JOURNEY TO NET ZERO

Strategies for a Sustainable Future
Karin Perissinotto, Sustainability Manager

Unlocking the Potential of Pozzolanic Materials to Curb CO2 Emissions in Cement Manufacturing
Luis Baquerizo, Director Central Research Lab

CONCRETE INNOVATIONS
NOVEMBER 20, 2024

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Company Background

- Founded in 1891 in Los Angeles, CA
- Largest building materials company producing cement and construction material products in the western United States
- 3000 employees – 150 facilities

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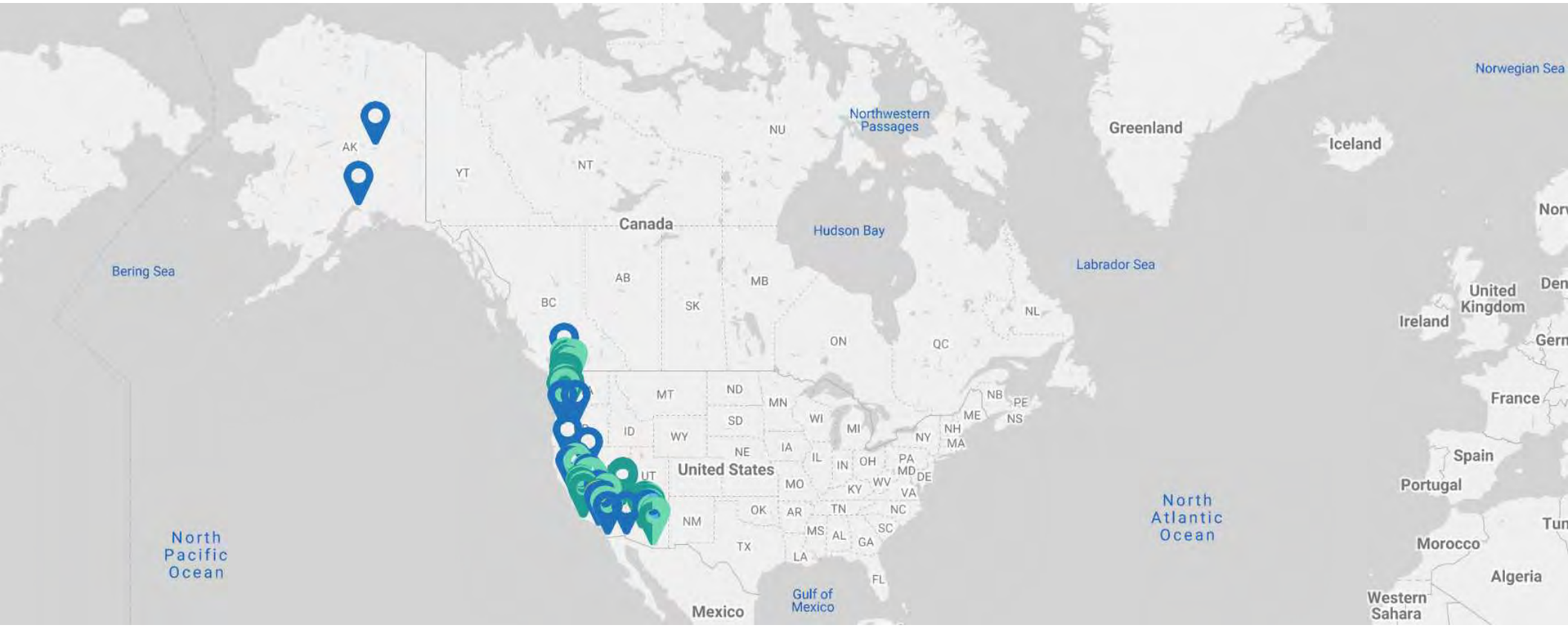
CalPortland Cement, Concrete, Aggregate Facilities



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A History of Sustainable Practices

ENERGY STAR AWARD 2024

PARTNER OF THE YEAR

Sustained Excellence

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ENERGY

- ENERGY STAR Partner since 1996
- Implemented company-wide energy management program in 2003
- Improved energy intensity by 17.5% since 2003, avoiding GHG emissions of over 2.75 million mtons
- Since 2006, consumed over 480 million kWh of zero emission wind energy from on-site wind turbines, avoiding over 350,000 tons of CO_2 or removing 74,310 cars from the road for one year
- ENERGY STAR Partner of the Year Award for Energy Management for 20 consecutive years

ENERGY STAR AWARD 2024
PARTNER OF THE YEAR
Sustained Excellence

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Mojave Cement Plant
24 MW Wind Turbine Electrical Generation

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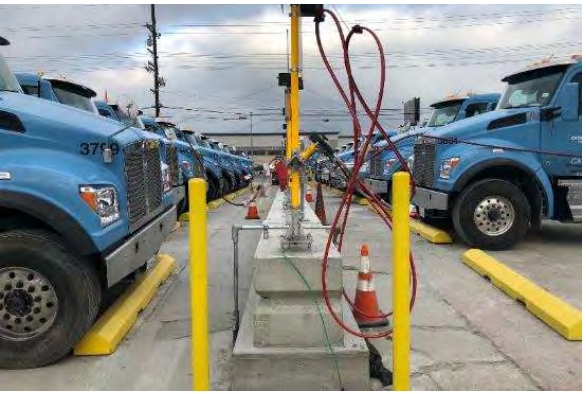

Mobile Fleet
Natural Gas Conversion

- Replaced 118 diesel ready mix trucks with new near zero emission CNG trucks
- Received $11.8 million grant
- Purchased 24 new CNG cement hauler trucks
- Constructed 3 new CNG stations
- Trucks use Renewable Natural Gas (RNG)
  - Landfill, dairy, organic waste, wastewater treatment by product
- Carbon intensity is less than half of diesel
- Low NOx, low particulate, reduced GHG
- Save over $1 million/year vs. diesel

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SUSTAINABILITY IMPACT OF RNG vs DIESEL

Redeem™ by Clean Energy®

CATALINA PACIFIC®
A CALPORTLAND® Company

READY MIX FLEET PROJECT

- 118 Diesel Ready Mix Trucks Switching to Redeem™ Renewable CNG
- 800,000 CNG Gallons Consumed by New Fleet

7,435 METRIC TONS — Total green house emissions reduced per year by switching to Redeem™ renewable natural gas fuel.

THAT'S LIKE:

PLANTING **190,354** TREES

OR

REMOVING **1,569** CARS OFF THE ROAD

OR

2,665 TONS OF WASTE RECYCLED INSTEAD OF LANDFILLED

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Conservation Initiatives

- How can we put nature “to work” for climate?
- Corporate lands can be a part of the solution
- Nature based Solutions (NbS) to address climate change
- Installing projects to enhance biodiversity conservation, improve habitat for local species, sequester carbon, and protect lands and livelihoods
- Wildlife Habitat Council member

WILDLIFE HABITAT COUNCIL℠

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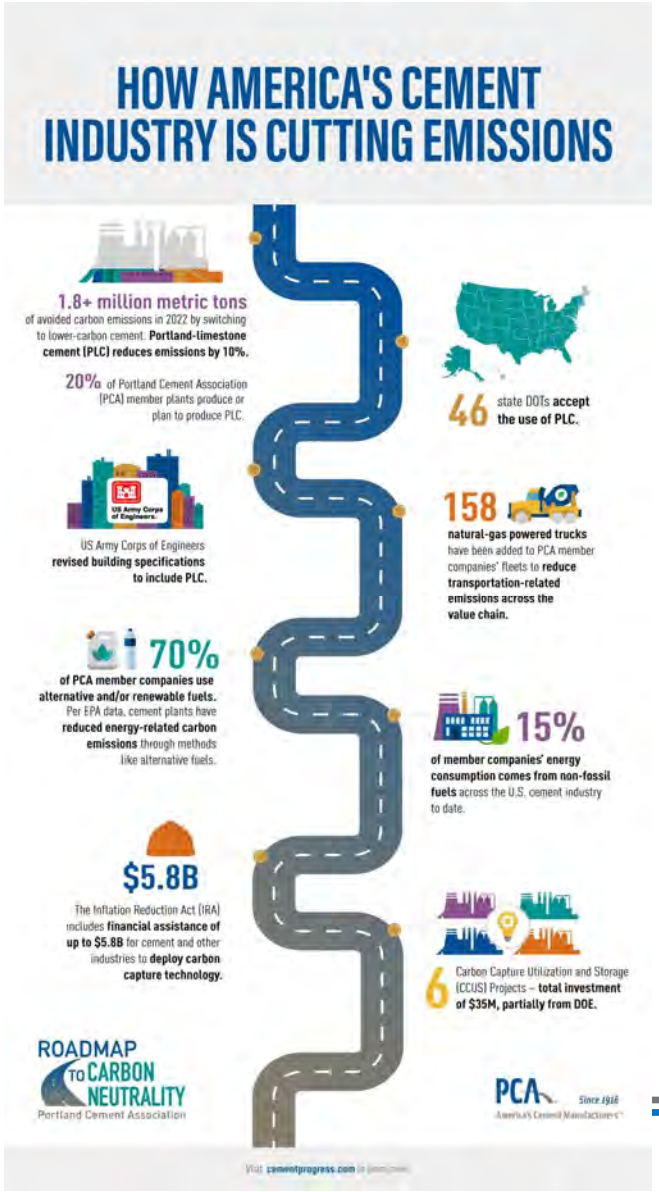

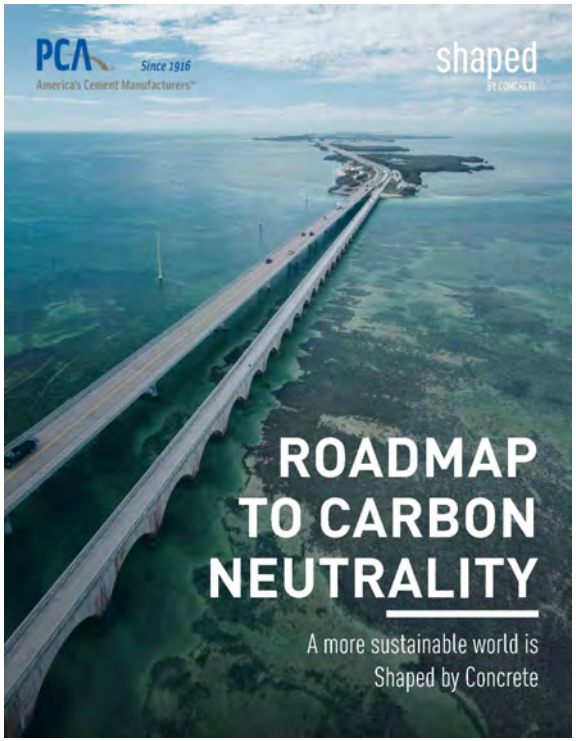

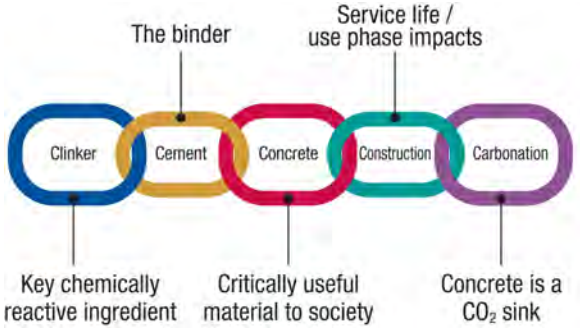

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Unlocking the Potential of Pozzolanic Materials to Curb CO_2 Emissions in Cement Manufacturing

Luis Baquerizo, Ph.D.

Director of the Central Research Lab, CalPortland Company, California

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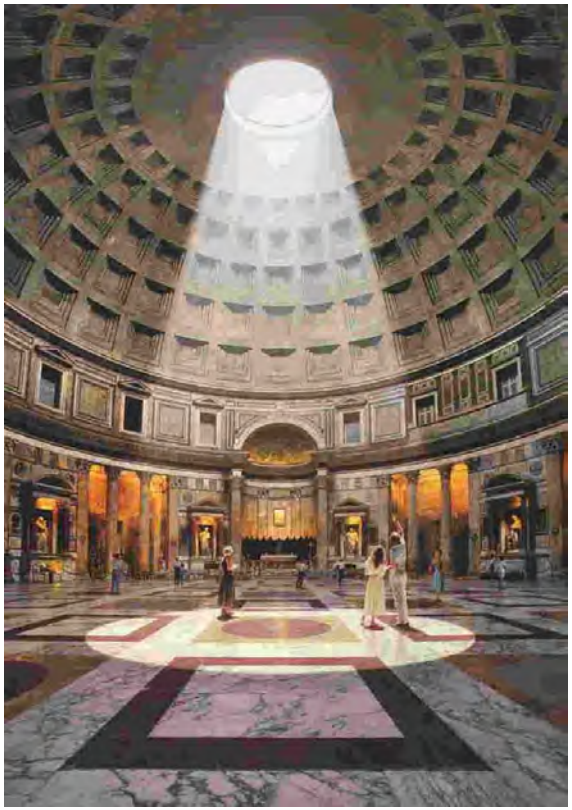
Natural Pozzolans

The term "**pozzolana**" originates from **Pozzuoli**, a town in Italy previously known as Pueoli, located east of Naples. In ancient times, this area was known for its abundant volcanic ash, which was used to create a material called "Opus Caementitium." This early form of concrete was made from stone, sand, calcined limestone (CaO), and pozzolana. It is the addition of pozzolana that gave this material hydraulic properties, allowing it to harden and gain strength when combined with water. Remarkably, some ancient structures built with this early concrete can still be seen today.



The Pantheon in Rome, Italy, features a dome that remains intact and holds the record as the world's largest unreinforced concrete dome. Built in the second century, this impressive structure has a diameter of 43.3 meters.

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Natural Pozzolans

Natural pozzolans are siliceous or siliceous-aluminous materials that, when finely ground, can react with calcium hydroxide in the presence of water to form compounds with cementitious properties

Volcanic pozzolans

Tuffs

Volcanic tuffs are soft, porous rocks typically formed through the compaction and cementation of volcanic ash or dust. They can be classified into three types: vitric, crystal, or lithic

Pumice

Pumice is a pyroclastic igneous rock that was nearly molten upon eruption and cooled too quickly to crystallize. As it solidified, trapped vapors escaped, causing the rock to expand into a frothy, porous structure.

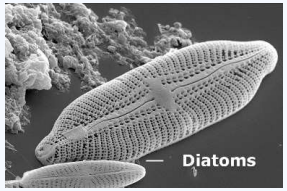
Zeolites

Hydrated aluminosilicate minerals that typically form when volcanic ash or tuffs alter over long periods in an alkaline environment, reacting with groundwater to create their unique crystal structure

Sedimentary pozzolans

Diatomite

Diatomite is a fine-grained, light-colored sedimentary rock, composed mainly of the fossilized remains of diatoms, which are microscopic aquatic algae with silica-rich cell walls.



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Natural Pozzolan

- Before fly ash became popular in concrete, regions in the Western U.S., like California and Nevada, widely used natural pozzolans. Their use grew in the early-to-mid 1900s for public works projects, including many dams.

- Using Portland cement alone in mass concrete posed challenges, such as high heat of hydration, susceptibility to chemical attack, and limited durability. To address these issues, natural pozzolans were added as SCMs, enhancing the strength and longevity of large concrete structures.

Davis Dam (AZ/NV)- Utilization of Natural Pozzolan as SCM in Mass Concrete.

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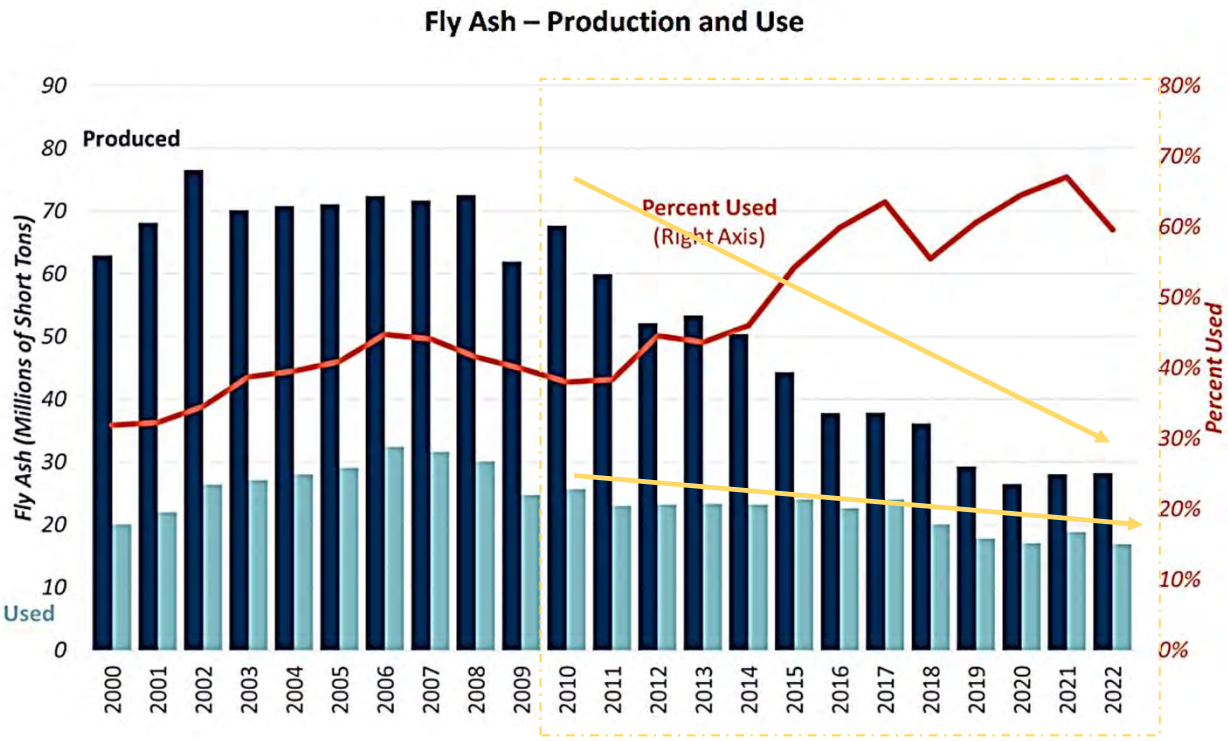
Fly Ash Production is Declining

- Fly Ash availability is limited and becoming harder to find, especially on the west coast of the U.S.
- Current Fly Ash **quality** is not the same as the pure sources we were using 10 years ago.
- Fly Ash producers are blending with other SCM's to help extend the availability of Fly Ash.
- This affects consistency and reactivity.



The American Coal Ash Association

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Why natural pozzolans

Benefits

- **Low Processing Needs**: Requires only grinding, reducing energy use.
- **Cost-Effective in Pozzolan-Rich Areas**: Ideal where locally available, lowering transport costs.

- **Durability Boost**: Enhances sulfate and ASR resistance, reduces permeability.

- **Long-Term Strength**: Pozzolanic reaction refines pore structure for lasting performance.

- **Eco-Friendly Cement Reduction**: Lowers clinker content, cutting the cement's carbon footprint.

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Availability of Natural Pozzolans in the US

- About 10 production facilities and 10 more in development
- List of producers:
  - National Pozzolan Association: Sourcing Natural Pozzolans

Our Natural Pozzolan is located in Mojave - CA

- *2024 IEEE-IAS/PCA Cement Conference, Blended cements: Background & History of Type IL in US, Experiences in Europe, Jamie Farny, Eric Giannini*
- *Natural Pozzolan Association: https://pozzolan.org/sourcing-pozzolan.html#CMD*

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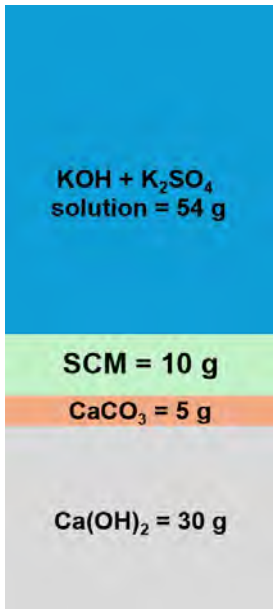
Characterization techniques to assess the potential of Natural Pozzolans

Reactivity

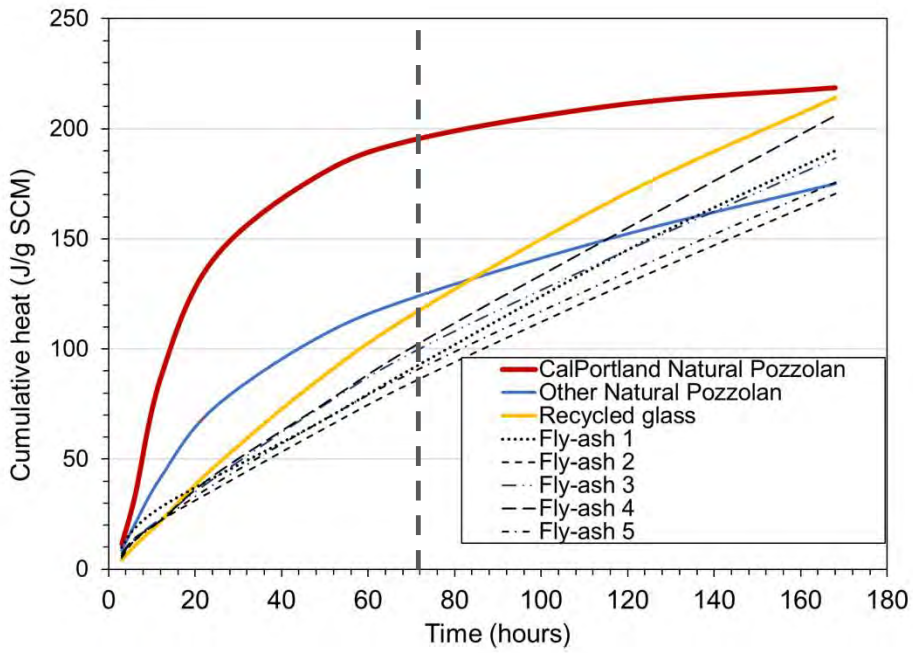
ASTM C1897: Standard Test Methods for Measuring the Reactivity of Supplementary Cementitious Materials by **Isothermal Calorimetry** and Bound Water Measurements

R3

40°C



Components



CalPortland Natural Pozzolan offers superior reactivity compared to most common fly ashes and other pozzolans available on the market

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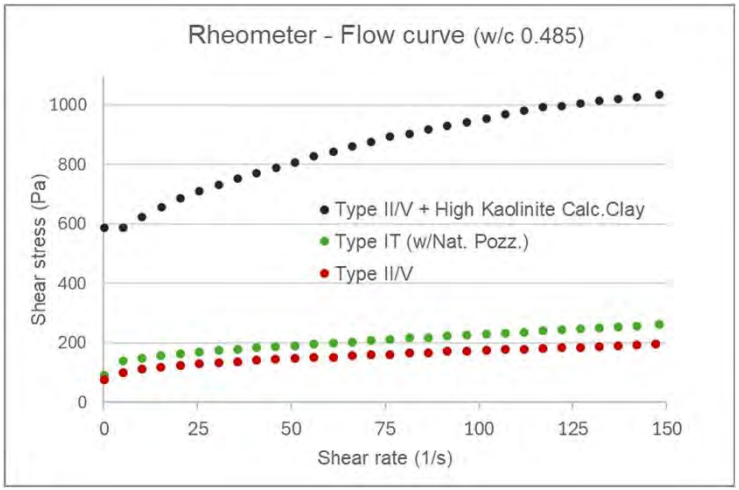
Characterization techniques to assess the potential of Natural Pozzolans

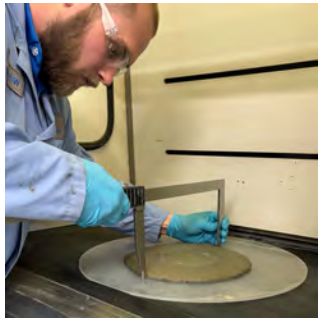
Workability

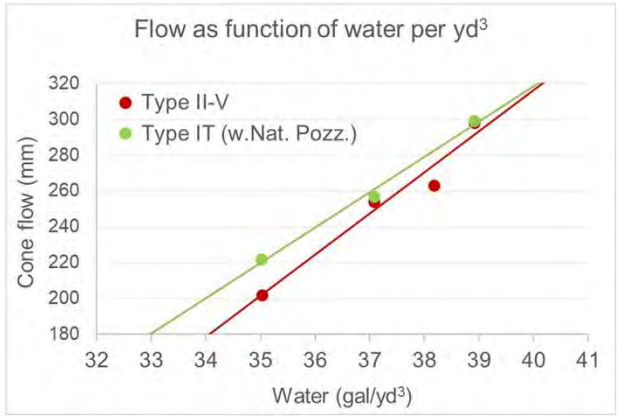
Rheometer
(cement paste)



Rheological properties of blends with our natural pozzolan are slightly different than II/V, but significantly better than other SCMs, such as calcined clays

Microconcrete
(Mortar mix)





Similar water demand in Microconcrete mixes, incorporating **additives and sand**

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Opportunity in Blended Cements – ASTM C595

Replacement of Clinker with SCMs

Cement Type	Type IP (Portland-Pozzolan Cement)	Type IL (Portland-Limestone Cement)	Type IT (Ternary Blended Cement)
Formulation	≥ 60% Clinker + Gypsum ≤ **40% Pozzolan**	≥ 85% Clinker + Gypsum 5% ≤ Limestone ≤ 15%	**IT(P#)(P#)** ≥ 60% Clinker + Gypsum ≤ **40% Two Pozzolans**
			IT(P#)(L#) ≥ 45% Clinker + Gypsum ≤ 15% Limestone ≤ **40% Pozzolan**
			IT(P#)(S#) ≥ 30% Clinker + Gypsum ≤ **40% Pozzolan** ≤ 30% Slag
			IT(S#)(L#) ≥ 15% Clinker + Gypsum ≤ 15% Limestone ≤ 70% Slag

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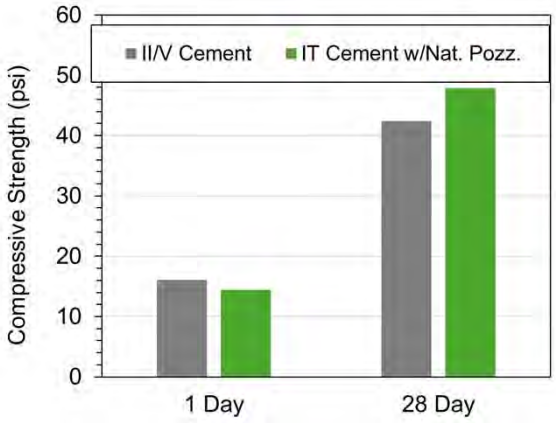
Ternary Blended Cement (IT) with Natural Pozzolan

ASTM specified and Caltrans approved

ASTM C109: Cement mortar strength



IT cement exhibits slightly reduced early strength but enhanced strength at later stages.

ASTM C1012

Property	HS Requirement	IT Cement
Sulfate resistance Expansion at 180d, max, %	0.05	0.02

IT cement offers outstanding resistance to sulfate attack.

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Opportunity in Concrete

ASTM C618: Standard Specification for Coal Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

Replacement of Cement with SCMs

4.1 Class N—**Raw** or calcined natural pozzolans that comply with the applicable requirements for the class as given herein, such as some diatomaceous earths; opaline cherts and shales; tuffs and volcanic ashes or pumicites, calcined or uncalcined; and various materials requiring calcination to induce satisfactory properties, such as some clays and shales.

Chemical Requirements	Class N	CalPortland Nat. Pozz.
SiO_2+Al2O3+Fe2O3, min, %	70	79.4
SO3, max, %	4	0.2
LOI, max, %	10	10

Physical requirements	Class N	CalPortland Nat. Pozz.
Fineness, retained No. 325 sieve, max, %	34	5
Strength Activity index		
with Portland cement, 7d, min, %	75	80
with Portland cement, 28d, min, %	75	93

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Concrete with Natural Pozzolan

- Approved by Arizona DOT and Caltrans.
- CalPortland has been using natural pozzolan in the Arizona market since 2020 for different applications, such as: shotcrete, high strength concrete, precast concrete and residential.
- Faster setting times compared to fly ash mixes.
- Comparable early age strength with II/V cement and fly ash mixes, and higher later age strength.
- Less plastic shrinkage cracking.

Tilt-Up Panels
4000 psi and 5000 psi with Natural Pozzolan.

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Key Takeaways:

Raw Natural Pozzolans unlock interesting opportunities for the Cement and Concrete Industry

- **Low Processing and Cost-Effective**
- **Improved Long term strength and Durability**:
- Offers interesting **opportunities as addition in cement** (blended cements) and in **concrete** (fly-ash and/or slag replacement)
- **New characterization techniques**, like the **R3** method, provide a **fast and reliable approach** to evaluate the performance of various natural pozzolans
- **Alternative to reduce GWP of cement and concrete**

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