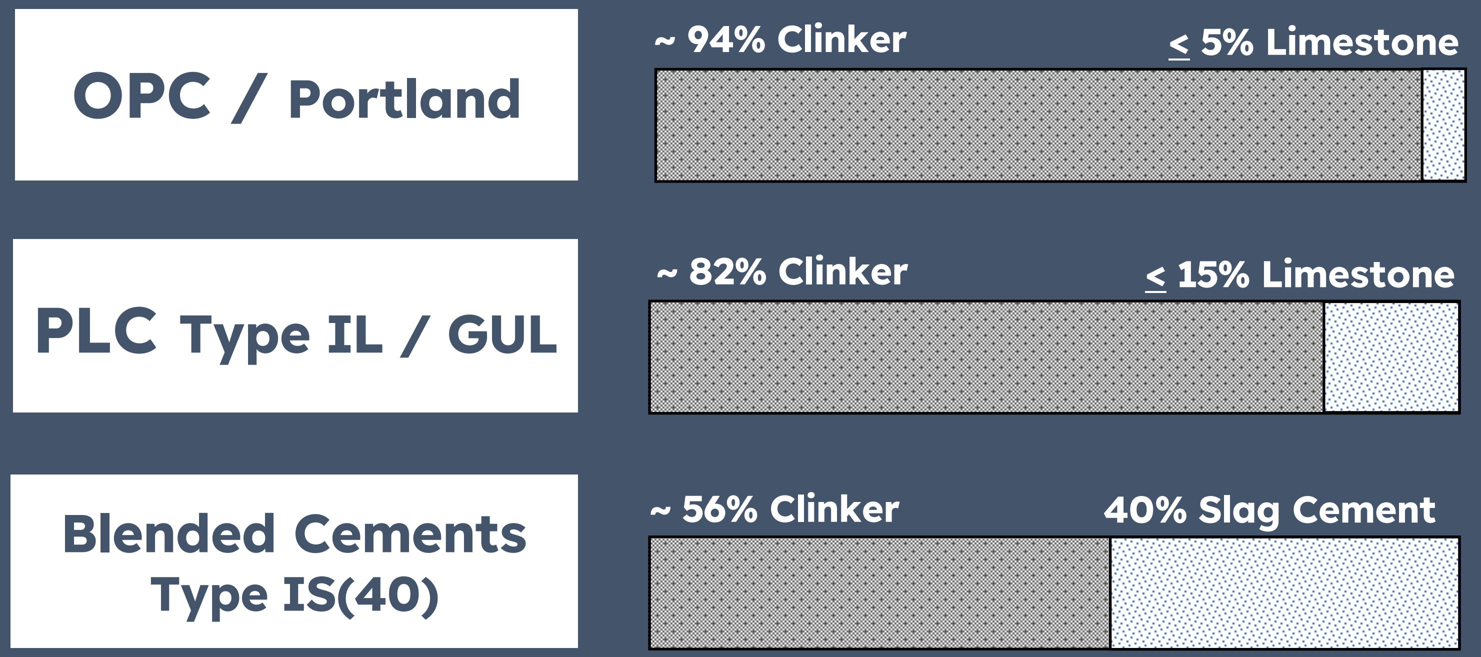
CO_2 in concrete is more than just cement… but…

Portland & PLC Cement CO_2 Emissions

Cement's CO_2 emissions are mostly from making clinker

- Clinker process emissions ~ 2/3
  - "Calcining" limestone $CaCO_3$
  - High heat + $CaCO_3 \rightarrow CaO + CO_2$
- Burning fuel/pyroprocessing ~ 1/3
  - Targeting temperatures ~ 2,800° F
  - Greatly reduced by Alternative Fuel use
- Remaining CO_2 from running equipment & misc. operations





Low-carbon Cement Strategies

- Clinker reduction
- Key strategy for reducing embodied CO_2 aka GWP
- Performance Specifications enable use
- Significant reduction potential depending on available materials and type of application

Current technologies at the cement plant

- Interground limestone and SCM incorporation
- Recycled raw materials for clinker production
- Alternative fuels and heat recovery technologies

Key Strategies to Decarbonize Cement & Concrete

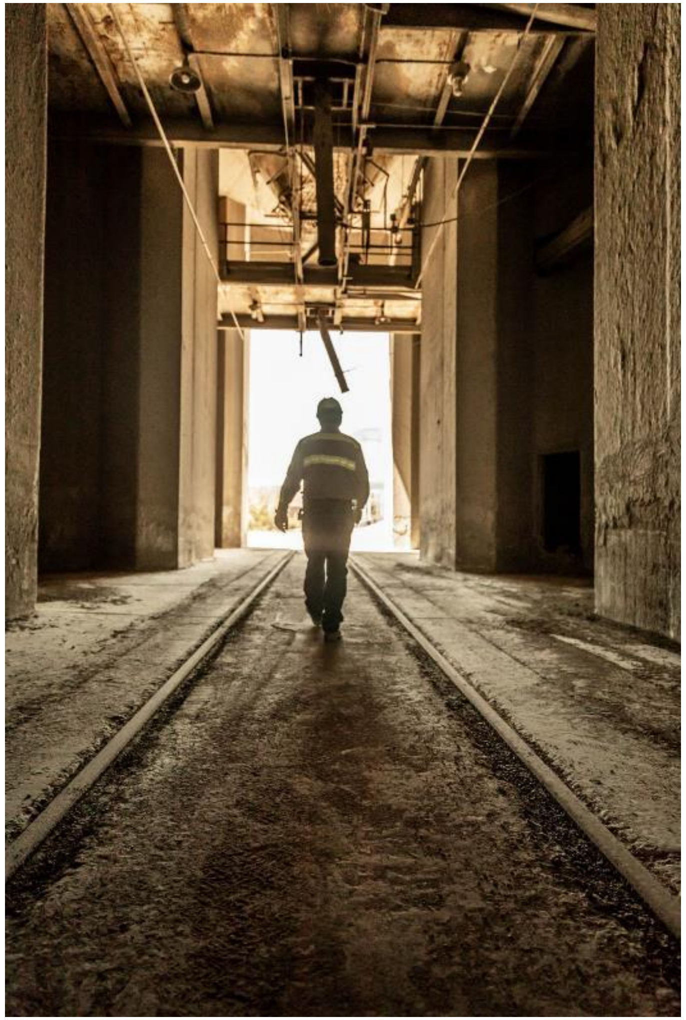
Reduce the CO_2 in clinker

- Energy efficiency in production
- Replace coal with Natural Gas and Alternative Fuels
- CCUS, the path to Net Zero Concrete
- Use alternative raw Materials

Reduce the clinker content in your concrete

- Use Blended Cements i.e. PLCs
- Use SCMs to replace PLC or Portland Cement
- Optimize mixes to reduce cementitious loading

National/Global Trends – More Use of Blended Cements



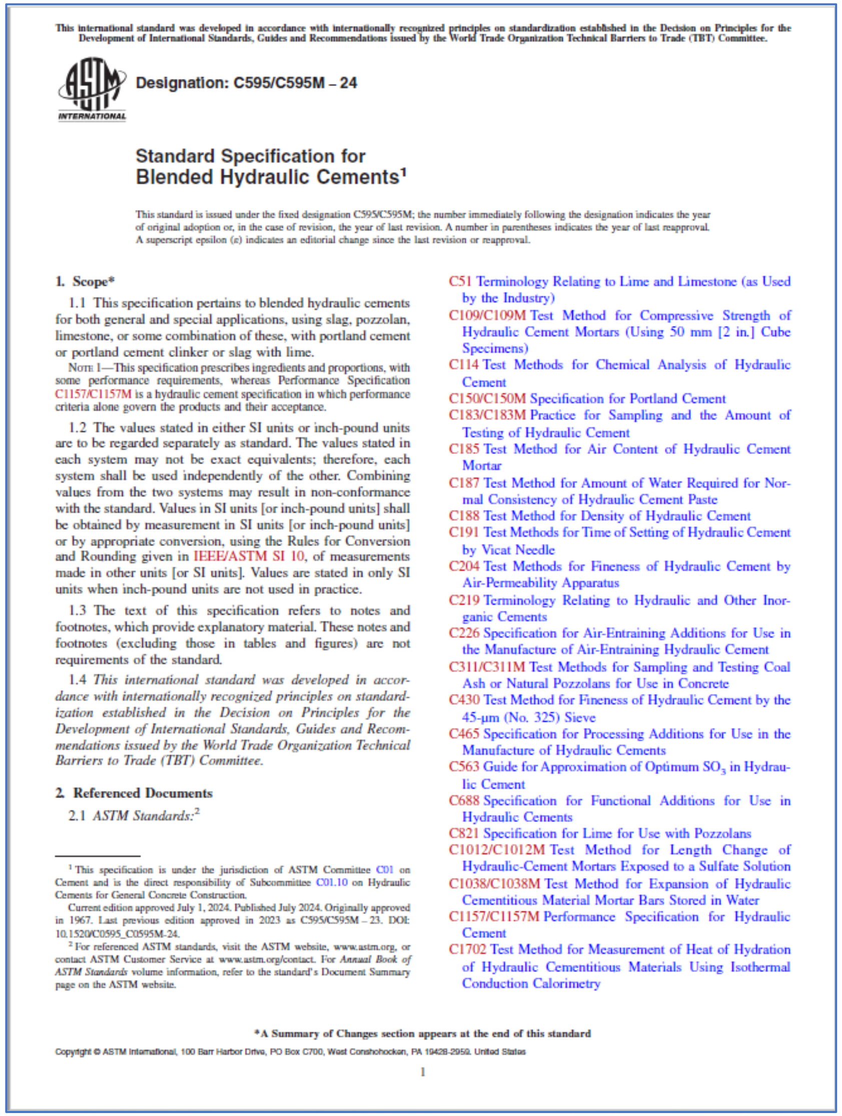
Specifications for Blended Cements in the US

Conform to ASTM C595 / AASHTO M 240 Specs

- Type IL - Portland-limestone cement
- Type IS - Portland blast-furnace slag cement
- Type IP - Portland-pozzolan cement
- Type IT - Ternary blended cement

ASTM C595 Blended Cements permitted for use in…

- ACI 318 Bld. Code for Structural Concrete
- ACI 301 Specification for Structural Concrete
- FAA Advisory Circular AC 150/5370-10H, Standard Specifications for Construction of Airports



This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

INTERNATIONAL

Designation: C595/C595M – 24

Standard Specification for Blended Hydraulic Cements[1]

This standard is issued under the fixed designation C595/C595M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This specification pertains to blended hydraulic cements for both general and special applications, using slag, pozzolan, limestone, or some combination of these, with portland cement or portland cement clinker or slag with lime.

NOTE 1—This specification prescribes ingredients and proportions, with some performance requirements, whereas Performance Specification C1157/C1157M is a hydraulic cement specification in which performance criteria alone govern the products and their acceptance.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard. Values in SI units [or inch-pound units] shall be obtained by measurement in SI units [or inch-pound units] or by appropriate conversion, using the Rules for Conversion and Rounding given in IEEE/ASTM SI 10, of measurements made in other units [or SI units]. Values are stated in only SI units when inch-pound units are not used in practice.

1.3 The text of this specification refers to notes and footnotes, which provide explanatory material. These notes and footnotes (excluding those in tables and figures) are not requirements of the standard.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C51 Terminology Relating to Lime and Limestone (as Used by the Industry)
C109/C109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 50 mm [2 in.] Cube Specimens)
C114 Test Methods for Chemical Analysis of Hydraulic Cement
C150/C150M Specification for Portland Cement
C183/C183M Practice for Sampling and the Amount of Testing of Hydraulic Cement
C185 Test Method for Air Content of Hydraulic Cement Mortar
C187 Test Method for Amount of Water Required for Normal Consistency of Hydraulic Cement Paste
C188 Test Method for Density of Hydraulic Cement
C191 Test Methods for Time of Setting of Hydraulic Cement by Vicat Needle
C204 Test Methods for Fineness of Hydraulic Cement by Air-Permeability Apparatus
C219 Terminology Relating to Hydraulic and Other Inorganic Cements
C226 Specification for Air-Entraining Additions for Use in the Manufacture of Air-Entraining Hydraulic Cement
C311/C311M Test Methods for Sampling and Testing Coal Ash or Natural Pozzolans for Use in Concrete
C430 Test Method for Fineness of Hydraulic Cement by the 45-μm (No. 325) Sieve
C465 Specification for Processing Additions for Use in the Manufacture of Hydraulic Cements
C563 Guide for Approximation of Optimum SO_3 in Hydraulic Cement
C688 Specification for Functional Additions for Use in Hydraulic Cements
C821 Specification for Lime for Use with Pozzolans
C1012/C1012M Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution
C1038/C1038M Test Method for Expansion of Hydraulic Cementitious Material Mortar Bars Stored in Water
C1157/C1157M Performance Specification for Hydraulic Cement
C1702 Test Method for Measurement of Heat of Hydration of Hydraulic Cementitious Materials Using Isothermal Conduction Calorimetry

[1] This specification is under the jurisdiction of ASTM Committee C01 on Cement and is the direct responsibility of Subcommittee C01.10 on Hydraulic Cements for General Concrete Construction.

Current edition approved July 1, 2024. Published July 2024. Originally approved in 1967. Last previous edition approved in 2023 as C595/C595M – 23. DOI: 10.1520/C0595_C0595M-24.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard

1

How Blended Cements are Classified by US Specifications

Requirements & naming provisions per Type ASTM C595-25 / AASHTO M 240

- **Most common is Portland Limestone Cements - Type IL**
- Type IL - Portland-limestone cement with 5% to 15% Limestone content. This compared with up to 5% Limestone per ASTM C150 Portland Cement (Types I, I/II, III and IV)

ASTM C595 – Current Status (C595-25)

	Limestone	Pozzolan	Slag	Sum (L + P + S)
Type IL	5 to 15%		--	--
Type IP		0 to 40%	--	--
Type IS			0 to 70%	--
Type IT	0 to 15%	0 to 40%	0 to 70%	0 to 70%

Type IT – Portland cement + 2 of (pozzolans, slag, or limestone). Maximum of 3 materials in total.

Not shown: Type IS(>70) and Type IT(S>70). These are rare and mostly unaffected by proposals.

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2026 To Bring Changes to Blended Cements Specifications

ASTM C595-26 (to publish in late July/early August; not in effect until published)

Type IT to require 2 SCMs; and permit 15% limestone in all C595 types

New C595 compositional limits (key changes highlighted):

	Limestone	Pozzolan	Slag	Sum (L + P + S)
Type IL	5 to 15%	--	--	--
Type IP	0 to 15%	0 to 40%	--	--
Type IS	0 to 15%	--	0 to 70%	--
Type IT	0 to 15%	0 to 40%	0 to 70%	0 to 70%

Type IT – Portland cement + 2 of (pozzolans or slag) + limestone (optional). Max. 4 materials in total.

Key changes to take effect when published ~ Summer 2026

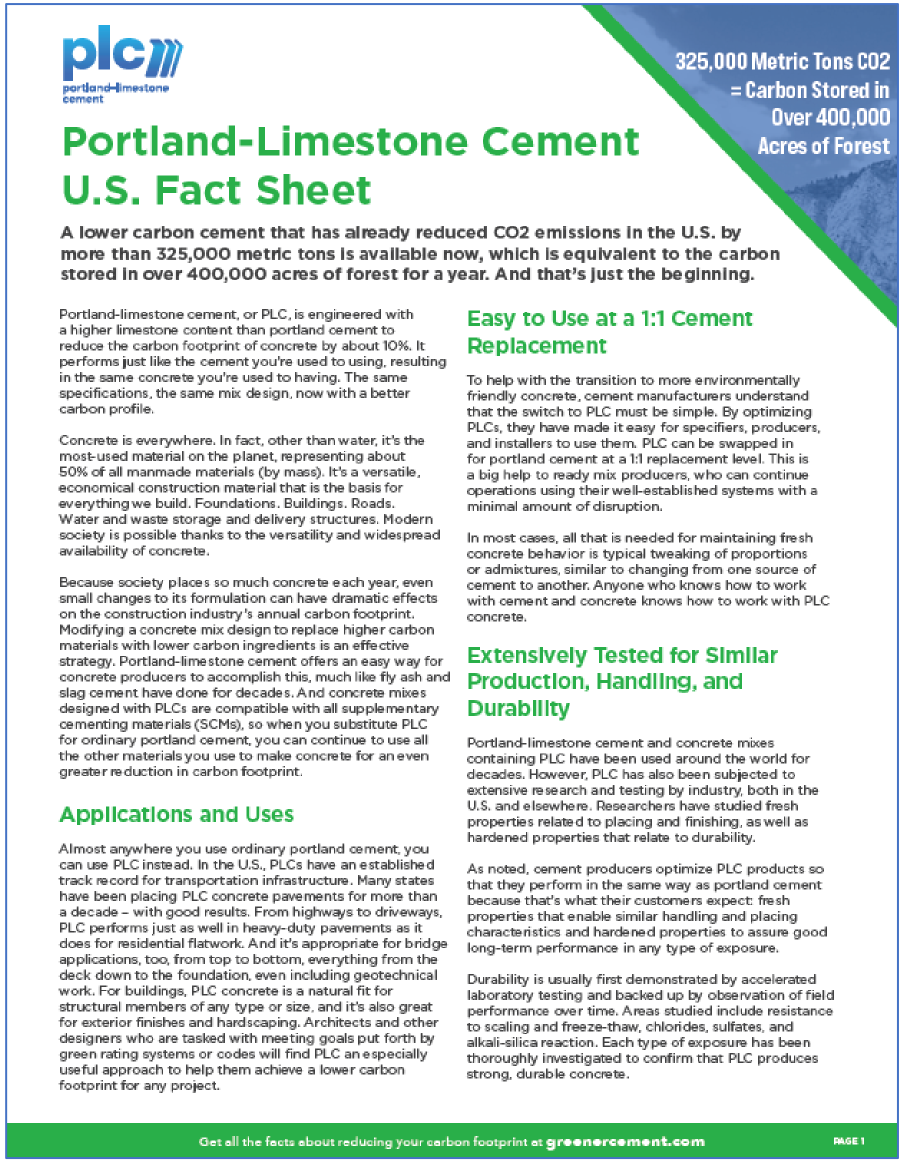
- Limestone addition of 5% to 15% allowed in all blended cement types
- Type IT cements now to have two SCMs (2 pozzolan or slag + a pozzolan) + Limestone (optional)
- Previously Type IT cements were limited to cement + 2 other materials, one allowed to be Limestone
- Type IL will still be most common blended cement you are likely to have access to

Resources/Insights for Your Teams

Type IL aka PLC is most common Blended Cement

Portland-Limestone Cement Fact Sheet from ACA

- Type IL is the new normal in many markets
- Expected to be most common type, if not already
- Increases limestone addition limit from 5% to 15%
  - ASTM C150 Portland Cement allows 5% limestone
- Typical limestone addition rates 10% - 12%
- Result is 30# - 40# additional ground limestone in a typical 3,850# cubic yard of concrete
- Set times and strength gain curves will likely be different



plc portland-limestone cement

325,000 Metric Tons CO2 = Carbon Stored in Over 400,000 Acres of Forest

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.

Portland-limestone cement, or PLC, is engineered with a higher limestone content than portland cement to reduce the carbon footprint of concrete by about 10%. It performs just like the cement you're used to using, resulting in the same concrete you're used to having. The same specifications, the same mix design, now with a better carbon profile.

Concrete is everywhere. In fact, other than water, it's the most-used material on the planet, representing about 50% of all manmade materials (by mass). It's a versatile, economical construction material that is the basis for everything we build. Foundations. Buildings. Roads. Water and waste storage and delivery structures. Modern society is possible thanks to the versatility and widespread availability of concrete.

Because society places so much concrete each year, even small changes to its formulation can have dramatic effects on the construction industry's annual carbon footprint. Modifying a concrete mix design to replace higher carbon materials with lower carbon ingredients is an effective strategy. Portland-limestone cement offers an easy way for concrete producers to accomplish this, much like fly ash and slag cement have done for decades. And concrete mixes designed with PLCs are compatible with all supplementary cementing materials (SCMs), so when you substitute PLC for ordinary portland cement, you can continue to use all the other materials you use to make concrete for an even greater reduction in carbon footprint.

Applications and Uses

Almost anywhere you use ordinary portland cement, you can use PLC instead. In the U.S., PLCs have an established track record for transportation infrastructure. Many states have been placing PLC concrete pavements for more than a decade – with good results. From highways to driveways, PLC performs just as well in heavy-duty pavements as it does for residential flatwork. And it's appropriate for bridge applications, too, from top to bottom, everything from the deck down to the foundation, even including geotechnical work. For buildings, PLC concrete is a natural fit for structural members of any type or size, and it's also great for exterior finishes and hardscaping. Architects and other designers who are tasked with meeting goals put forth by green rating systems or codes will find PLC an especially useful approach to help them achieve a lower carbon footprint for any project.

Easy to Use at a 1:1 Cement Replacement

To help with the transition to more environmentally friendly concrete, cement manufacturers understand that the switch to PLC must be simple. By optimizing PLCs, they have made it easy for specifiers, producers, and installers to use them. PLC can be swapped in for portland cement at a 1:1 replacement level. This is a big help to ready mix producers, who can continue operations using their well-established systems with a minimal amount of disruption.

In most cases, all that is needed for maintaining fresh concrete behavior is typical tweaking of proportions or admixtures, similar to changing from one source of cement to another. Anyone who knows how to work with cement and concrete knows how to work with PLC concrete.

Extensively Tested for Similar Production, Handling, and Durability

Portland-limestone cement and concrete mixes containing PLC have been used around the world for decades. However, PLC has also been subjected to extensive research and testing by industry, both in the U.S. and elsewhere. Researchers have studied fresh properties related to placing and finishing, as well as hardened properties that relate to durability.

As noted, cement producers optimize PLC products so that they perform in the same way as portland cement because that's what their customers expect: fresh properties that enable similar handling and placing characteristics and hardened properties to assure good long-term performance in any type of exposure.

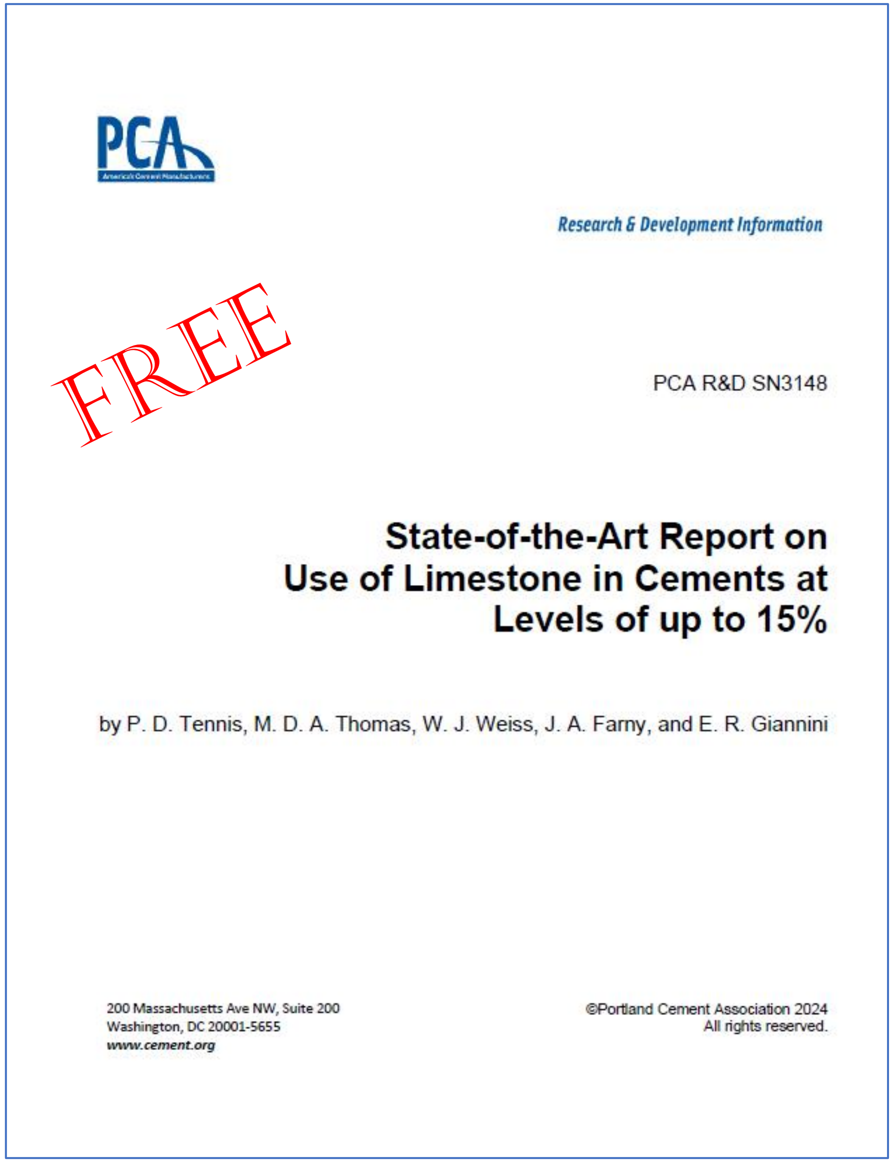
Durability is usually first demonstrated by accelerated laboratory testing and backed up by observation of field performance over time. Areas studied include resistance to scaling and freeze-thaw, chlorides, sulfates, and alkali-silica reaction. Each type of exposure has been thoroughly investigated to confirm that PLC produces strong, durable concrete.

Get all the facts about reducing your carbon footprint at greenercement.com PAGE 1

Resources/Insights for Your Teams

State-of-the-Art Report on Use… Excellent more in depth it is a FREE publication updated in 2024

- Type IL will remain most common blended cement
- Manufactured to have similar performance to Type I/II
- Has lower GWP (CO_2) due to lower clinker content
- Typical that the 10% - 12%, "limestone fraction" will be finer than the ground cement clinker, resulting in a higher Blaine
- Bleed rates, and bleed characteristics will be different
- May have increased water demand and require additional water and admixture adjustments


PCA

Research & Development Information

FREE

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, W. J. Weiss, J. A. Farny, and E. R. Giannini

200 Massachusetts Ave NW, Suite 200
Washington, DC 20001-5655
www.cement.org

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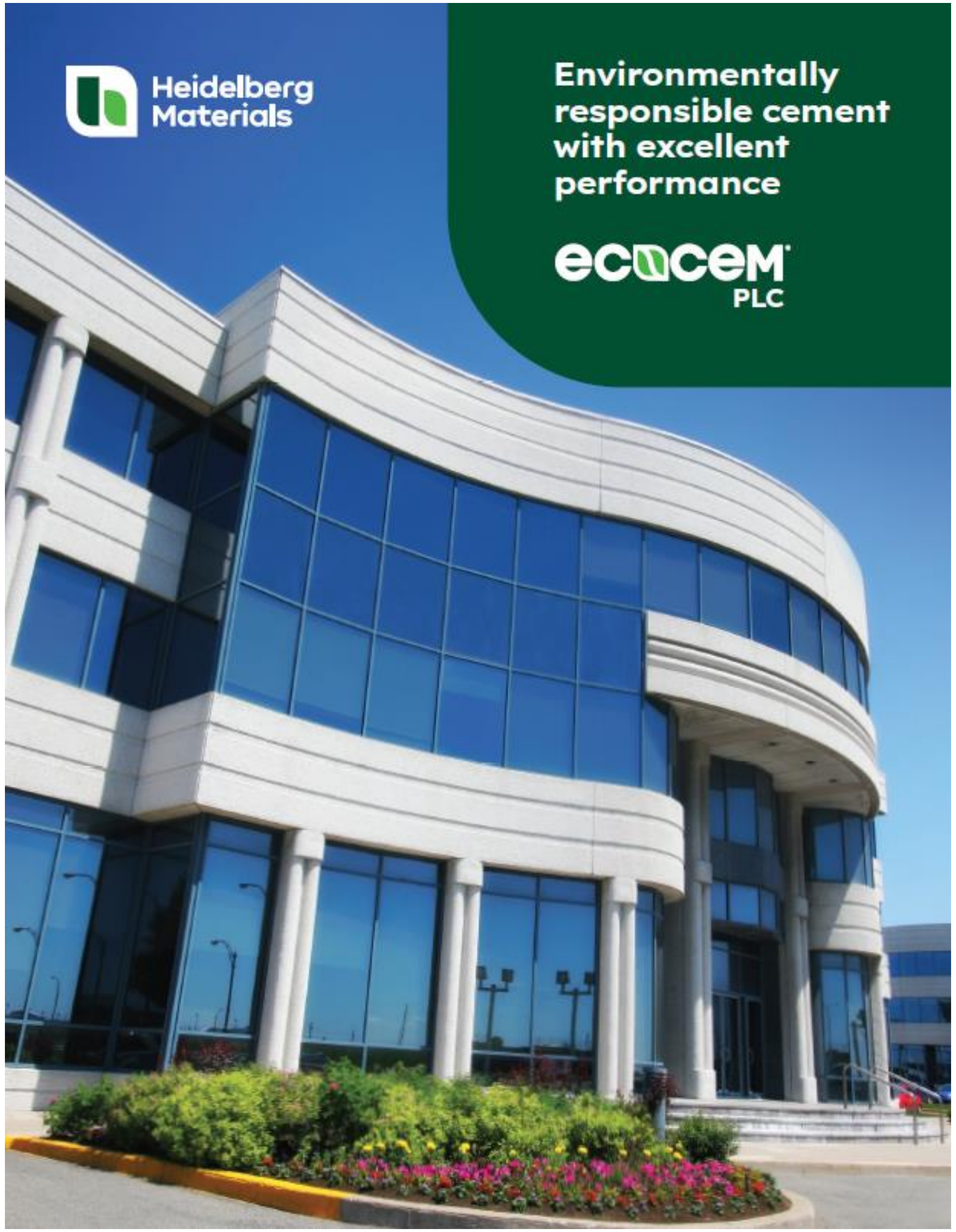


Our Experience with PLCs

- "At Heidelberg Materials, we aim to be the industry leader on the path to net zero concrete." We sell Type IL, low-carbon cement.
- Rigorous internal test and field trials which started years prior to wide-spread distribution
- Assembled comparative data with OPC and IL from multiple plants in a standard concrete mix design, tested…
  - Plastic and hardened testing: Slump, air, bleed rate, set time, mix consistency
  - Compressive & flexural strength
  - Shrinkage
  - Slump loss and workability
  - Durability
  - Impact of Admixture and SCMs
- Our result closely aligned with ACA and industry findings

Adapting Mixes for Type IL Cement, Gained Experiences

Adjusting admixture combinations always key for change in cements/SCMs

- Water demand often higher due fineness & may require slightly higher w/c ratios
- Consult cement Tech Service team and admixture suppliers for insights. Double check WRAs are not retarding your mix, watch for:
  - Type D – Water-reducing and retarding admixtures… and
  - Type G – Water-reducing, high-range and retarding admixtures
- PLCs have slightly lower Specific Gravity, which effects yield slightly
- Usually get a bit of a psi bump when combined with Slag
- Strength gain timing may affect performance tied to some test
  - Modulus of elasticity
  - Creep & volume stability

Larry Rowland, Heidelberg Materials

Advantages of “Other” Blended Cements - Type IS, IP and IT

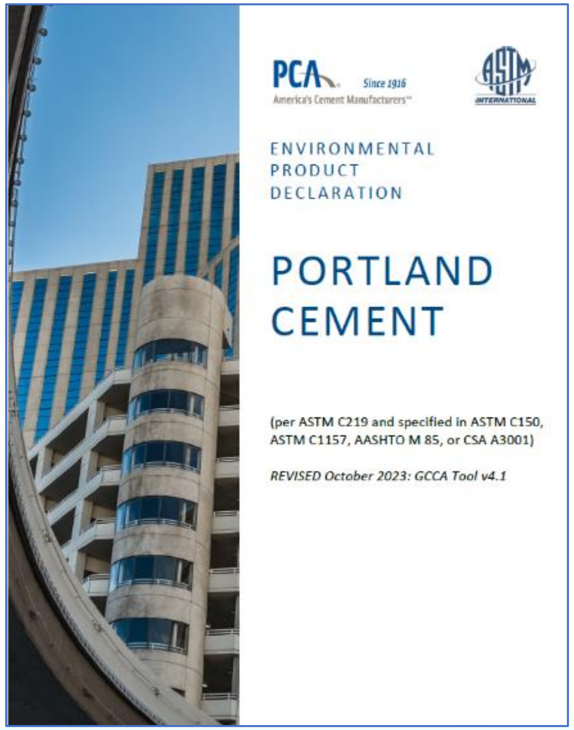
Slag granules, Ash or Natural Pozzolans are typically interground with portland cement clinker at the plant

- Can also be produced through blending
- Have all the advantages of using an SCM, plus…
- Quality control managed by cement supplier
- Reduced storage needs, users need only one silo
- Ease of use and simplified batching concrete mixtures
- Can be combined with other SCMs, pozzolans or limestone to produce Ternary blends
  - Take advantage of existing storage
  - Optimizing environmental benefits & performance
  - Drive down the GWP of your products

EPDs Provide Transparency & GWPs (embodied CO_2)

Having a way to compare environmental impact is crucial. GWPs are a good indicator

EPDs make an accounting, furthering the transparency of environmental claims

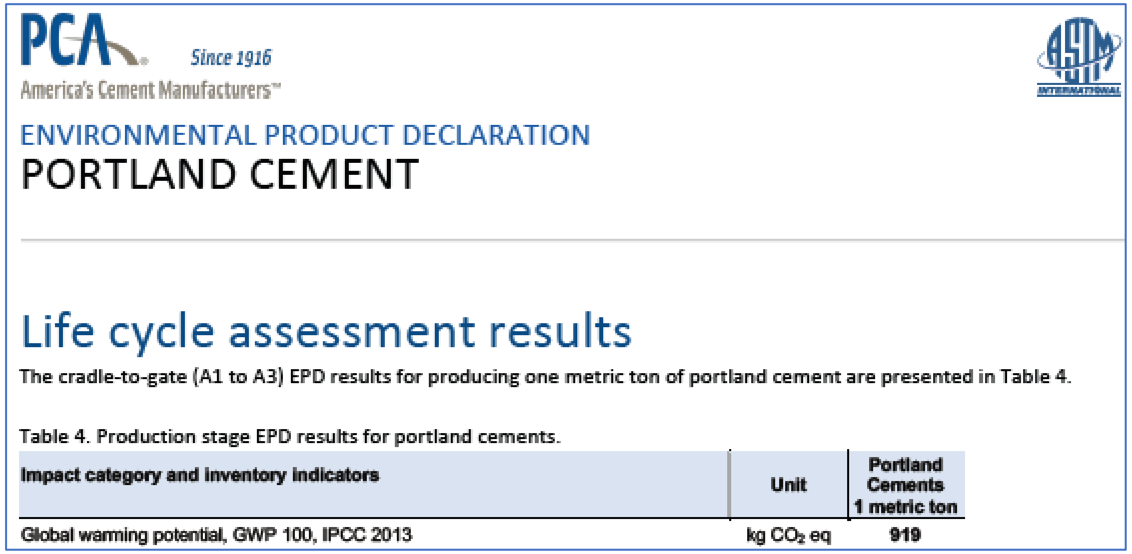

PCA Since 1916
America's Cement Manufacturers™

ENVIRONMENTAL PRODUCT DECLARATION

PORTLAND CEMENT

(per ASTM C219 and specified in ASTM C150, ASTM C1157, AASHTO M 85, or CSA A3001)

REVISED October 2023: GCCA Tool v4.1


PCA Since 1916
America's Cement Manufacturers™

ENVIRONMENTAL PRODUCT DECLARATION
PORTLAND CEMENT

Life cycle assessment results

The cradle-to-gate (A1 to A3) EPD results for producing one metric ton of portland cement are presented in Table 4.

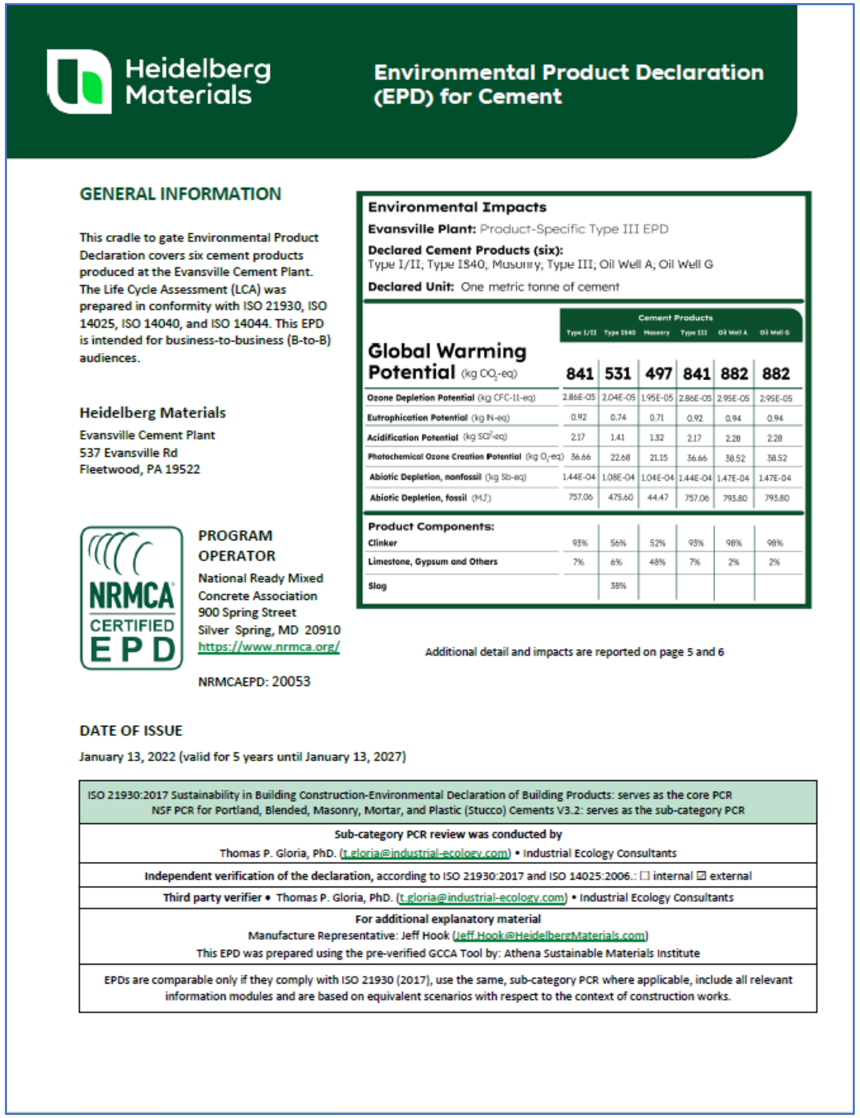
Table 4. Production stage EPD results for portland cements.

Impact category and inventory indicators	Unit	Portland Cements 1 metric ton
Global warming potential, GWP 100, IPCC 2013	kg CO_2 eq	919

Industry Average GWP* for Portland Cement
919

* GWP = kg CO_2 equiv. / M. ton

Stakeholders Use EPDs to Make Quick Judgements



Heidelberg Materials

Environmental Product Declaration (EPD) for Cement

GENERAL INFORMATION

This cradle to gate Environmental Product Declaration covers six cement products produced at the Evansville Cement Plant. The Life Cycle Assessment (LCA) was prepared in conformity with ISO 21930, ISO 14025, ISO 14040, and ISO 14044. This EPD is intended for business-to-business (B-to-B) audiences.

Heidelberg Materials
Evansville Cement Plant
537 Evansville Rd
Fleetwood, PA 19522

NRMCA CERTIFIED EPD

PROGRAM OPERATOR
National Ready Mixed Concrete Association
900 Spring Street
Silver Spring, MD 20910
https://www.nrmca.org/

NRMCAEPD: 20053

Environmental Impacts

Evansville Plant: Product-Specific Type III EPD

Declared Cement Products (six): Type I/II; Type IS40; Masonry; Type III; Oil Well A; Oil Well G

Declared Unit: One metric tonne of cement

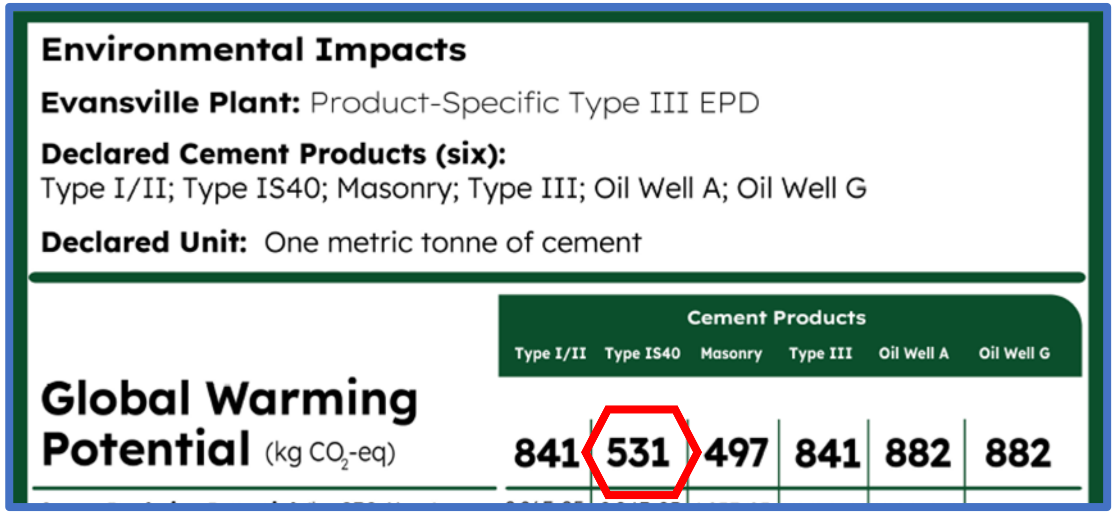
	Cement Products					
	Type I/II	Type IS40	Masonry	Type III	Oil Well A	Oil Well G
Global Warming Potential (kg CO_2-eq)	841	531	497	841	882	882
Ozone Depletion Potential (kg CFC-11-eq)	2.86E-05	2.04E-05	1.95E-05	2.86E-05	2.95E-05	2.95E-05
Eutrophication Potential (kg N-eq)	0.92	0.74	0.71	0.92	0.94	0.94
Acidification Potential (kg SO_2-eq)	2.17	1.41	1.32	2.17	2.28	2.28
Photochemical Ozone Creation Potential (kg O_3-eq)	36.66	22.68	21.15	36.66	38.52	38.52
Abiotic Depletion, nonfossil (kg Sb-eq)	1.44E-04	1.08E-04	1.04E-04	1.44E-04	1.47E-04	1.47E-04
Abiotic Depletion, fossil (MJ)	757.06	475.60	44.47	757.06	793.80	793.80
Product Components:						
Clinker	93%	56%	52%	93%	98%	98%
Limestone, Gypsum and Others	7%	6%	48%	7%	2%	2%
Slag		38%				

Additional detail and impacts are reported on page 5 and 6

DATE OF ISSUE

January 13, 2022 (valid for 5 years until January 13, 2027)

ISO 21930:2017 Sustainability in Building Construction-Environmental Declaration of Building Products: serves as the core PCR NSF PCR for Portland, Blended, Masonry, Mortar, and Plastic (Stucco) Cements V3.2: serves as the sub-category PCR
Sub-category PCR review was conducted by Thomas P. Gloria, PhD. (t.gloria@industrial-ecology.com) • Industrial Ecology Consultants
Independent verification of the declaration, according to ISO 21930:2017 and ISO 14025:2006.: ☐ internal ☑ external
Third party verifier • Thomas P. Gloria, PhD. (t.gloria@industrial-ecology.com) • Industrial Ecology Consultants
For additional explanatory material Manufacture Representative: Jeff Hook (Jeff.Hook@HeidelbergMaterials.com) This EPD was prepared using the pre-verified GCCA Tool by: Athena Sustainable Materials Institute
EPDs are comparable only if they comply with ISO 21930 (2017), use the same, sub-category PCR where applicable, include all relevant information modules and are based on equivalent scenarios with respect to the context of construction works.



Environmental Impacts

Evansville Plant: Product-Specific Type III EPD

Declared Cement Products (six):
Type I/II; Type IS40; Masonry; Type III; Oil Well A; Oil Well G

Declared Unit: One metric tonne of cement

	Cement Products					
	Type I/II	Type IS40	Masonry	Type III	Oil Well A	Oil Well G
Global Warming Potential (kg CO_2-eq)	841	531	497	841	882	882

Portland Cement	Evansville Plant	
Industry Avg.	Type III	Type IS(40)
919	841	531

Example GWP Calculations Using Mix Components Only

Apply GWP values to Generic Mix

- Binder, 350 kg/m^3 "Average" Portland Cement
- No SCMs for ~ 600#/cy mix
- "Generic" course and fine aggregate
- Water reducing & Air-entraining admixtures
- **This Baseline Mix has GWP of 373.7**
- Note inclusion of A1 – A3 LCA Modules

GWP for A1	330.2
GWP for A2	34.1
GWP for A3	9.4
Mix GWP Total	**373.7 CO_2 eq.**

SCM, Aggregate and Admixture Data via FHWA Report No. FHWA-HIF-22-032, LCA Pave

Generic Concrete Mix Raw Materials A1	Quantity kg/m^3	GWP / Metric ton (1,000 kg)	GWP in Mix
Industry Average Portland Cement (GU / Type I)	350	919	321.7
Generic Fly Ash	0	14.7	0.0
Generic Slag Cement	0	146.6	0.0
Generic Crushed Stone Course Aggregate	1,046	4.6	4.8
Generic Concrete Sand Fine Aggregate	791	2.8	2.2
Water	156	0.0	0.0
Generic Water Reducing Admixture	0.80	1880.6	1.5
Generic Air-Entrainer	0.05	524.7	0.03
Raw Materials Production CO_2 Footprint - Total A1			**330.2**
Material Transport to Concrete Plant A2			
Summary for Transport to BC Ready Mix CO_2 Footprint - Total A2			**34.1**
Concrete Manufacturing @ RM Plant			
Material Handling, Batching & Misc. Operations CO_2 Footprint - Total A3			**9.4**
	Total A1 + A2 + A3		**373.7**

Example GWP Calculations Using Type IS(40) Cement

GWP values in Generic Mix w/ Type IS Cement

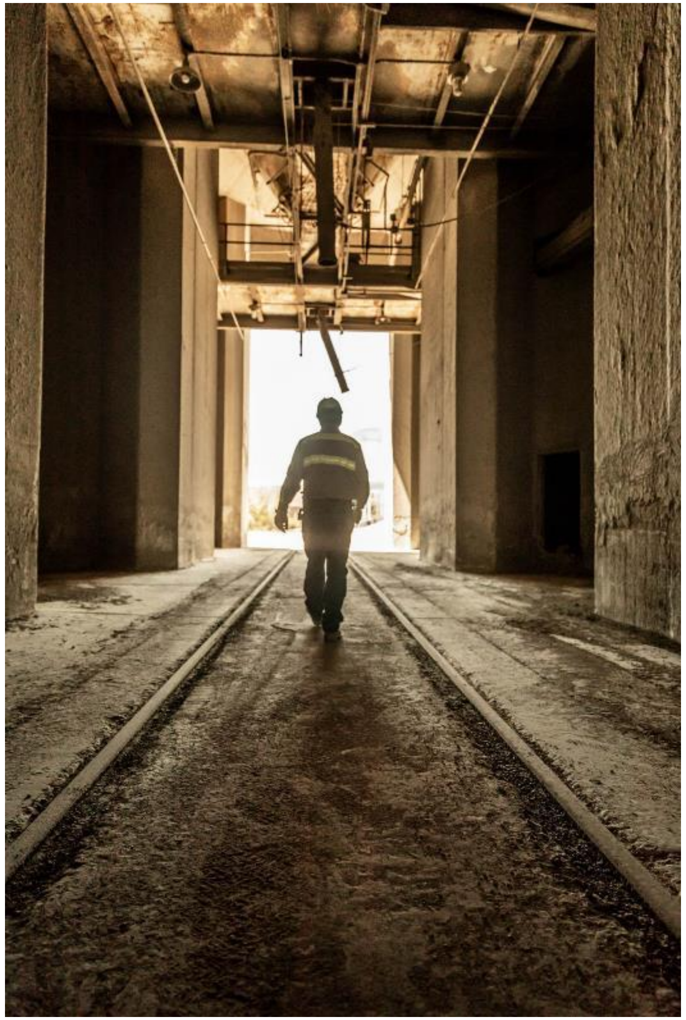
- Binder is 350 kg/m^3 Evansville Type IS(40)
- No other SCMs
- "Generic" course and fine aggregate
- Water reducing & Air-entraining admixtures
- **Using Evansville IS(40) = - 36% vs Baseline Mix**
- Note inclusion of A1 – A3 LCA Modules
  - GWP for A1 194.4
  - GWP for A2 34.1
  - GWP for A3 9.4

Mix GWP Total 237.9 CO2 eq.

SCM, Aggregate and Admixture Data via FHWA Report No. FHWA-HIF-22-032, LCA Pave

Generic Concrete Mix Global Warming Potential A1 - A3			
Generic Concrete Mix Raw Materials + Actual Cement GWP Values A1	**Quantity kg/m^3**	**GWP / Metric ton (1,000 kg)**	**GWP in Mix**
Heidelberg Materials Evansville Type IS(40) Cement	350	531	185.9
Generic Fly Ash	0	14.7	0.0
Generic Slag Cement	0	146.6	0.0
Generic Crushed Stone Course Aggregate	1,046	4.6	4.8
Generic Concrerte Sand Fine Aggregate	791	2.8	2.2
Water	156	0.0	0.0
Generic Water Reducing Admixture	0.80	1880.6	1.5
Generic Air-Entrainer	0.05	524.7	0.03
Raw Materials Production CO_2 Footprint - Total A1			**194.4**
Material Transport to Concrete Plant A2			
Summary for Transport to BC Ready Mix CO_2 Footprint - Total A2			**34.1**
Concrete Manufacturing @ RM Plant			
Material Handling, Batching & Misc. Operations CO_2 Footprint - Total A3			**9.4**
		Total A1 + A2 + A3	**237.9**

National/Global Trends – SCMs, i.e. Slag Cement & Ash



SCMs/Cement Replacements Added to Mixes at the Plant

Supplementary Cementitious Materials (SCMs)

- Defined by ACI Concrete Terminology ACI CT-23

  "Supplementary cementitious material - inorganic material such as fly ash, silica fume, metakaolin, or slag cement that reacts pozzolanically or hydraulically"

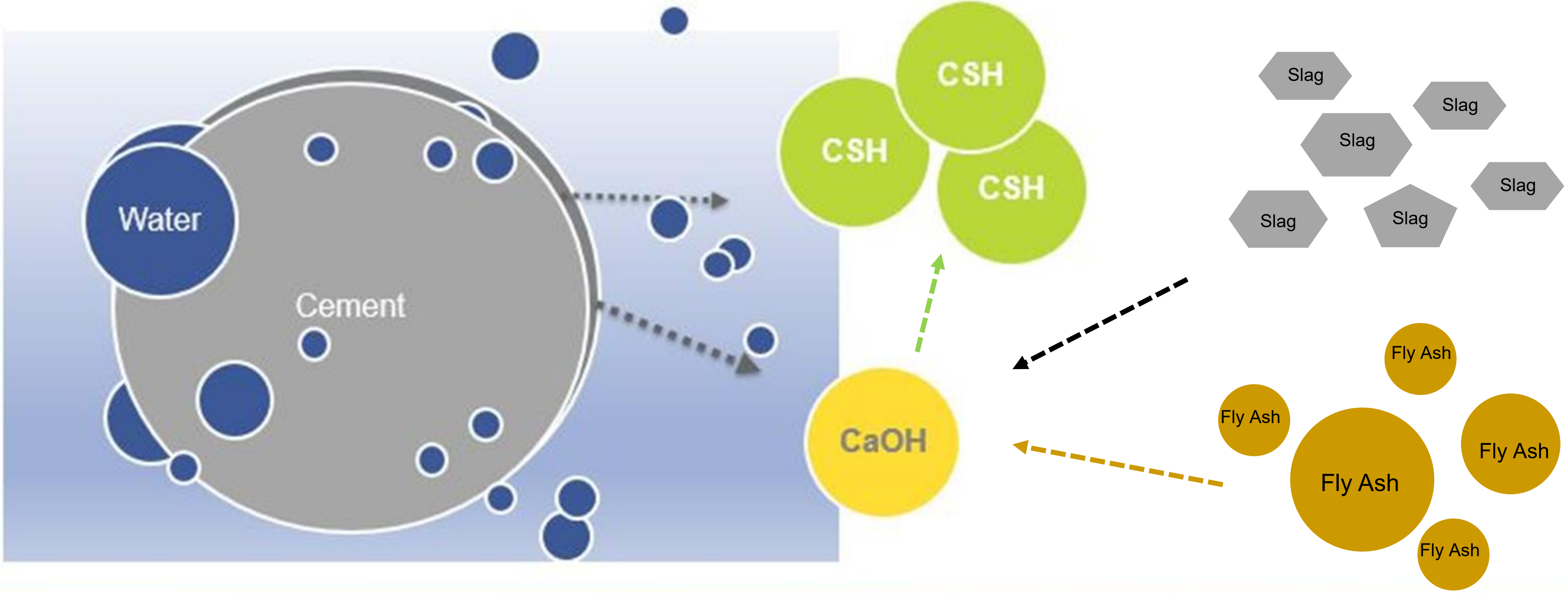
- Combined in concrete mixes in conjunction with and to replace some of the Portland Limestone or Portland Cement binder

- SCMs have lower Global Warming Potentials (GWP*) than Portland cement-based binders

  *GWP (kg CO_2 equivalent / M. ton aka CO_2 eq.)

SCMs Typically Drive Pozzolanic Reactions in Concrete

- Portland Cement / Portland Limestone Cement systems generate calcium hydroxide ($Ca(OH)_2$) as a natural hydration product
- SCMs like Fly Ash and Slag Cement react with $Ca(OH)_2$ to form more CSH



Benefits of Pozzolanic Reactions

- They consume calcium hydroxide aka "free-lime" to form Calcium Silicate Hydrate (C-S-H) gel / amorphous material
- Pozzolanic reactions reduce the presence of large calcium hydroxide crystals ($Ca(OH)_2$), fill capillary pores, and improve the overall microstructure of the hardened paste.
- Replacing soluble calcium hydroxide and filling capillary voids with CSH yields less permeable concrete which is more resistance to chemical attack.
- Less calcium hydroxide = less susceptible to alkali-silica reactions & sulfate attack since there is less "free lime" to contribute to expansive reactions i.e. ettringite formation
- SCMs are used in high-strength, high-performance mixes to increase flexural and compressive strength

Calcium hydroxide (flakes/plates) and Ettringite (needle-like/snowball-like) crystals

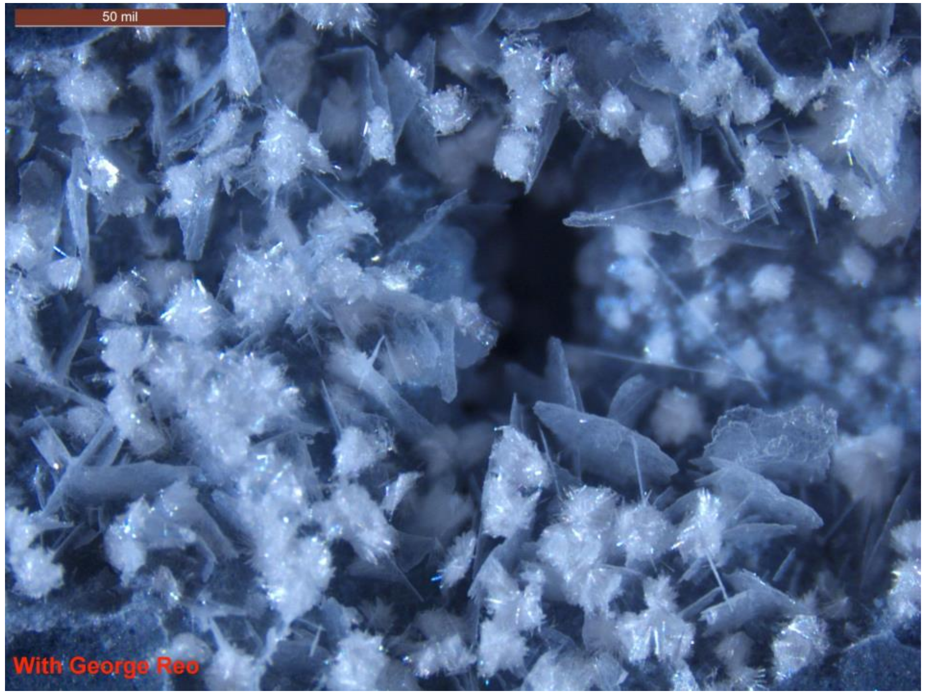


Image courtesy of Hugh (Xiaoqiang) Hou, with George Reo, LinkedIn Post, 8/2025

Slag Cement as SCM made to ASTM C989 / AASHTO M 302

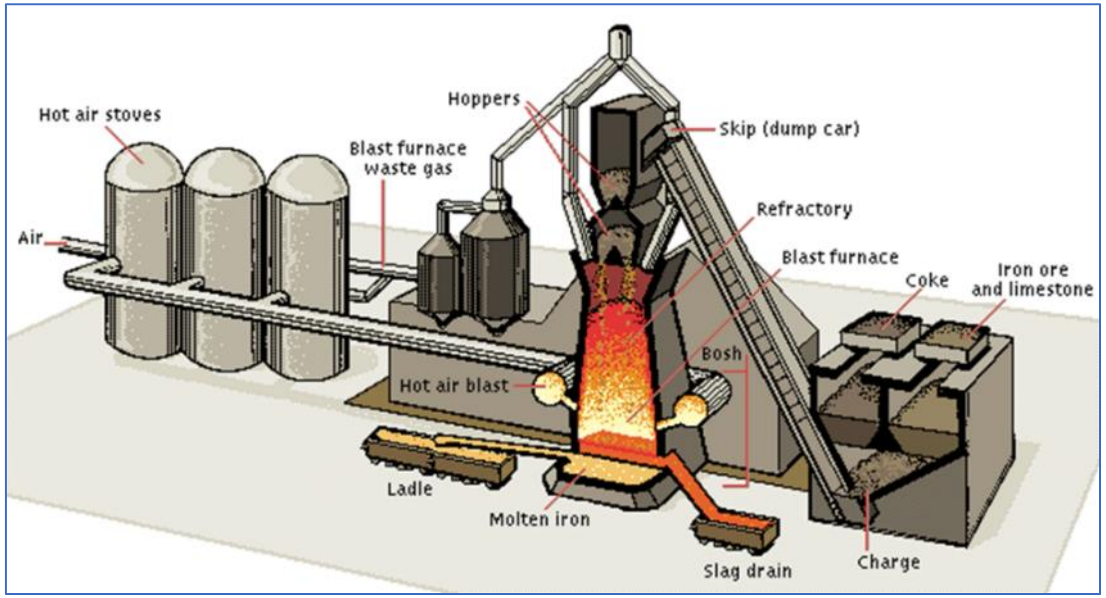
Slag Cement (Ground Granulated Bast Furnace Slag (GGBFS)) is excellent low GWP cement replacement

- Typical Slag doses start at ~ 40% replacement
- Slag granules can be stored outside/easily transported
- International slag granules imported via into marine ports
- Main sources for United States come from America’s “rust belt”, i.e. Ohio, Western PA, and Illinois
- Last major American BF Slag sources installing granulators
- Requires significant capital investment & steady market
- Globally many more blast furnace operations would benefit from installing granulators to produce slag cement

Slag Cement - What is it?

Slag cement aka Ground Granulated Blast Furnace Slag

- A byproduct of primary iron production
- It is a hydraulic cement but relies on clinker to really kick
- Air cooled slag will crystallize and become non-reactive, mainly suitable for use as aggregate.



Slag Cement - What is it?

Slag cement aka Ground Granulated Blast Furnace Slag

- Slag granules look like angular coarse sand
- Lighter color than cement due to having almost no iron
- Chemistry similar to Portland Cement in different ratios

Comparing Slag Cement “Slag” to Portland Cement

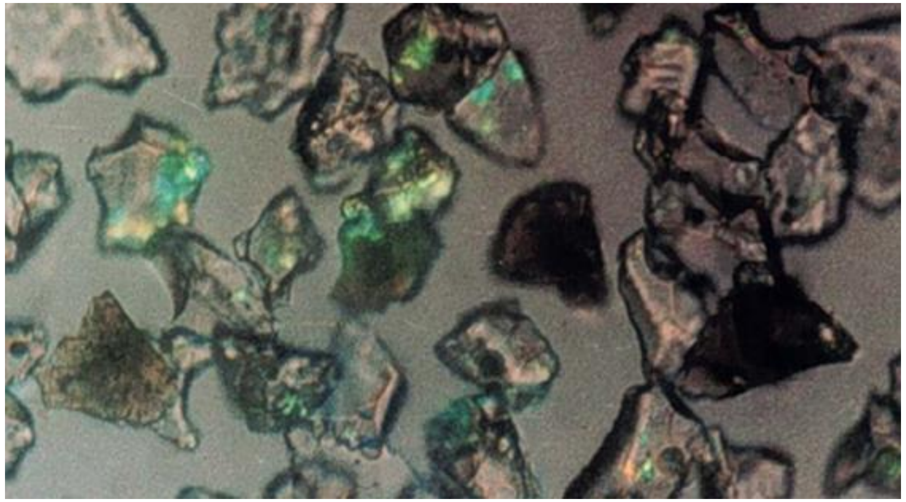
- Slag contains calcium, silica, and alumina compounds

  Typical compound ranges are shown >

- Actual chemical makeup will vary lightly by source and region
- It is critical that the slag be quenched in a granulator rapidly cooling it, so the slag “freezes” in a glassy state
- This glassy state is essential to make it reactive
- Air cooled slag will crystallize and become non-reactive
  - Is used as fill material or
  - As an aggregate in certain civil applications
  - Used in other industrial uses

	Portland Cement	Slag Cement*
CaO	65%	38%
SiO2	20%	36%
Al2O3	4%	10%
Fe2O3	3%	0%
MgO	3%	11%
Alkalis'	1%	1%

*Percentages vary based upon the source of slag granules and cement manufacturing.



From Slag Granules to Slag Cement

Ground Granulated Blast Furnace Slag (GGBFS)

- Grinding is critical to reactivity, once ground, must be stored in silos
- Slag Cement powder similar, often finer than cement in fineness
- Increasing fineness = increased reactivity

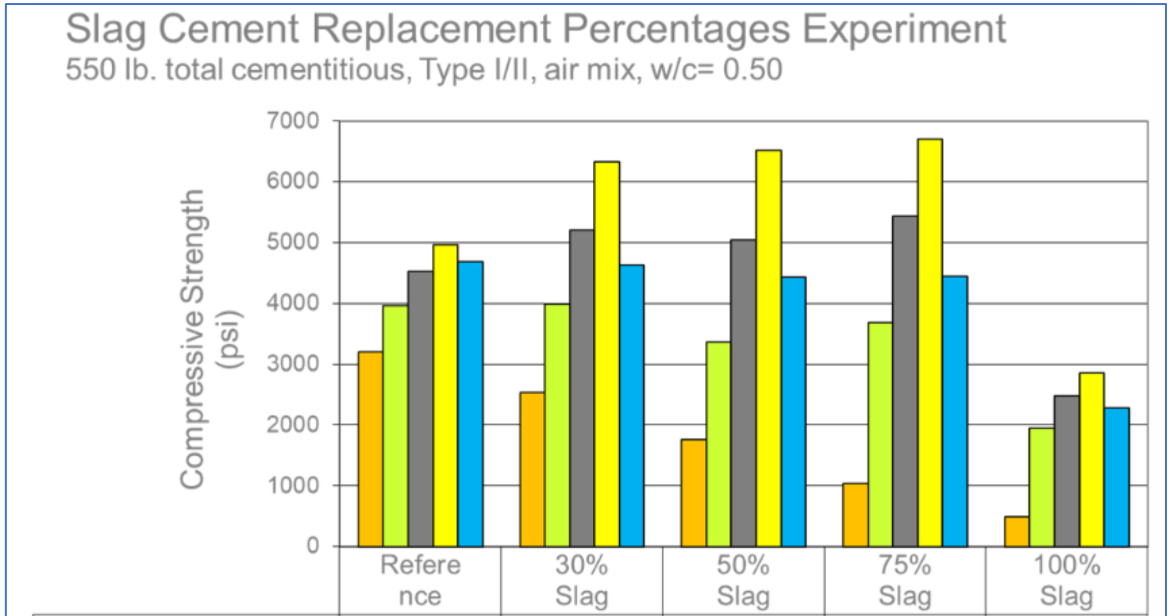
What it means for precast concrete producers… adjust

- Rule-of-thumb: Dose admixtures to 120% of the PLC/OPC then adjust
- Slag matches well with Type IL (PLCs), gives a marked strength kick
- Slag loves heat/hot water, if you have it, use it to kick off the mix
- Typically, precasters start with conservative ~ 30% to 40% dose
- Make lighter colored finished elements, high doses and low w/c ration can generate the “bluing effect” with some slags

Slag Cement in High Performance Concrete

Slag Cement will increase strengths of mixes

- Slower strength gain @ standard curing temps (72° F)
- Catches up/exceeds reference mix @ 14-days in all % additions, without heat and or admixtures
- Slag responds very favorably to heat, hot weather
- Increase ultimate strengths, especially flexural vs straight cement mixes at all addition rates
- And pairs very well with PLC cements
    - Synergy with increased limestone addition
    - Further GWP reductions



	Reference	30% Slag	50% Slag	75% Slag	100% Slag
3day	3196	2533	1757	1039	482
7day	3961	3985	3359	3677	1939
14day	4520	5200	5043	5433	2486
28day	4960	6330	6520	6700	2850
28day (50degree cure)	4680	4630	4430	4440	2280

References for Using Slag Cement

ACI 233R-17 Guide for the Use of Slag Cement in Concrete and Mortar

- Gives guidance on the use of slag cement
  - Gives overview of material
  - Includes typical replacement rates
  - Gives info on Batching and Proportioning
  - Effects on Fresh and Hardened properties
  - Outlines typical applications

Specifications

- ASTM C989 / AASHTO M 302 for use as SCM
- ASTM C595 / AASHTO M 240 in Blended Cements
- Is allowed in cements conforming to ASTM C1157 Performance Spec for Hydraulic Cements

What is the Trend and Why is it Important to Precasters

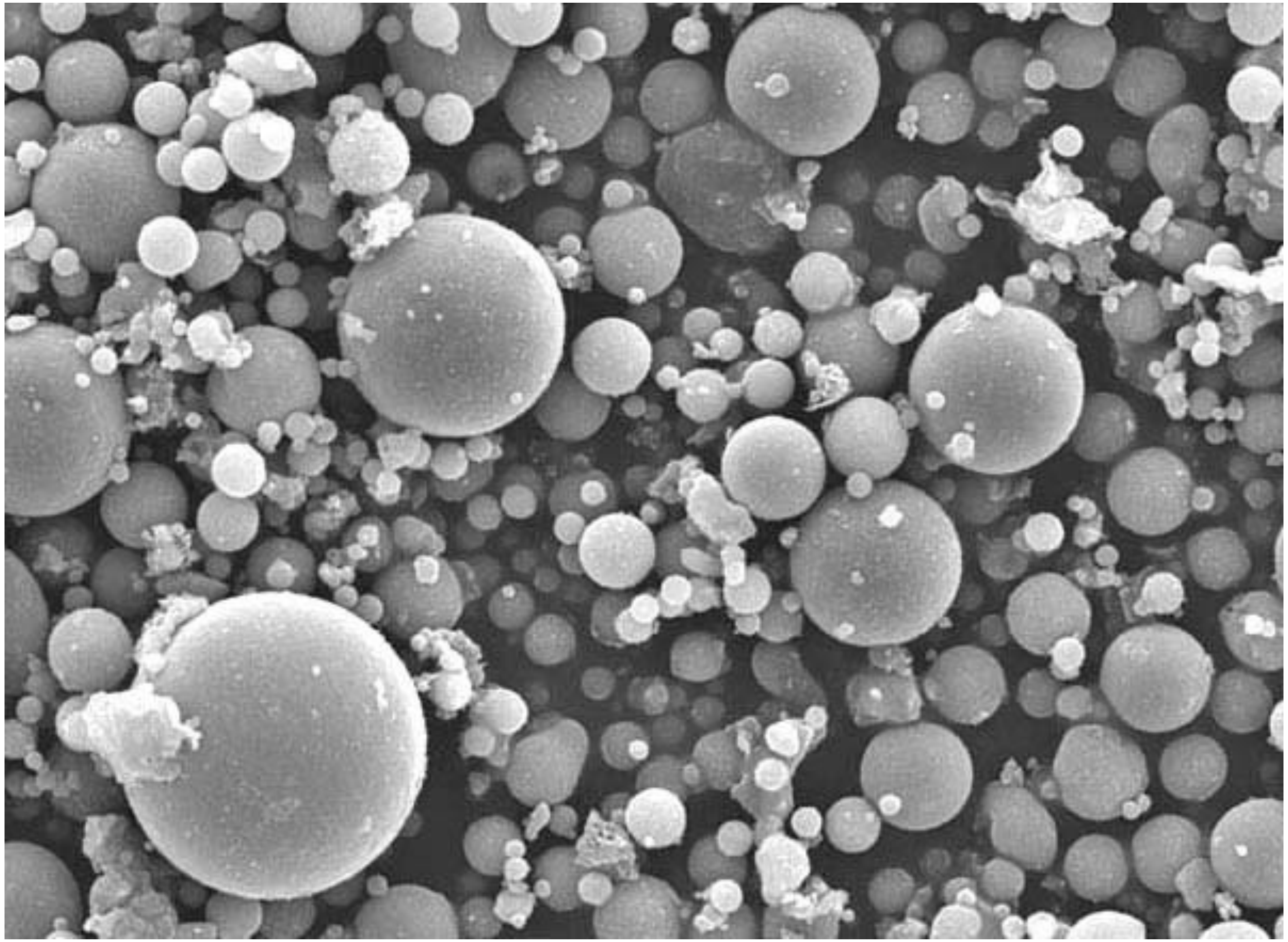
Slag Cement will be important SCM for decades

- Final domestic Blast Furnace operations installing granulators
- New “Blue Blast Furnace” conversions eliminate coke not the slag
- Future domestic supply impacted by EAF/BOF technology
- Traditional Blast Furnaces are “best” option for many regions

Long-term outlook for Slag Cement by the ~ 2040s

- As Blast Furnaces are replaced by less CO_2 intensive technologies
  - More reliance on imported granules as domestic supplies dwindle
  - Blue (low-carbon) Blast Furnaces to come online, currently very rare in market
  - Iron production will shift from Blast Furnaces to Direct Reduced Iron (DRI)
  - DRI coupled with Electric Arc Furnaces up to 70% less CO_2 emissions
  - These methods produce “non-reactive” slags, not yet useful in concrete

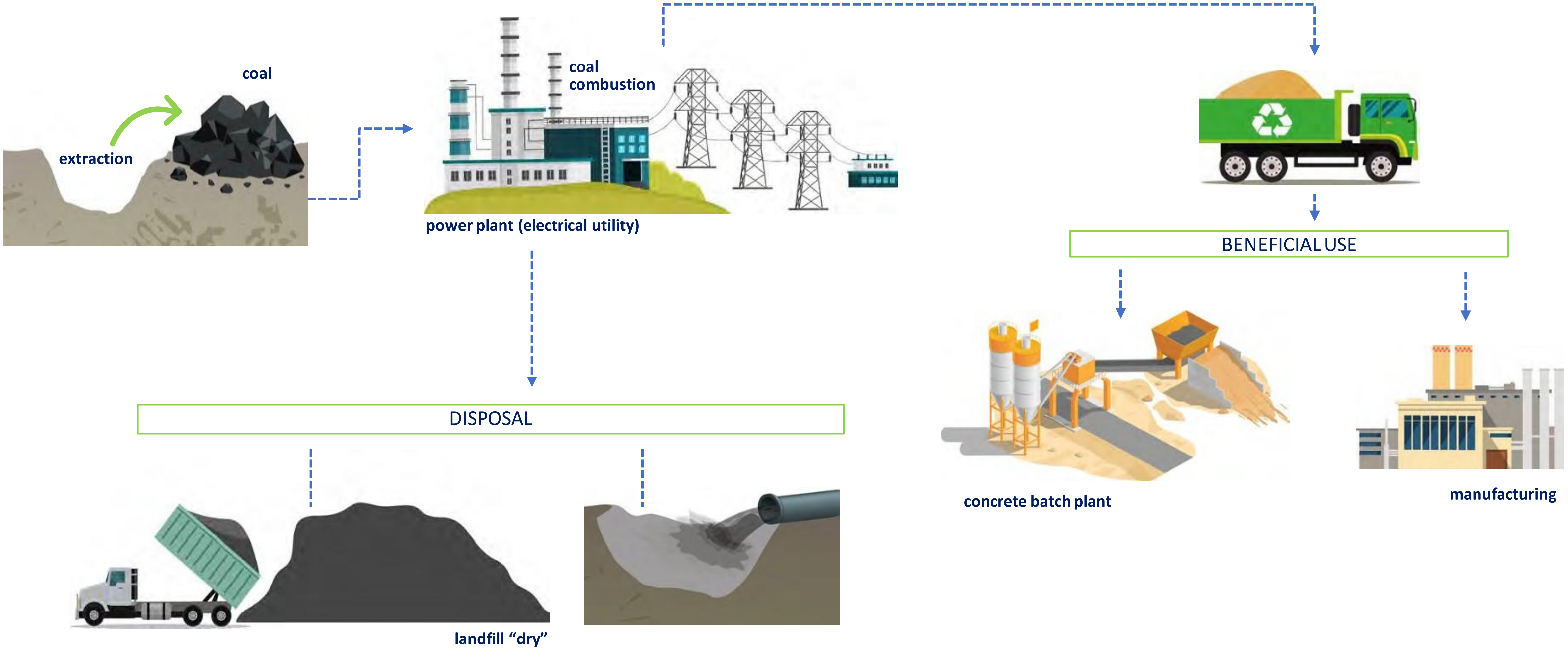
ASTM C618 - Coal Ash and Raw or Calcined Natural Pozzolan



ASTM C618-25 Standard Spec. for Coal Ash and Pozzolans … for Use in Concrete

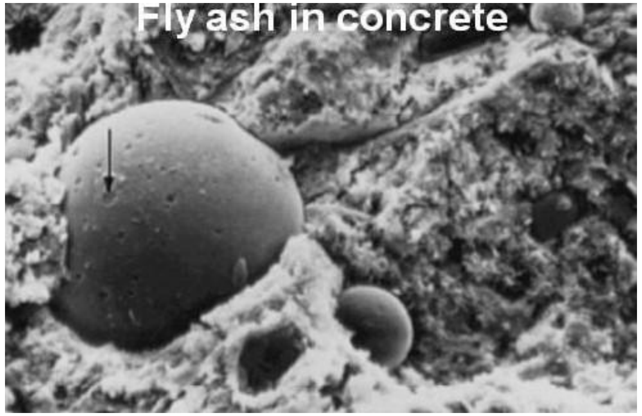
- Chemical Requirements
  - Loss on Ignition (Carbon)
  - Chemical Composition
  - Moisture
- Physical Requirements
  - Reactivity (SAI) min. 75%
  - Fineness

Coal Ash aka Fly Ash, From Electrical Energy Production

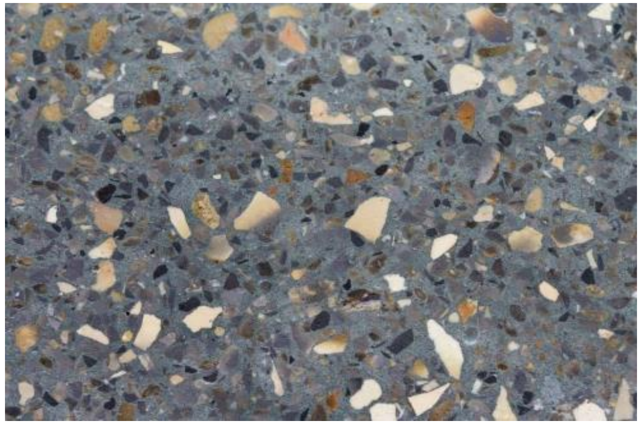


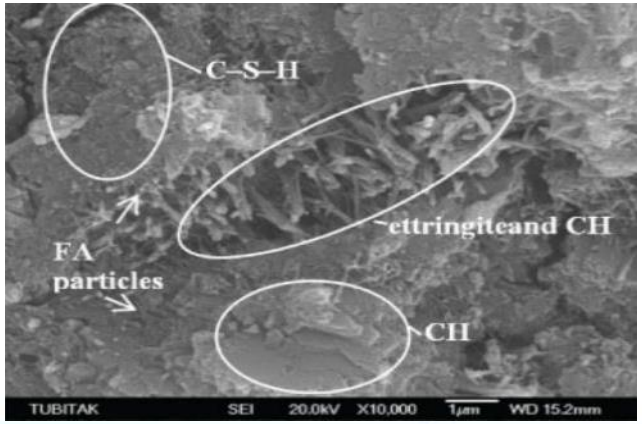
How Coal Ash (Fly Ash) Works in Concrete

- Fly Ash and other SCMs bind up $Ca(OH)_2$ by forming Calcium-Silicate-Hydrates (CSH), the crystals that make concrete work
- Remove alkalis from system, improves resistance to ASR
- Increased CSH reduces voids, fills areas around aggregates, can increased compressive, tensile, and flexural strengths
- Concrete with Fly Ash is less permeable which helps prevent chemical attack from chlorides and sulphates
- Used in High-strength, high-performance mixes to increase strength
- **Because Fly Ash is a waste products and reduces the clinker content in concrete mixes it reduces concrete's carbon footprint.**



Electron Micrograph Fly Ash in Fresh Concrete


Cross-section of Concrete



Electron micrograph 10,000x magnification of hardened concrete @ 7-days

Accounting for Concrete Mix GWP with Fly Ash

Apply GWP values to Generic Mix for all mix components

- Binder, 350 kg/m^3 "Average" Portland Cement
- 20% Fly Ash ~ 600#/cy mix
- "Generic" course and fine aggregate
- **Evansville 20% Ash = - 23% vs Baseline Mix**
- Note inclusion of A1 – A3 LCA Modules

GWP for A1	245.1
GWP for A2	34.1
GWP for A3	9.4
Mix GWP Total	**288.6 CO_2 eq.**

Generic Concrete Mix Raw Materials + Actual Cement GWP Values A1 Type I +20% Slag	Quantity kg/m^3	GWP / Metric ton (1,000 kg)	GWP in Mix
Heidelberg Materials Evansville Type I	280	841	235.5
Generic Fly Ash	**70**	**14.7**	1.0
Generic Slag Cement	0	146.6	0.0
Generic Crushed Stone Course Aggregate	1,046	4.6	4.8
Generic Concrete Sand Fine Aggregate	791	2.8	2.2
Water	156	0.0	0.0
Generic Water Reducing Admixture	0.80	1880.6	1.5
Generic Air-Entrainer	0.05	524.7	0.03
Raw Materials Production CO_2 Footprint - Total A1			**245.1**
Material Transport to Concrete Plant A2			
Summary for Transport to BC Ready Mix CO_2 Footprint - Total A2			**34.1**
Concrete Manufacturing @ RM Plant			
Material Handling, Batching & Misc. Operations CO_2 Footprint - Total A3			**9.4**
		Total A1 + A2 + A3	**288.6**

SCM, Aggregate and Admixture Data via FHWA Report No. FHWA-HIF-22-032, LCA Pave

Accounting for Concrete Mix GWP with Fly Ash

Apply GWP values to Generic Mix for all mix components

- Binder, 350 kg/m^3 "Average" Portland Cement
- 20% Fly Ash ~ 600#/cy mix
- "Generic" course and fine aggregate
- **Evansville 20% Ash = - 23% vs Baseline Mix**
- Note inclusion of A1 – A3 LCA Modules

GWP for A1	245.1
GWP for A2	34.1
GWP for A3	9.4
Mix GWP Total	**288.6 CO_2 eq.**

Example IS(40) = - 36% vs Baseline Mix

40% Slag Mix GWP was 237.9 CO2 eq.

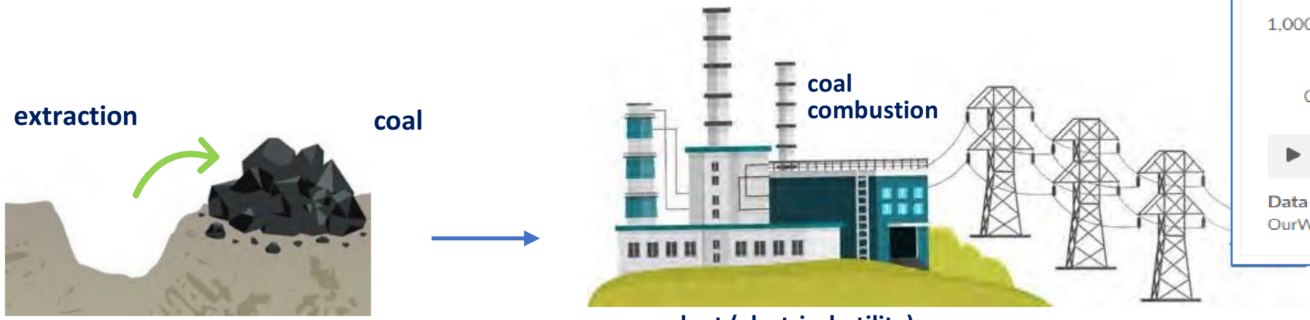
Generic Concrete Mix Raw Materials + Actual Cement GWP Values A1 Type I +20% Slag	Quantity kg/m^3	GWP / Metric ton (1,000 kg)	GWP in Mix
Heidelberg Materials Evansville Type I	280	841	235.5
Generic Fly Ash	**70**	**14.7**	1.0
Generic Slag Cement	0	146.6	0.0
Generic Crushed Stone Course Aggregate	1,046	4.6	4.8
Generic Concrete Sand Fine Aggregate	791	2.8	2.2
Water	156	0.0	0.0
Generic Water Reducing Admixture	0.80	1880.6	1.5
Generic Air-Entrainer	0.05	524.7	0.03
Raw Materials Production CO_2 Footprint - Total A1			**245.1**
Material Transport to Concrete Plant A2			
Summary for Transport to BC Ready Mix CO_2 Footprint - Total A2			**34.1**
Concrete Manufacturing @ RM Plant			
Material Handling, Batching & Misc. Operations CO_2 Footprint - Total A3			**9.4**
	Total A1 + A2 + A3		**288.6**

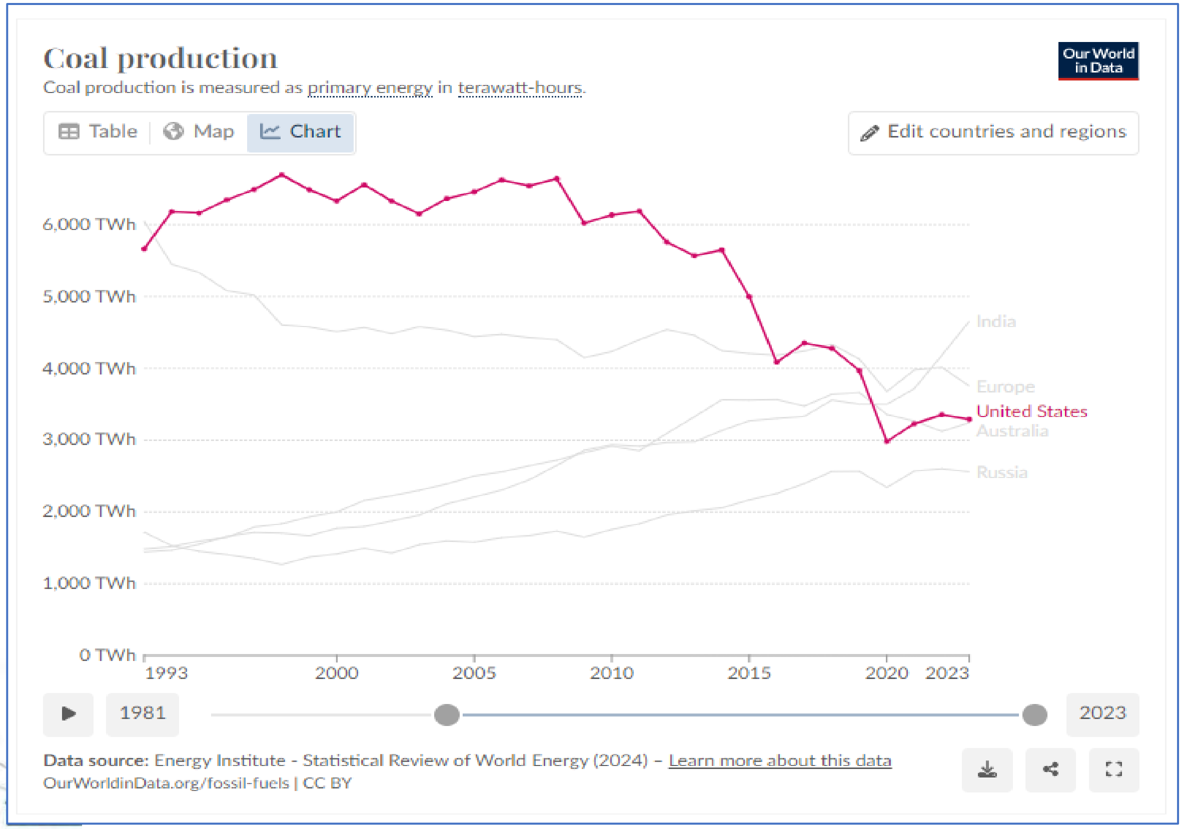
SCM, Aggregate and Admixture Data via FHWA Report No. FHWA-HIF-22-032, LCA Pave

What is the Trend and Why is it Important to Precasters

Coal Ash (Fly Ash) is low GWP replacement for PLC/OPC

- Waste from coal combustion to produce electricity
- ASTM C618-25 covers: fly, bottom and harvested ash
- Historically had stable supply through the decades
- Utilities made much more ash than was used
- Economics/drive for renewable clean energy means…
  - Far less "production" ash in the coming decades
  - > 90% coal use in phased out by 2050





Hannah Ritchie, Pablo Rosado and Max Roser (2023) - "Energy" Published online at OurWorldinData.org. Retrieved from: 'https://ourworldindata.org/energy' [Online Resource]

What is the Trend and Why is it Important to Precasters

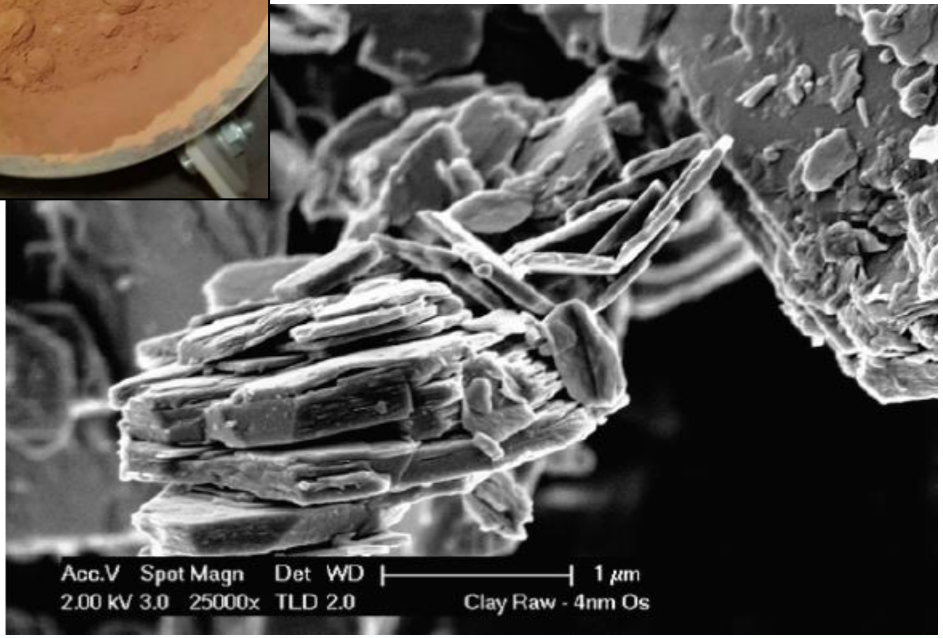
Reclaiming Coal Ash from landfills will increase

- 2-Billion tons of Coal Ash (Fly Ash) stored in landfills
- For many decades much more coal ash made then used
- Projections of 40 to 60-years of supply at current use
- Millions of tons of beneficiated ash already in structures
- Beneficiation i.e. with the STAR® process critical
  - Result is very consistent SCM for use in concrete
  - Primary objective to reduce carbon and its effects
  - Better control of air content in concrete mixes
  - Can yield a reactivity boost

Buck STAR® Fly Ash Facility, 855 Dukeville Rd, Salisbury, NC 28146

Alternative SCMs May Reduce Emissions, & May Change Concrete

Photos courtesy Prof. Franco Zunino, 2020



Various SCMs of note from waste streams

- Activated waste slags/minerals some using geopolymer technology
- GGP – ground glass pozzolan i.e. Pozzotive from Urban Mining Northeast
- Agg waste producers pushing Bio Char to “sequester” CO_2 in concrete

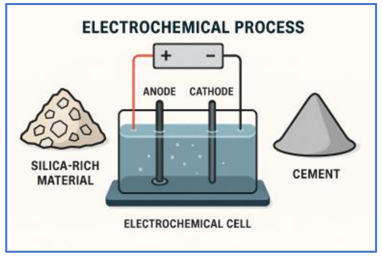
Other SCMs, Natural and Mineral based

- Calcined Clays
  - LC2 – Limestone Calcined Clays
  - LC3 – Limestone Calcined Clays Cements
  - Metakaolin – calcined high alumina clay
- Volcanic deposits
  - Volcanic tuffs, pumicites, and zeolites

Alternative Cements & Cement Clinker Production & Novel SCMs

Some other Alternative Cements and SCMs you may see in your market

- Electrochemical based process coverts silica rich materials for low-carbon "e-cement" - no pyroprocessing
  - Sublime Systems
  - EDAC Labs
  - CURA & Others



- Prometheus Materials – uses microalgae & natural binders for ProZERO™ Bio-based SCM
- Fortera – Uses a "bolt-on" ReCarb® process and CO_2 captured at a cement plant to make aggregate and…
  - Low-carbon ReAct™ Cement and Blend uses a reactive calcium carbonate polymorph process
  - Produces cement that meets ASTM C1157 Hydraulic Cement Specification
  - Has been described as a forced carbonation process

ReConcrete as an Alternative Cement Replacement (SCM)

Recycled Concrete Paste to cRCP for raw materials & SCMs

- Heidelberg Materials low-carbon solution
- Self described as an <u>enforced carbonation process</u> aka ‘forced’
- Uses the ultra-fine “paste” portion from concrete recycling operations
- Alternative low-carbon raw material in cement clinker production
- Used as SCM to replace Portland or Portland Limestone Cement
- Can “carbonate” to permanently absorb/sequester CO_2
  - Via exposure to flue gasses resulting carbonated RCP (cRCP)
  - cRCP has potential to mineralize ~ 150 kg CO_2 per ton, (roughly 30% of “process” CO_2 from calcination)
- Will be important part of the Circular Economy


Heidelberg Materials
Press Release

25 July 2024

Closing the loop: Heidelberg Materials inaugurates first-of-its-kind recycling plant for selective separation of demolition concrete in Poland

- State-of-the-art facility near Katowice, Poland, introduces high-quality separation and sorting at industrial scale to fully recycle demolition concrete.
- The proprietary crushing mechanism enables sophisticated separation and sorting capabilities obtaining aggregates of the highest quality, equivalent to the one of virgin raw materials.
- Through the patented ReConcrete process, recycled concrete paste (RCP) is recovered combining circularity with decarbonisation.
- RCP can be used as an alternative raw material in clinker production or as an alternative cementitious m
- In addition, it c
- Heidelberg Mat circular alterna

Heidelberg Materials ha production site near Ka mechanism that enable concrete and substitute concrete per hour, Heid selective concrete sepa

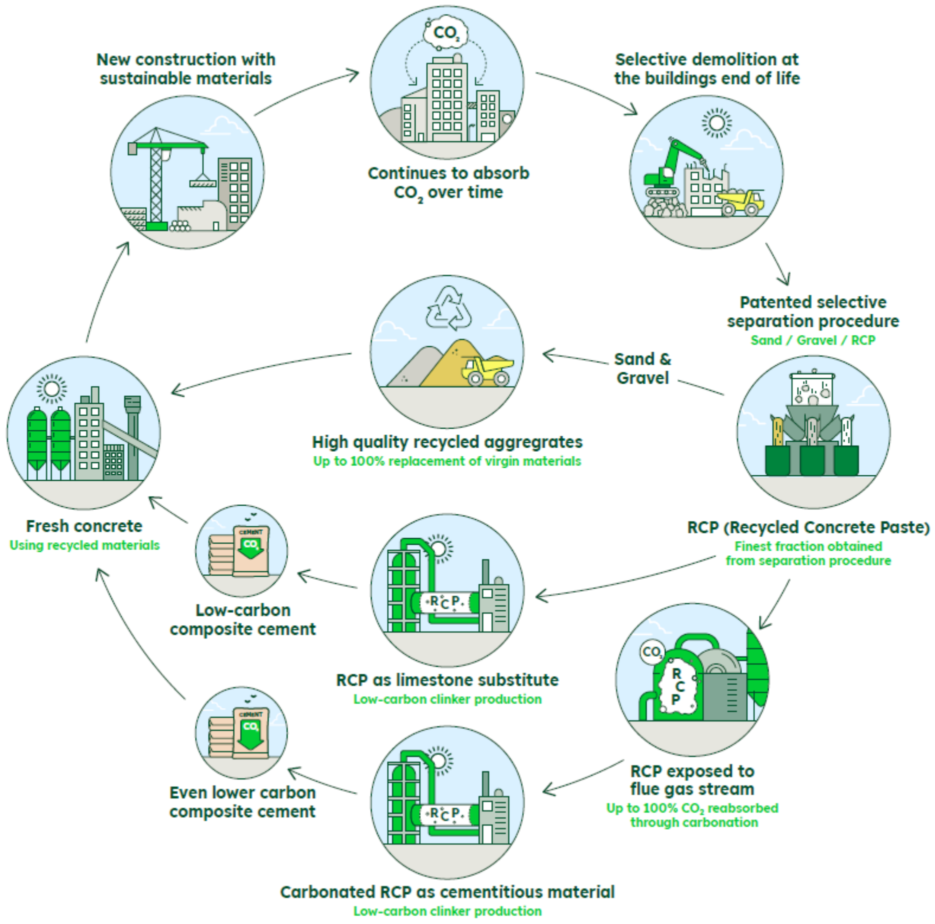
Nicola Kimm, Chief Sust said: “Thanks to our str revolutionary and comm path to net zero. Innova ambition to closing the

“With our award-winni can be fully recycled wi Heidelberg Materials ar

How a ReConcrete SCM Will Fit into Circular Economy

Recycled Concrete Paste (RCP) and cRCP for recycling of excess batched, or demolished & come-back concrete

- Reclaimed aggregate to be used in concrete or as road base
- Paste to be alternative raw material for cement clinker
- As SCM to replace Portland/Portland Limestone Cement
- Can "carbonate" to permanently absorb/sequester CO_2
    - Exposure to flue gasses resulting carbonated RCP (cRCP)
    - cRCP has potential to mineralize ~ 150 kg CO_2 per ton
    - Or roughly = to 30% of "process" CO_2 from calcination
- Important part of Circular Economy and reduce landfilled waste



What is the Trend and Why is it Important to Precasters

Production of "Innovative" SCMs and Cements driven by push to reduce embodied CO_2

Positives:

- Start-up push the boundaries and exploit novel technologies and approaches, lots to teach the establishment
- Have generated a lot of interest and investment, especially under previous political climates
- Have had some success and a few solid products, i.e. LC^3 (Calcined Clays), Fortera, and Pozzotive

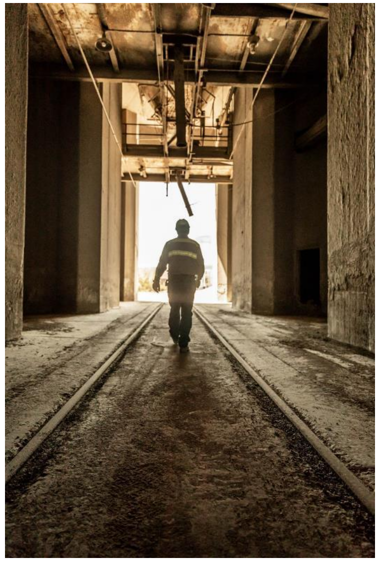
Negatives:

- **Scale** - We need many thousands of tones… not pounds
- **Availability** - Precast producers need dependable products
- **Cost** - Must compete with existing low-carbon options
- **Acceptance** - Consider the relatively small change of Type IL
- **GWP Reduction** – Not all "new" alternatives pencil out

Where We Are Headed Next – National/Global Trends

"The reports of my death are greatly exaggerated," Mark Twain (Sustainability is Still Alive)

- Owners and some big contractors are looking for the cheapest way to reduce their scope[3] emissions
- Want big carbon reductions but, don't want to wait for slow strength gains i.e. from high SCM dose mixes
- Looking to novel approaches including CCUS (Carbon Capture Utilization and Storage)
  - Post-production process so no cement change
  - evoZero CCS Cement has near zero GWP
  - EAC (Env. Attribute Certs.) standards evolving
  - Critical part of cement industry roadmap
  - The only real way to get to Net Zero



The world's 1st CCS, Near-Zero Cement Without Offsets

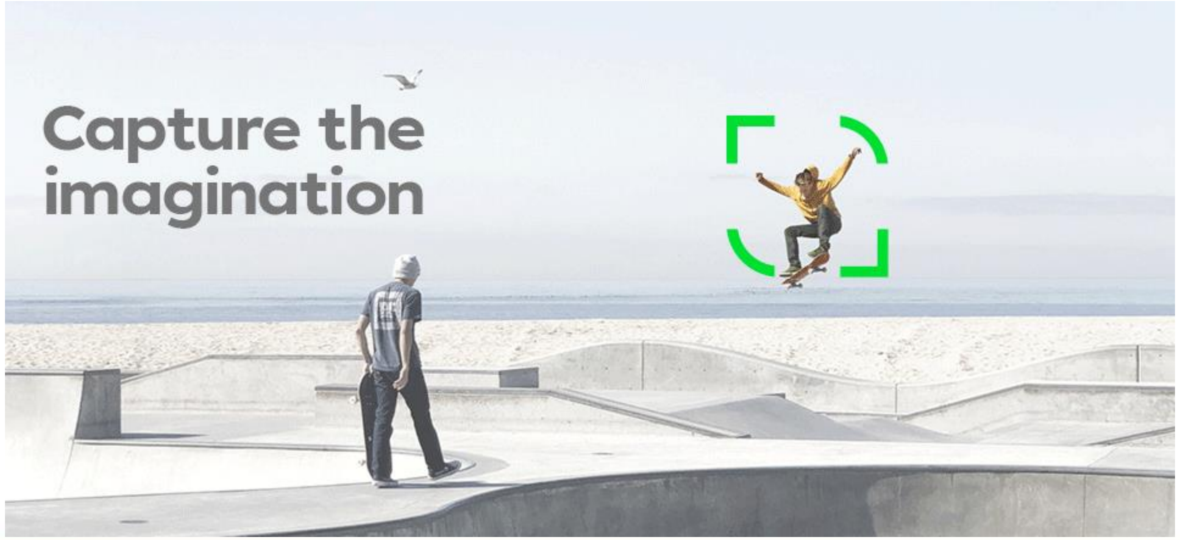
1st industrial scale CCUS in Brevik, Norway

Will capture ~ 400,000 tons of CO_2 annually

4 things you should know about evoZero:

- **evoZero** is the world's first carbon captured net-zero cement offered at scale and without compromising on quality.
- **CCUS** is key to achieve our sustainability goals, a safe, reliable means to decarbonize our industry.
- Thousands of tons captured to date
- **Available for sale** in Europe Now!
- Coming to soon to a market near you

evozero



Padeswood in UK is Next, Will Capture 1,000,000-tons a Year

Heidelberg Materials

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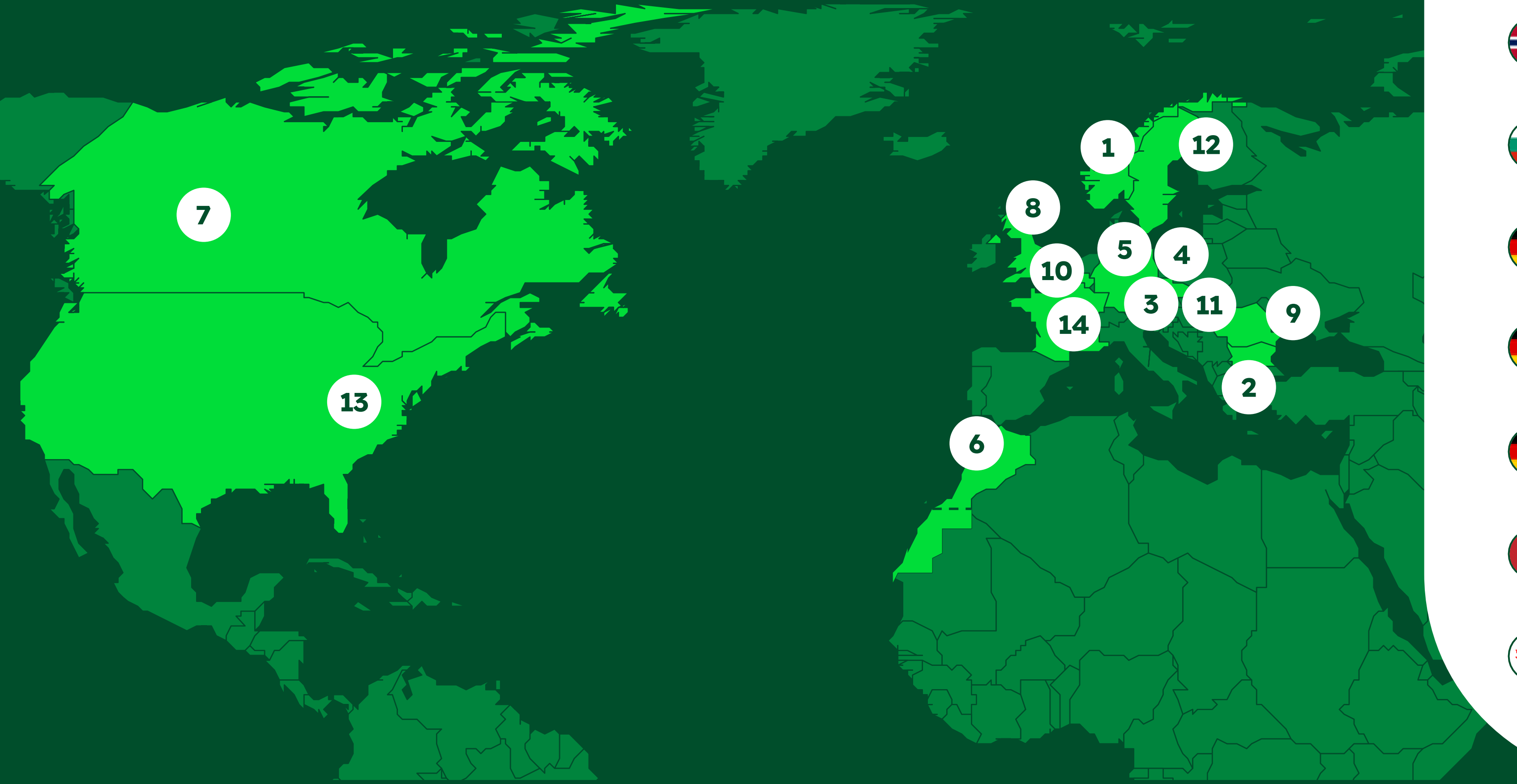
Heidelberg Materials takes the next step with CCS – Final Investment Decision in the UK

1 October 2025

It is Happening: The most advanced CCUS project portfolio in the sector



1 | CCS 2025
Brevik, Norway
400 kt CO_2 p.a.

2 | CC 2024*
Devnya, Bulgaria
OxyCal pilot site

3 | CC 2025
Mergelstetten, Germany
Oxyfuel pilot

4 | CCU 2025
Lengfurt, Germany
70 kt CO_2 p.a.

5 | CC 2026
Ennigerloh, Germany
LEILAC1+2, 100 kt CO_2

6 | CCU 2025
Safi, Morocco
Upscaling capacity

7 | CCUS
Edmonton, Canada
> 1,000 kt CO_2 p.a.

8 | CCS 2028
Padeswood, UK
800 kt CO_2 p.a.

9 | CCUS
Devnya, Bulgaria
800 kt CO_2 p.a.

10 | CCUS
Antoing, Belgium
800 kt CO_2 p.a.

11 | CCS
Geseke, Germany
700 kt CO_2 p.a.

12 | CCS
Slite, Sweden
1,800 kt CO_2 p.a.

13 | CCUS
Mitchell, USA
2,000 kt CO_2 p.a.

14 | CCS
Airvault, France
1,000 kt CO_2 p.a.

***EU funded projects**
All dates estimated start of operations, timing dependent on various factors, incl. funding decision

Edmonton's Net Zero Future

1 million

mt CO_2 p.a.

Scope: Amine-based CO_2 removal system & Combined Heat & Power Plant

Status: Feasibility study complete and project preparation well on track

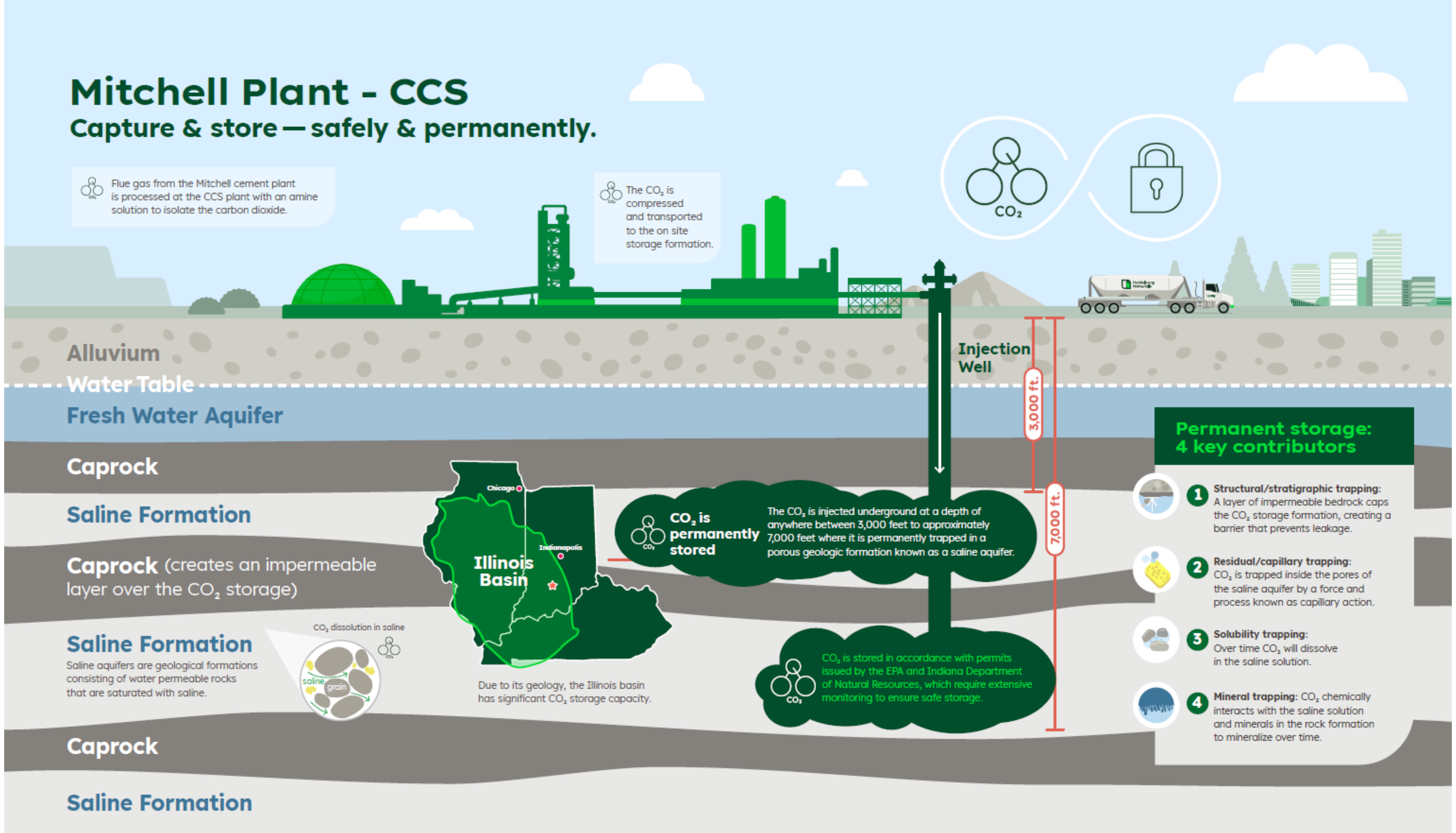
Objective: The world's first full-scale carbon neutral cement plant

Rendering Edmonton, Alberta

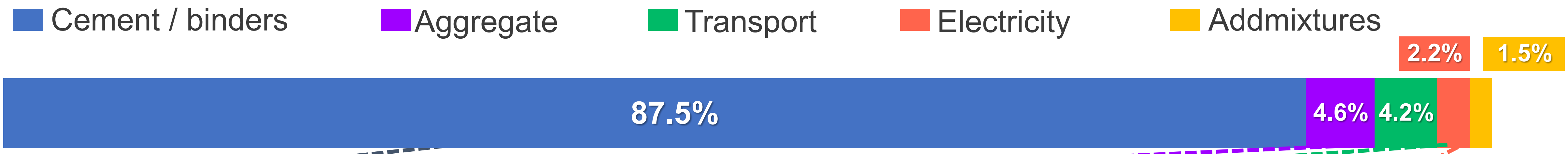
Carbon Capture Must Be Coupled with *Permanent* Storage

Storage

- CO_2 to be stored in deep saline reservoirs
- Permanent storage 1,500-3,000 meters below ground in porous brine filled rock under multiple layers of impermeable cap-rock
- Far below potable water and oil and gas reservoirs
- Current known global storage capacity 40 million tons/yr.
- Storage capacity and efficacy subject to MMV (Measurement, Monitoring, and Verification)



Precast – Embodied CO_2 by Component & Activity



- Use SCMS vs. Cement
- Incorporate limestone and SCMs in Blended Cements
- Use alternate fuels

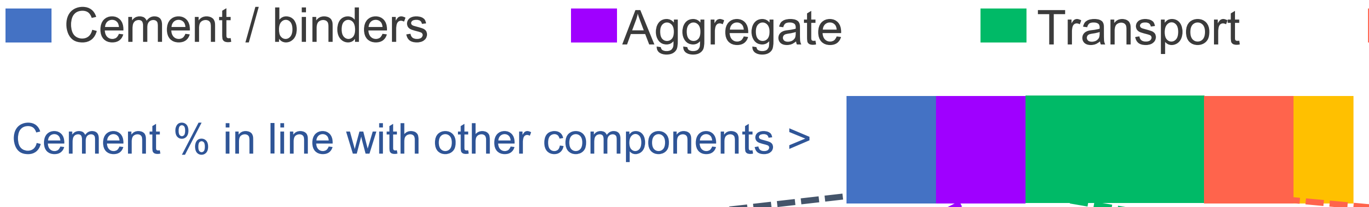
- Aggregate is local, and very low energy and GWP building material.
- Often overlooked CO_2 success factor

- Work with suppliers to minimize empty back-hauls
- Ask them to document CO_2 emissions

- Dependent on power mix from the grid
- Renewable energy credits are usable benefit today

CO_2 in concrete is more than just cement… but…

What CO_2 for Precast Might Look Like After CCUS



evozero

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CO_2 in concrete is dramatically reduced with CCS / CCUS technology

Takeaways, Trends, and Key Points

- Concrete is a sustainable, low-carbon building material
- Cement is key to strength and largest CO_2 contributor
- All changes to your mix must come with admix/materials adjustments
- Blended Cements are on the rise and will becoming more prevalent
  - Type IL (Portland Limestone Cements) are most common
  - Types IS, IP, and IT can deliver large CO_2 reductions w/ low GWPs
- SCMs are reliable, proven, path to high-performance low-carbon concrete
  - Slag is strong CO_2 reduction tool due to high replacement levels
  - Coal Ash (Fly Ash) is plentiful, beneficiation is key to future use
  - Alternative SCMs / cements are coming but few are market ready
- CCS / CCUS necessary to reach decarbonization goals
  - Near-zero CCS cements available now and more are coming

Questions?

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Thank you