THINK pozzotive®

A proven and cost-effective solution to make high-performance, low carbon concrete from unwanted waste glass

Who We Are

Urban Mining Industries produces Pozzotive®, a ground glass cement replacement made from post-consumer waste glass.

It is a proven, safer, sustainable and higher-performing material that dramatically reduces embodied CO_2 emissions in concrete.

The Company opened the first full-scale production facility of its kind worldwide in CT in early 2021.

To date, the equivalent of about 150 million bottles have been repurposed.

Prior to that, UMI had been making the product for over 10 years in its product validation plant.

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Halletts Point, the first high-rise built with Pozzotive ground glass pozzolan in the concrete mix

What's a Pozzolan?

- A pozzolan is a fine powder that, by itself, is not cementitious but, when mixed with water and portland cement, becomes cementitious.
- Pozzolans are essential to making stronger and more durable high-performance concrete.
- Ground Glass Pozzolans (GGP) not only create a low-carbon, high-performance concrete, they solve the challenge of what to do with our nation's unwanted recycled glass.

How does it work?

- When cement hydrates in a concrete mixture with aggregates:
- Calcium-silicate-hydrate (C-S-H or the good stuff) is formed. It's what binds the overall concrete mix.
- Calcium hydroxide (CH or the not so good stuff) is also formed. It weakens the concrete and causes porosity.
- Pozzolans react with deleterious CH, converting it to additional beneficial C-S-H, by giving up a silica atom and creating stronger and more durable concrete. Glass is about 72% SiO_2.

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The Ongoing Glass Challenge

- **8M+ tons** of non-degradable post-consumer glass is sent to landfills every year in the U.S.
- **Only about a third of glass is recycled** in the U.S. The majority is redemption glass.
- **Single stream recycling in the US is the most convenient for consumers but more challenging for processors.** Bottle manufacturers require a minimum size for color segregation and ceramics and porcelains removed from comingled collections.
- Many times, **transporting the heavy, low value commodity beyond its metro area is cost prohibitive.**

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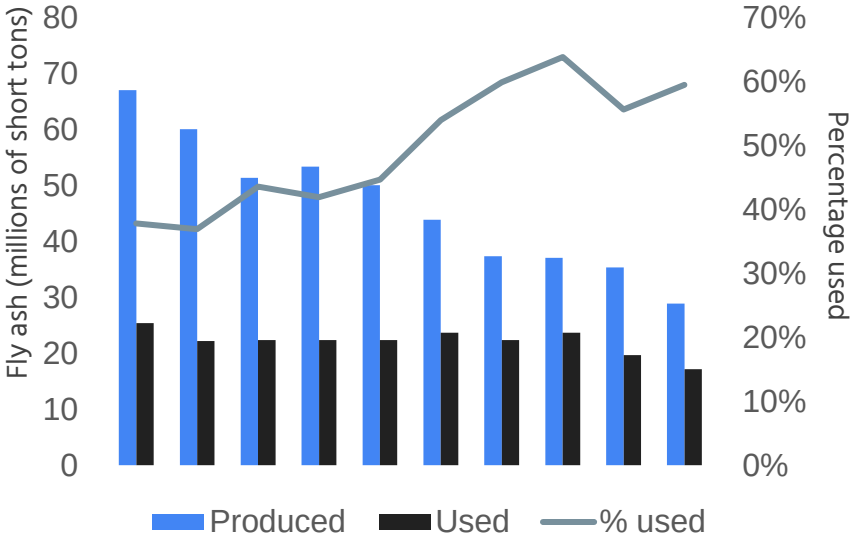
Why Now? Decline of traditional cement replacements drives demand for new and cleaner alternatives

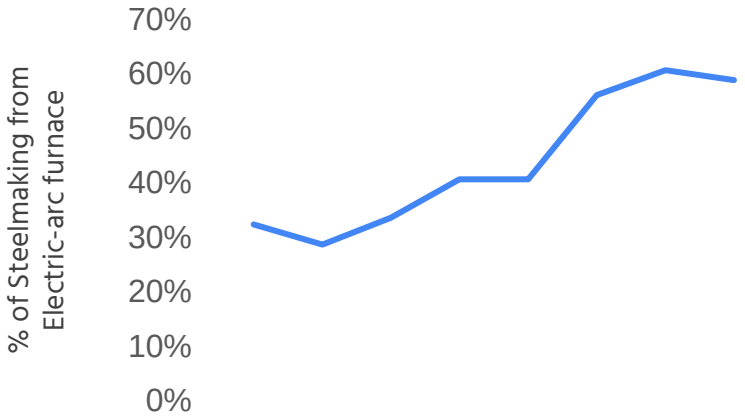
Available fly ash is steadily declining

Fly ash global production and usage



Source: American Iron and Steel Institute, 2019.

Conversions to Electric-arc furnaces are reducing the availability of slag



Source: Institute for Energy Economics and Financial Analysis, World Steel Assoc., 2020.

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Think Planet *and* Performance with Pozzotive

1. Reduces CO_2 emissions by ~95%+
Low energy intensive process versus cement

2. Reduces waste
Uses post-consumer glass in any color or size and ceramics

3. Reduces heat island effect
Lighter material that increases reflectivity

4. Creates stronger concrete
Better performing, low-carbon concrete at no additional cost

5. Increases concrete life
5X more resistant to chloride and moisture penetration

6. Safer material
Free of crystalline silica, a carcinogen, and toxic heavy metals

Promoting a circular economy

1. Used
Glass is valued for holding the strength, safety, aroma and flavors of products.

2. Disposed
Glass and ceramic are sent to a local material recovery facility.

3. Transformed
Processed glass and ceramic are used to produce Pozzotive®.

4. Reused
Up to 50% of cement is replaced with Pozzotive® in concrete.

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Cement/Concrete in America

- What's the difference between the two?
- The US uses over 100 mm tons of cement a year.
- Concrete usage worldwide, ton for ton, is twice that of steel, wood, plastics, and aluminum combined.
- It's critical for the rebuilding of American infrastructure and is by far the most disaster-resilient material.
- Longer lasting materials = less maintenance. It is non-combustible, and does not rot, warp or mold.
- High-performance concrete typically requires supplemental cementitious materials –historically, Fly Ash, and to a lesser extent -silica fume and metakaolin.
- But concrete does have its environmental challenges.

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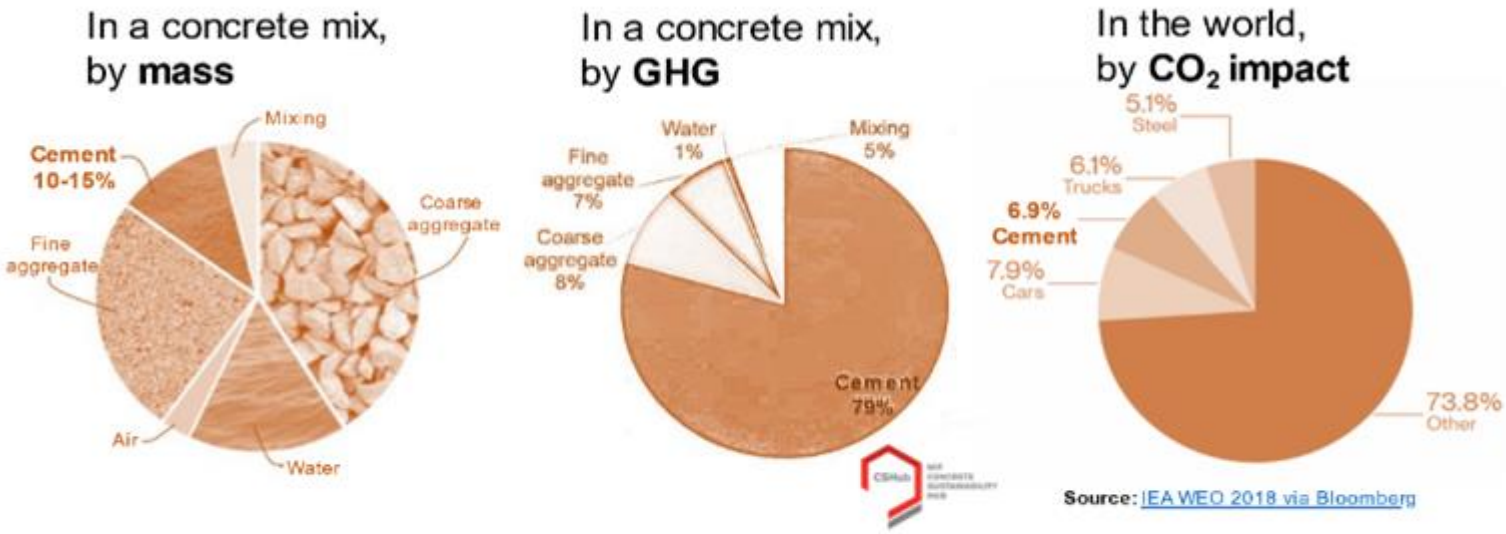
Cement's disproportionate impact in concrete



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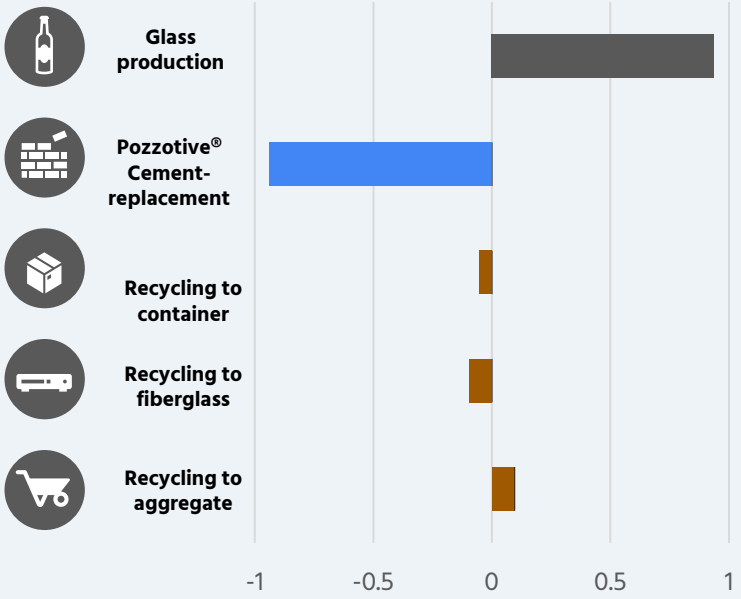
The positive climate impact of glass-to-concrete is over 5x the alternatives

CO_2 equivalent impact comparison per ton of product



12 mm

tons of glass is generated annually in the US

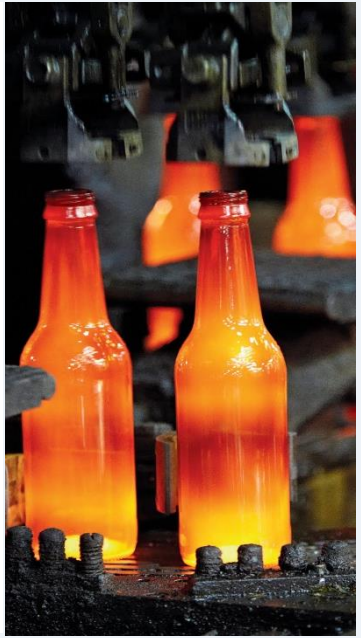
GHG potential reduction

2 mm

tons if all back to bottles

11+ mm

tons if all is used for Pozzotive®



Source: Oregon Department of Environmental Quality.

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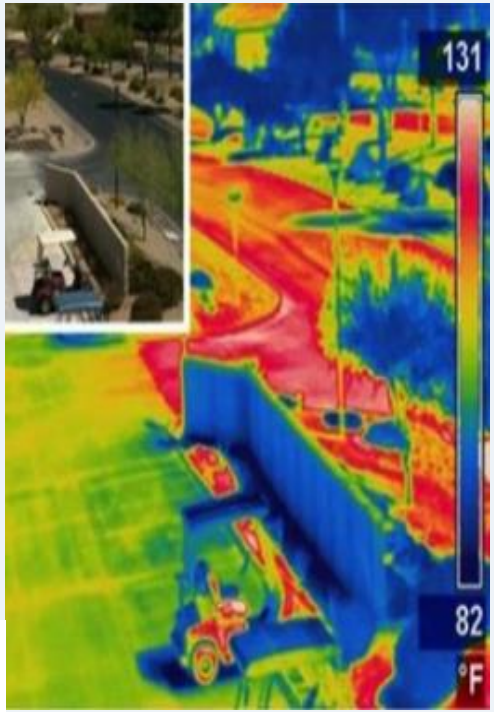
Lighter color significantly reduces the heat island effect



Above: NYC DOT Pilot Sidewalk Program with Pozzotive

- The lighter color of Pozzotive® **reduces the harmful urban heat island effect** by reducing air temperatures.
- **Building operations generate 3x more emissions** than construction.
- Creating cool white rooftops, floors and building surfaces lower energy use in buildings by **reducing both cooling and lighting needs.**

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42% reduction in concrete's carbon footprint

Cradle to Gate GWP (kg CO2e) per cubic yard of a 9,000 psi mix design with and without Pozzotive®

Material	Units	Quantity/Cubic Yard	
		W/out Pozzotive	With Pozzotive
Type I/II Cement	lb	850	425
Pozzotive	lb	-	425
Sand	lb	1,150	1,150
Stone 1	lb	1,000	1,000
Stone 2	lb	700	700
Water	Gal	34.7	34.7
Admix1	fl.oz	46.8	46.8
Admix2	fl.oz	17.0	17.0
Admix3	fl.oz	25.5	25.5
GWP (kg CO2e)		**625.0**	**361.0**
28-day break (psi)			**9,623**
56-day break (psi)			**12,852**

A 50% replacement of cement in a 9,000-psi concrete mix design yielded a 42% reduction in the concrete carbon footprint.

The 28-day break was 9,623 psi and the 56-day break was 12,852 – outstanding strength performance

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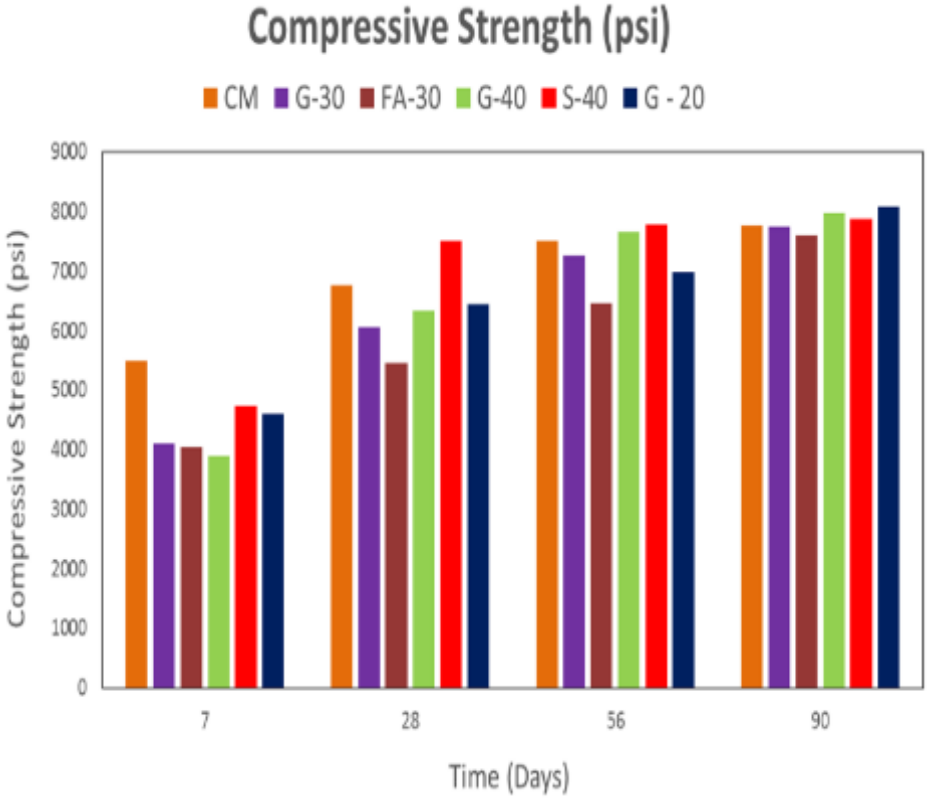
The protection against Chloride is more than 5x that of cement-only concrete

Rapid Chloride Permeability Test (ASTM C1202)

Concrete Mix	Coulombs
Cement only	1,617
40% of cement replaced with slag	1,100
30% of cement replaced with fly ash	500
20% of cement replaced with Pozzotive	456
30% of cement replaced with Pozzotive	436
40% of cement replaced with Pozzotive	282

Impressive compressive strengths through and beyond 90 days



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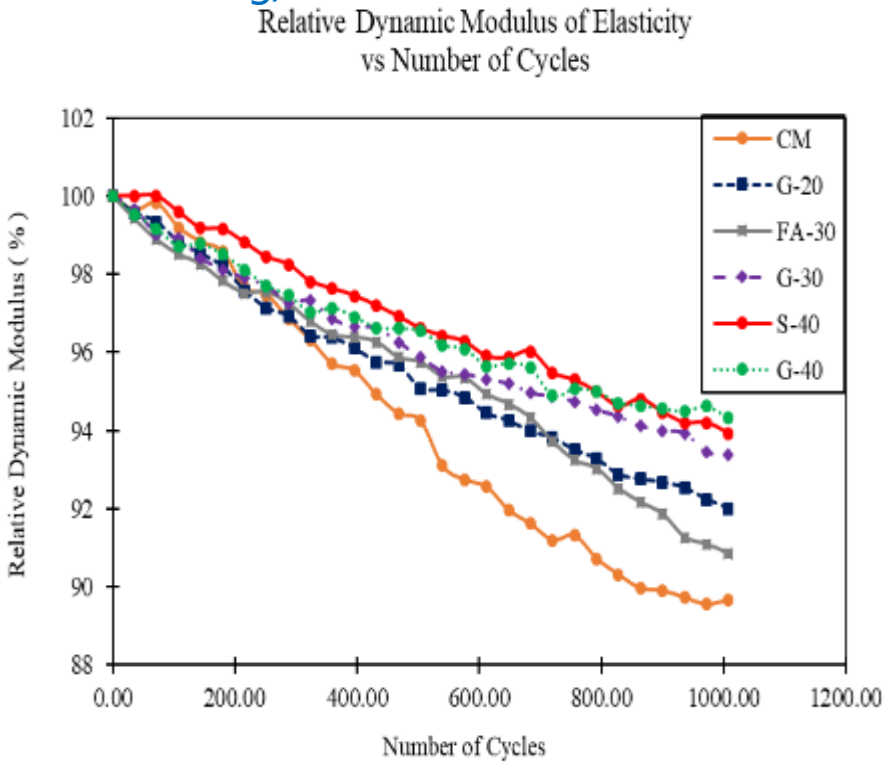
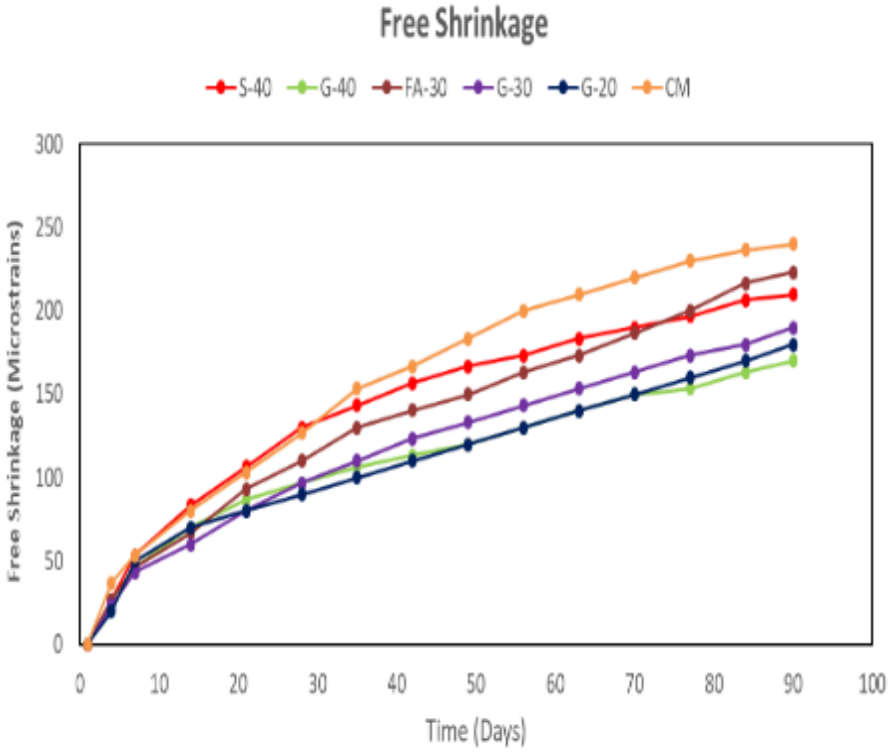
After 1,000 freeze-thaw cycles, mass loss was less than 1%; no visible cracks or scaling;



GGP mixes significantly reduced concrete shrinkage vs. mixes with cement only, fly ash and slag



Blends with Other SCMs

- Research on ternary and quaternary blends with other SCMs indicates that there is a synergistic effect when GGP is combined with slag and/or metakaolin, most likely due to the contribution of alumina from these SCMs into the pore solution.
- This filed test reflects a 50% cement replacement ternary blend with 25% Pozzotive and 25% slag in a 10,000 – 12,000 psi SCC mix, all showing outstanding strengths.

Queens Plaza Park, Queens, NY

GGP and Slag Mix Design Study: 10,000 - 12,000 psi Mix

Design Strength Range (psi)	Total Cementi-tious (lbs/yd)	Portland Cement %	Slag %	GGP %	Compressive Strength				% of Design Strength @ 56 Days	Slump (in)	Air %
					3-Day	7-Day	28-day	56-day			
10,000	850	50	25	25	6,299	7,802	10,403	12,202	122%	11.50	3.2%
10,667	900	50	25	25	6,649	8,728	11,850	13,132	123%	11.00	2.4%
11,333	950	50	25	25	7,345	9,824	13,160	15,063	133%	10.75	2.5%
12,000	1,000	50	25	25	8,448	10,455	13,873	16,178	135%	11.00	3.1%

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Early and Final Strength Gains

- One concern with the use of pozzolans is set time and early strength gain.
- A study by McInnis Cement showed that a 35% replacement with Pozzotive increased initial set time but significantly reduced final set time.
- New York Precast has produced over 500,000 sf of prestress plank with no delay in stripping forms.

Set Time (min) Study with McInnis Cement

Design Strength (psi)	% Pozzotive	Initial Set (min)	% of Control	Final Set (min)	% of Control
6,000	0%	209	Control	469	Control
6,000	35%	268	128%	408	87%
8,000	35%	239	114%	346	74%
10,000	35%	236	113%	344	73%

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ASTM C1866 Specification for the Use of GGPs in Concrete

Designation: C1866/C1866M – 20

Standard Specification for Ground-Glass Pozzolan for Use in Concrete[1]

- UMI, working closely with an ASTM work group made up of concrete experts, was instrumental in creating and passing ASTM C1866 Standard Specification for Ground-Glass Pozzolan for Use in Concrete.
- Over over 100 concrete experts in industry and academia had to agree that GGPs are excellent pozzolans and improve concrete quality
- The standard was **published in April 2020.**

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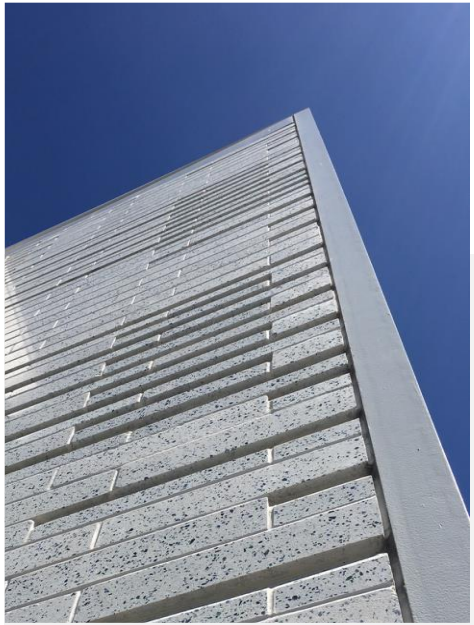
Pozzotive® GGP used across a wide range of applications

More than 250,000 yd³ of cast-in-place concrete including the first ever high-rise structural pour

12 million+ architectural and structural concrete masonry units



500,000 ft² of pre-stressed concrete planks

Nearly 750,000 ft² of pavers

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Local Glass Back To Local, Low-Carbon Projects

DeCicco's & Sons Sleepy Hollow, NY

New Canaan Library, CT ***2024 Concrete Innovations Award Winner***

Ox Ridge Elementary School, CT

DEEP Western District Headquarters, CT

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Local Glass Back To Local, Low-Carbon Projects

New Fairfield High School, CT

Torrington High School, CT

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Select NYC flagship applications with Pozzotive

United Nations Plaza – New York, NY
Application
Pavers and Architectural CMU made from 60 tons of windows glass harvested from the UN General Assembly Building specified by diDomenico + Partners
GGP utilized
60 tons in UN Plaza + other projects
Total CO_2 savings
57 tons

2nd Ave Subway – New York, NY
Application
30% GGP replacement in CMU for construction of every station on the subway line specified by AECOM
GGP utilized
1,050 tons
Total CO_2 savings
998 tons

JPMorgan Chase Global HQ, New York, NY
Application
40%+ GGP replacement in building floor slabs and CMU specified by Severud Associates
GGP utilized
5,375 tons
Total CO_2 savings
5,106 tons

Halletts Point + Halletts Point 20-30
Application
40% GGP replacement in structural concrete specified by Severud Associates
GGP utilized
2,460 tons
Total CO_2 savings
2,337 tons

Harvard University and Urban Mining Industries: Decarbonizing the Supply Chain

HARVARD | BUSINESS | SCHOOL

9-123-076

REV: JUNE 6, 2023

SHIRLEY LU
ROBERT S. KAPLAN

Harvard University and Urban Mining Industries: Decarbonizing the Supply Chain

Harvard's potential use of Urban Mining Industries' products illustrates how the university can credibly reduce its carbon footprint. Today, our stakeholders lack confidence in the emissions and other data coming to us from complex supply chains. The "holy grail" is having access to valid, certified data of the carbon and health content in all our purchased materials, products, and services.

— Heather Henriksen, Chief Sustainability Officer, Harvard University

Harvard President Drew Faust announced in February 2018 that the university would be fossil-fuel neutral by 2026 and fossil-fuel free by 2050.[1] Faust had, previously, established a university-level Office for Sustainability, which had helped Harvard reduce on-campus absolute greenhouse gas (GHG) emissions by 30 percent from 2006 to 2016. Eliminating fossil fuel use, not just their GHG emissions, reflected Harvard's concerns with the total health and ecosystem impacts from fossil fuel use. Faust's 2018 announcement emphasized the university's commitment to be a sustainable community, delivering positive social, economic, and environmental benefits through institutional action and best-practice sharing in addition to education and research (see **Exhibit 1**). Achieving this target would require purchasing 100% renewable electricity, using zero fossil fuels in buildings, Harvard's district energy plants or fleet vehicles, and extensive efforts and coordination across the university's 12 decentralized schools and other units, its broad range of building types and land uses in Cambridge and Boston, and its tens of thousands of faculty, students, and staff.

Lawrence Bacow, Faust's successor, embraced her vision for Harvard to become a living laboratory for reducing global carbon emissions. He established a Presidential Committee on Sustainability, composed of senior faculty and staff, and students, to advise the university's leaders on implementing its sustainability plan:

> Harvard's campus should serve as a testbed for experimentation that evolves with our knowledge of climate change and sustainable development. From the construction and maintenance of our buildings; to the design of our food; and more, Harvard is leveraging our EV buses; to the sourcing and preparation of our food; and more, Harvard is leveraging our strengths to translate research and teaching into practice to pilot, prove, and implement solutions that can be replicated and scaled locally and globally.[2]

Professor Shirley Lu and Senior Fellow Robert S. Kaplan prepared this case. It was reviewed and approved before publication by a company-Anonymous. Funding for the development of this case was provided by Harvard Business School and not by the company. HBS cases are developed solely as the basis for class discussion. Cases are not intended to serve as endorsements, sources of primary data, or illustrations of effective or ineffective management.

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Harvard University is pushing the construction industry to focus on transparent ways to reduce embodied carbon through their campus expansion projects. Through a clear-eyed examination of the concrete industry, this important case study showcases the need to understand the real (transparent) embodied carbon consequence for materials we use to reduce the embodied carbon associated with heavily emitting cement. Transparency is key to understand and value the true embodied carbon offset.

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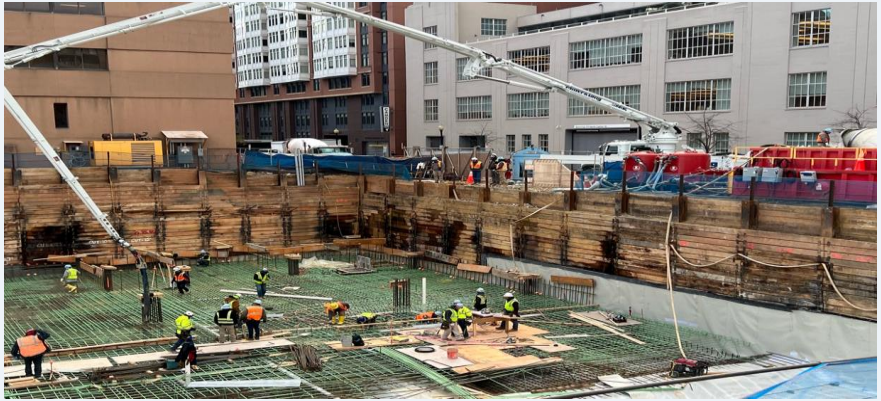
Providing Low-Carbon Concrete Solutions Nationally



1133 North. Capital St. NE, Washington, D.C.

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Providing Low-Carbon Concrete Solutions Nationally

Howard University – The Langston

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Providing Low-Carbon Concrete Solutions Nationally

Children’s Hospital, Philadelphia, PA

Lord Fairfax Community College, Warrenton, VA

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Contributing to Envision & LEED Certification

Institute for Sustainable Infrastructure

Materials
RA1.1 Reduce Net Embodied Energy
RA1.3 Use Recycled Materials
RA1.4 Use Regional Materials
RA1.5 Divert Waste From Landfills

Energy
RA2.1 Reduce Energy Consumption

Emissions
CR1.1 Reduce Greenhouse Gas Emissions
CR1.2 Reduce Air Pollutant Emissions

Resilience
CR2.5 Manage Heat Island Effects

City Point, Brooklyn, NY. One of the largest mixed-use developments in New York City built with Pozzotive®

Why Ground Glass Pozzolan Now?

- Years of proven performance
- Urgency to significantly reduce GHG emissions from the manufacturing of cement and to better use waste glass
- New ASTM standard makes it easier to specify Pozzotive®
- Diminishing supply of primary historic alternatives, i.e. fly ash and slag while demand and prices increase
- Health/Equity Benefits of reducing urban heat island effect while avoiding heavy metals
- Contributing broadly to Envision & LEED certification

What Can You Do?

- Keep glass in your collection streams and *keep track of it!*
- Specify high-performance, low-carbon concrete and concrete-based products using a ground glass pozzolan for new projects in our towns and communities to:
  - Significantly reduce the carbon footprint of concrete while enhancing its performance;
  - Help solve the challenges of waste glass;
  - Extend the life of our nation's infrastructure.

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Thank you!

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