A proven and cost-effective low-carbon, high-performance solution for concrete

Ground Glass Pozzolans



Urban Mining Industries produces Pozzotive[®], a ground glass cement replacement made from post-consumer glass. It is a proven, safer, sustainable and higherperforming material that dramatically reduces embodied CO₂ emissions in concrete O&G Industries is Connecticut's largest privately-held construction company and one of the Northeast's leading providers of construction services and products. The company owns and operates a network of ready-mix concrete and asphalt plants, quarries, and supply yards



Patrick A. Grasso pgrasso@urbanminingind.com TJ Oneglia tjoneglia@ogind.com Halletts Point, the first high-rise built with a 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 highperformance concrete.
- Ground Glass Pozzolans (GGP) not only create a low-carbon, highperformance 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 bad 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% SiO2.





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.



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

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



Source: American Iron and Steel Institute, 2019.

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



Think Planet <u>and</u> Performance with Glass Pozzolans



1. Reduces CO₂ emissions by ~95%+ Low energy intensity process versus cement



2. Reduces waste

Uses post-consumer glass in any color or size and ceramics





4. Creates stronger concrete

Better performing, lowcarbon 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 local material recovery facility



3. Transformed

Processed glass and ceramic is used to produce Pozzotive®



4. Reused

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







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 noncombustible, 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.



Cement's disproportionate impact in concrete





The cement and concrete industries need new and affordable technologies to fight climate change

Cement is one of the largest CO₂ emitters

Share of global CO₂ emissions

Cement generates the most CO₂ per \$ of revenue Kg of CO₂ per \$ of product sales





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

> CO₂ equivalent impact comparison per ton of product



12+M

tons of glass is generated annually in the US

GHG potential reduction

11+ 2 **M** tons If all back to

bottles

M tons if all is used for Pozzotive®







Source: Oregon Department of Environmental Quality.

Lighter color significantly reduces the heat island effect



- 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



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®

		Quantity/Cubic Yard	
		W/out	With
Material	Units	Pozzotive	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



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

Compressive Strength (psi)

■ CM ■ G-30 ■ FA-30 ■ G-40 ■ S-40 ■ G - 20



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

> Relative Dynamic Modulus of Elasticity vs Number of Cycles



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





Ground-Glass Pozzolan for Use in Concrete

Members of ASTM Subcommittee C09.24 summarize industry context behind new ASTM standard specification

pozzotive

by Amanda Kaminsky, Marija Krstic, Prasad Rangaraju, Arezki Tagnit-Hamou, and Michael D.A. Thomas

be construction sector is continually seeking new sources of supplementary committions materials (SCMs) to augment the portland cement, fly sah, slag ement, and slick fume used in modern concrete mixtures, tensive research and testing have shown that several types ground plass will perform well as a pozzolan in concrete. popted by those results, ASTM subcommittee C00 24, plementary Cementitions Materials, has drafted ASTM 66/C1866M-20, "Standard Specification for Ground-Pozzolan for Use in Concrete," "The new Specification ublished earlier this year, after 3-1/2 years of balloting committee. This article provides much of the bund information and industry context that anied the balloting.

clion moduction is a major source of preenhouse pases vehing can reduce the environmental impact,¹ toos (7.6 million tonnes) of container glass is amally in the United States (almost triple the is receyted).² A significant resource is therefore led A preliminary, third-party life-yete one promod-plans, pozzolan (GGP) producer's es that the global warming potential (GWP) 10.09 toons) of GGP is 56 (20 23 lb) CO₂, the U.S. industry average GWP for portland to U.S. industry average GWP for potential to CO₂.

York City project concrete mixture with 50% excement with GGP would be about 40% less than GWP for a concrete mixture with cement only.

Glass Sources and Chemistry

- Much of the glass produced in the world is one of the following types. • Container glass (used in packaging)—This material is
- Container glass (used in packaging) This material is
- 24 NOVEMBER 2020 | CI | www.concreteinternational.com

generally soda-lime glass produced in flint (clear), green, blue, or amber colors and formed by air pressure in molds,

- Plate glass (used as glazing in buildings and automobiles)—This material is also generally soda-lime glass produced in clear or tinted colors and formed by floating on mollen tm, or
- E glass (used as reinforcement in fiber reinforced polymers)—This material is low alkali glass formed by extrusion through a bushing to form filaments that are rapidly drawn to a fine diameter before solidifying.

Table 1 summarzes the chemistry of these glass (ppes and other pozolanic or cementious materials used in concrete, and Fig. 1 contextualizes GGP versus ordinary portland cement (OPC) and other SCMs. Although the chemistry of E-glass is quite different from the chemistry of container or plate glass, all three glass types have been shown to be suitable for use as a pozzolan m portland cement concrete. Also, because of the controlled processes used to manufacture these glass types, each has a very uniform chemistry worldwide, as demonstrated by the standard deviation reported in Table 2 for container plates chemistry

The subcommittee members agreed that the three glass sources listed in ASTM C1866/C1866M are produced in sufficient quantities to provide viable resources for concrete production. The subcommittee also agreed that ground plass could be used acfely (Glass production is regulated to limit toxic materials content, and the glasses listed in the standard are not included on the U.S. Environmental Protection Agency (EPA) Resource Conservation and Recovery Act (RCRA) lists of hazardous wastes.⁵ Purther, the glass pozzolan sources are composed of amorphous silica lunike crystalline silica, amorphous silica has not been found to produce cancer in lung tissue.¹¹ However, as with all nonhazardous dusts, the U.S. Occupational Safety and Health Administration (OSHA) provides permissible exposure levels (PEL) for amorphous

Pozzotive® GGP used across a wide range of applications



pozzotive

Local Glass Back To Local, Low Carbon Projects





Select flagship applications of a Ground Glass Pozzolan



Construction 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 CO₂ savings** 57 tons Construction 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 CO₂ savings 998 tons

Construction New headquarters for JPMorgan Chase – 270 Park Ave, New York, NY Application 40%+ GGP replacement in building floor slabs and CMU specified by Severerud Associates GGP utilized 5,375 tons Total CO₂ savings 5,106 tons Construction Halletts Point + Halletts Point 20-30 Application 50% GGP replacement in structural concrete specified by Severerud Associates GGP utilized 7,000 tons Total CO₂ savings 6,650 tons

Providing Low Carbon Concrete Solutions Nationally





Why GGP Pozzolans Now?

What Can You Do?



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



Contributing broadly to Envision & LEED certification



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:

- Help solve the challenges of waste glass;
- Significantly reduce the carbon footprint of concrete while enhance its performance
- Extend the life of our nation's infrastructure.



Thank you!





Patrick A. Grasso pgrasso@urbanminingind.com

Urban Mining Industries (917) 515-5751 www.pozzotive.com

TJ Oneglia tjoneglia@ogind.com

> O&G Industries (860) 489-9261 www.ogind.com



