ASTM Adds New Glass Pozzolan Standard ASTM C1866

Designation C1866/C1866M-20

Link to ASTM C1866 Standard Specification for Ground Glass Pozzolan

VitroMinerals
Glass Pozzolans & Additives

ASTM has established a new standard for glass pozzolans. ASTM C1866/C1866M-20, effective March 1, 2020.

The glass pozzolan standard references two chemistries of glass; Type GS, which includes container and plate glass; and Type GE, known as VCAS which is E Glass powder derived from fiberglass reinforcements. The glass pozzolans must be powder finer than 95% passing 325 mesh (44 microns). As such, glass powder pozzolans have a d50 particle size of 10-15 microns and a Blaine fineness of 4000 or finer. The primary difference between the two glass chemistries is alkali content; wherein container and plate glass Type GS have 13% Na2O, and Type GE has less than 1%. In practice, Type GE will mitigate ASR, while Type GS is more suited for indoor locations and non-reactive aggregates.

Table 1 shows the chemistry of the glass pozzolans as compared to other common SCMs (Supplementary Cementitious Materials) like Class F Fly Ash, Blast Furnace Slag, Metakaolin.

TABLE 1: Glass Pozzolan/SCM Chemistry

Typical composition of Type GS/GE glass types alongside common SCMs used in concrete

	Weight Percent					
	Type GS Soda Lime		Type GE	ASTM Specified Materials		
Element Oxide	Bottle Glass	Plate Glass	E Glass	Class F Fly Ash	Slag Cement	Metakaolin
SiO2	71.0	71.2	59.9	50-60	39.4	51-53
Al2O3	1.82	0.36	12.5	25-35	9.1	42-44
FE2O3	0.61	0.44	0.37	5-10	0.32	0.52
CaO	10.9	9.33	21.4	1-12	38.7	<0.5
MgO	0.94	3.86	2.91	1-3	11.9	<0.5
Na2O	13.0	13.2	0.77	0.2-1.0	0.29	<0.1
K2O	0.52	0.04	0.06	1-3	0.63	<0.5
SO3	<0.1	<0.1	<0.1	0.1-1.0	2	<0.5
LOI	<0.5	<0.1	<0.1	0.5-5	<0.01	0.7
Organic Content, Max %	0.5*	0	0	6.0**	0	0

*Label Remnants

**Fly Ash Carbon

Vitro Minerals Glass Pozzolans

Container Glass, Type GS

There are approximately 9 million tons per year of container glass produced in the USA, mostly in the traditional colors of amber, clear, and green glass. Perhaps 30% of container glass is recycled via curbside pick-up or drop-off sites. The container glass recycled goes into new bottles or into home insulation products.

Plate Glass, Type GS

There are approximately 6 million tons per year of plate glass produced in the USA. Plate glass is clear or tinted flat glass used for windows or auto windshields. Plate glass scrap is mostly recycled back into new plate, traffic beads, insulation, and fine white powders and sands used in a variety of applications.

E Glass, Type GE

There are approximately 1 million tons of E glass manufactured for use in fiberglass reinforcements. E glass factories generate waste during manufacture and that waste serves as feedstock for E glass powder. E glass is low alkali 100% glass and is very effective for ASR mitigation.

Nanosilica HR50

Nanosilica HR50 is a new concrete additive especially useful for UHPC and Ductal Concrete.™

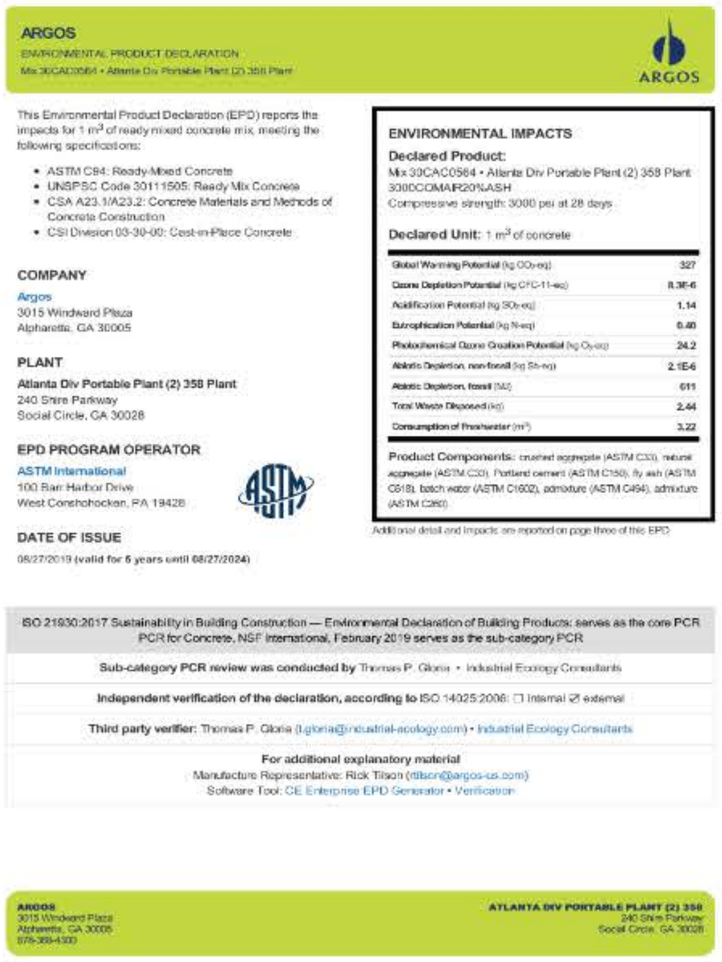
At 100 GE Brightness, it is the whitest concrete pozzolanic additive available, and is somewhat more reactive than silica fume. While HR 50 is not a part of the new ASTM C1866 glass pozzolan standard, it exceeds all the performance criteria for the ASTM C1240 silica fume standard. HR 50 Nanosilica offers high early strength and requires the same water-reducing admixtures as silica fume. It can be blended with other ASTM C1866 glass pozzolans to increase one and three-day strengths as well as increase durability for Type GS pozzolans. Performance data for HR 50 and glass is shown in figure 3.

Pozzolan Color Effects

The HR 50 Nanosilica, Type GE VCAS Pozzolan, and Type GS plate glass pozzolan all have color whiter than white Portland cement. As such, they can be widely used in Architectural Precast, GFRC, Pool Plaster, and mixed with color Pigments to enhance colorfastness.

Reagan Place,
Parkland Texas
Made with VCAS 160

TechnicalSales@VitroMinerals.com
www.VitroMinerals.com



ARGOS
ENVIRONMENTAL PRODUCT DECLARATION
Mix 30CAC0564 • Atlanta Div Portable Plant (2) 358 Plant

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

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

COMPANY
Argos
3015 Windward Plaza
Alpharetta, GA 30005

PLANT
Atlanta Div Portable Plant (2) 358 Plant
240 Shire Parkway
Social Circle, GA 30026

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

DATE OF ISSUE
08/27/2019 (valid for 5 years until 08/27/2024)

ENVIRONMENTAL IMPACTS

Declared Product:
Mix 30CAC0564 • Atlanta Div Portable Plant (2) 358 Plant
30IDCOMAR20%ASH
Compressive strength: 3000 psi at 28 days

Declared Unit: 1 m³ of concrete

Global Warming Potential (kg CO_2-eq)	327
Ozone Depletion Potential (kg CFC-11-eq)	8.3E-6
Acidification Potential (kg SO_2-eq)	1.14
Eutrophication Potential (kg N-eq)	0.40
Photochemical Ozone Creation Potential (kg O_3-eq)	24.2
Abiotic Depletion, non-fossil (kg Sb-eq)	2.1E-6
Abiotic Depletion, fossil (MJ)	611
Total Waste Disposed (kg)	2.44
Consumption of Freshwater (m^3)	3.22

Product Components: crushed aggregate (ASTM C33), natural aggregate (ASTM C33), Portland cement (ASTM C150), fly ash (ASTM C618), batch water (ASTM C1602), admixture (ASTM C494), admixture (ASTM C260)

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

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

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

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

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

For additional explanatory material
Manufacture Representative: Rick Tilson (rtilson@argos-us.com)
Software Tool: CE Enterprise EPD Generator • Verification

Environmental Product Declarations

The largest environmental impact of using pozzolans is to replace 15-30% of cement powder in the mix design, which reduces GHG. What is required is a third party certified Life Cycle Analysis, LCA, and an EPD, Environmental Product Declaration. Cement manufacture releases 0.88 tons of CO2 into the atmosphere per ton of cement produced. Type GE and Type GS glass pozzolans are diverted from landfill streams and will have a large impact on CO2 emissions for concrete parts using ASTM C1866 glass pozzolans in the mix design.

Pozzolans

A pozzolan is defined as a material that is not cementitious when mixed with water but when added to cement powder and water reacts with the lime (CaOH) generated to form additional cement binder (Calcium Alumino Silicate Hydrate). A pozzolan is amorphous (non-crystalline in glass form). True pozzolans that meet the definition are glass, metakaolin, silica fume, and some Types of Class F Fly Ash.

Other SCMs have pozzolanic reactions but are weakly cementitious due to their calcium content. These include some Class F Fly Ashes, C Ash, and GGBFS (blast furnace slag). As such, they are highly valuable components of concrete mix designs worldwide.

Another rapidly growing concrete component is natural pozzolans, primarily glassy components derived from volcanic ash. These include pumices, volcanic tuffs, and related minerals.

VCAS in Swimming Pools

Glass Pozzolan Performance

Over the years, and during the development of the new ASTM C1866 glass pozzolan standard, a substantial amount of concrete performance data has been developed by many researchers, and that data is attached below. The full description of the ASTM and AASHTO tests is in the Appendix.

ASR (Alkali Silica Reaction)

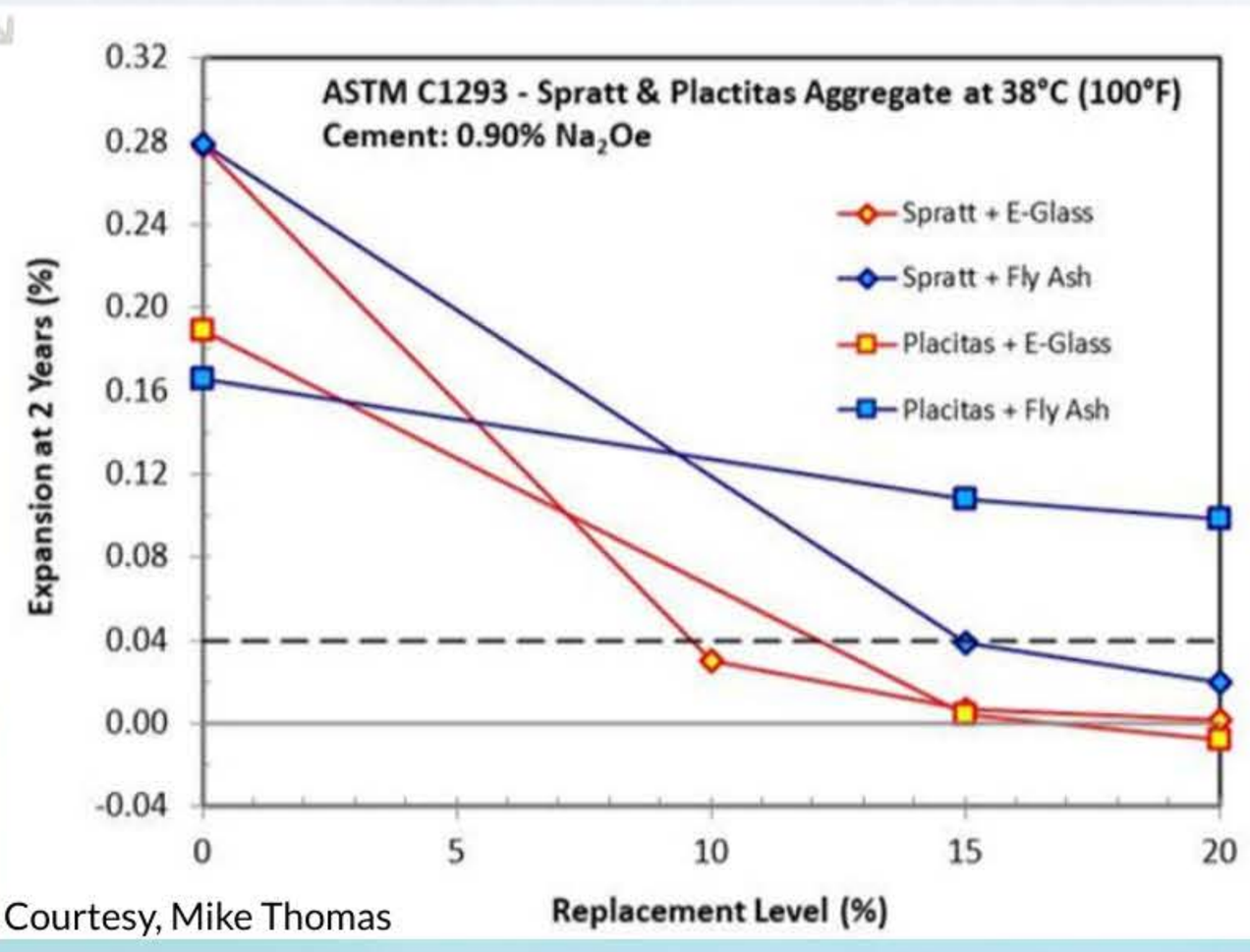
ASR is an expansive reaction in concrete caused by alkali attack on reactive aggregates, forming an expansive gel. The primary drivers for use of Class F Fly Ash in concrete have been cost reduction and mitigation of ASR. As fly ash production decreases, the limited availability will drive the price up, plus available ash will require more processing and have higher logistics costs to get to the use location.

Therefore, in some areas, local DOT and other ASR sensitive users will require replacements.

ASR Testing is governed by ASTM C1778 which is constantly evolving to accommodate new pozzolans. For high alkali pozzolans (>4.5%) such as Type GS glass, ASTM C1293 testing is required. For low alkali pozzolans such as Type GE e glass, ASTM C1567 testing can be used.

ASTM C441 and AASHTO TP110 are also excellent screening tests.

Container and plate glass pozzolans, Type GS, do not cause ASR nor do they fully mitigate ASR. When used, Type GS pozzolans can reduce ASR, but still not pass ASTM C1293 for reactive aggregates. Type GE glass pozzolans effectively remediate ASR better than Class F Fly Ash. As an example, Type GE cement replacement of 10% will mitigate Spratt aggregate, and 15% Placitas aggregate.



Courtesy, Mike Thomas

Frequently Asked Questions

Q. How pure are glass pozzolans?
A. The standard calls for >99.5% purity.

Q. What cement replacements are used?
A. 10-40%

Q. What is the water demand for glass pozzolans?
A. Neutral as compared to cement powder.

Q. Do glass pozzolans mitigate ASR?
A. Type GE mitigates ASR at quite low cement replacement rates (10-12% for Spratt aggregates, 14-17% for New Mexico aggregates) Type GS glass does not fully mitigate ASR.

Q. Do glass pozzolans meet ASTM C618 standards for strength development at 7 and 28 days?
A. Glass pozzolans usually reach 80 and 90% of control at 7 and 28 days.

Q. How long have glass pozzolans been used in Concrete?
A. While Type GS glass pozzolans have been used mostly in small demonstration pours over the past 2-4 years, Type GE glass pozzolans have been widely used in Swimming Pools, Architectural Precast, Decorative Concretes, GFRC, and Pigmented Grouts and Mortars for about 15 years.

Q. Why do pigmented concrete surfaces maintain brighter colors with Type GE glass pozzolans?
A. Color fading is mostly an efflorescence phenomena and Type GE glass pozzolans reduce efflorescence and concrete permeability.

Q. What is the color impact of glass pozzolans?
A. Type GE and GS(plate) are as white as white cement. Type GS (container) is tan.

Q. Where can we get a sample?
A. Go to VitroMinerals.com, click on order samples, Vitro Minerals Online Store.

Q. Is there application data and more tech data available?
A. Go to VitroMinerals.com, click on Products, click on VCAS Type GE pozzolans page.

Q. Is there LCA/EPD data available, or specific additional questions about glass pozzolans?
A. Yes, go to VitroMinerals.com, click on Contact Us, and leave a short message. You will be contacted within 48 hours.

Q. Is there any downside to using VCAS Glass Pozzolans?
A. In every instance, the concrete will be stronger, denser, whiter, more colorfast, protected from ASR, and have less embodied carbon than concrete without VCAS.

Glass Pozzolan Technical Data, Introduction

Extensive test data has been generated for glass pozzolan performance required by the ASTM C1866 Standard.

First, the chemistry of glass pozzolans is very consistent across North America and the pozzolans are required to be 99.5% pure glass. Given that exceptional consistency, the focus of the test data is to compare the two classifications of glass with each other and fly ash; to determine the effect of pozzolan particle size on performance, and to determine the optimum cement replacement levels.

The durability data is based on Spratt and Placitas aggregates over a wide spectrum of test methods, including ASTM C1293, ASTM C441, and AASHTO TP110.

Further, test data on chloride ion permeability and sulfate resistance is included.

Strength Activity Index (SAI) of Glass Pozzolans

A historical measure of pozzolan reactivity has been the strength activity index (SAI). This test measures whether the pozzolan adds compressive strength to the concrete compound versus a control mix design without the pozzolan.

At ASTM, there are efforts underway to replace this test with other indicia, such as calcium hydroxide content, LOI, resistivity, and others, so the measurement of pozzolanic reaction is evolving.

The new ASTM standard for glass pozzolans calls for an SAI of 75% of control at 7 days and 85% of control at 28 days. The ASTM C618 standard for fly ash and natural pozzolans calls for 75% of control at 7 days or 75 % of control at 28 days, a much lower standard than glass.

Figure 1

Type GE Glass: Strength development and strength activity index (SAI) for different finenesses (d50 3-8 µm)

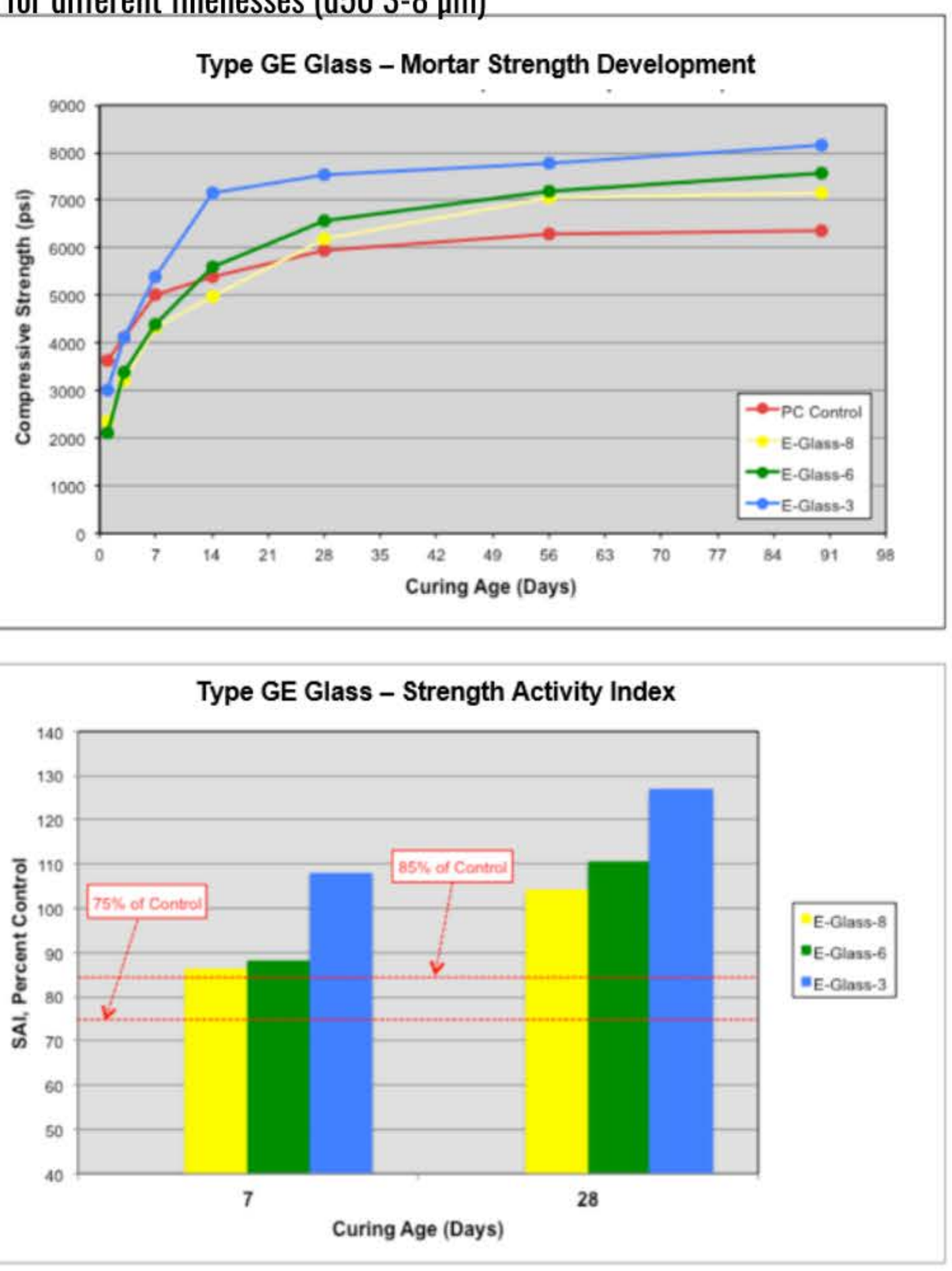
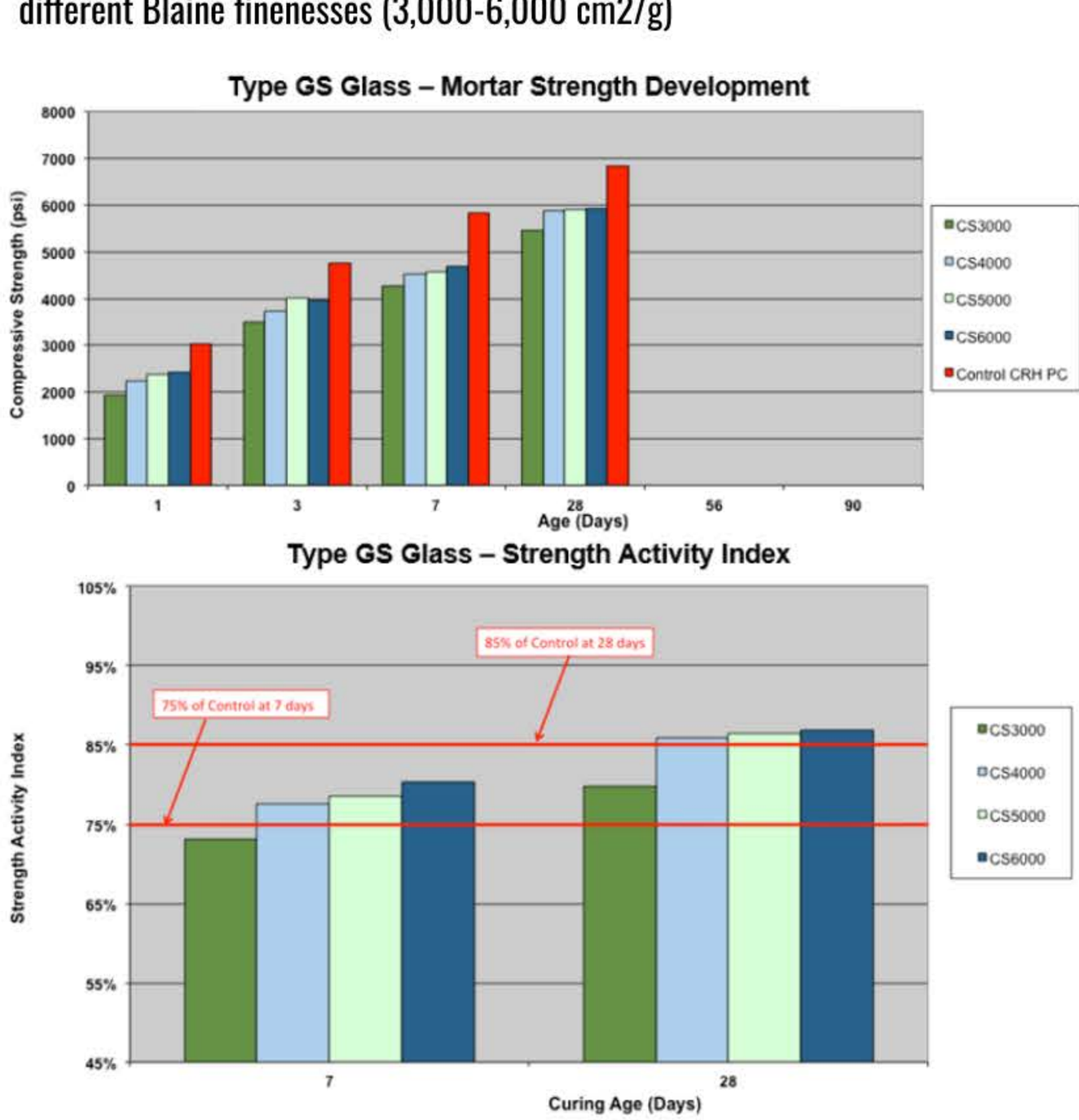


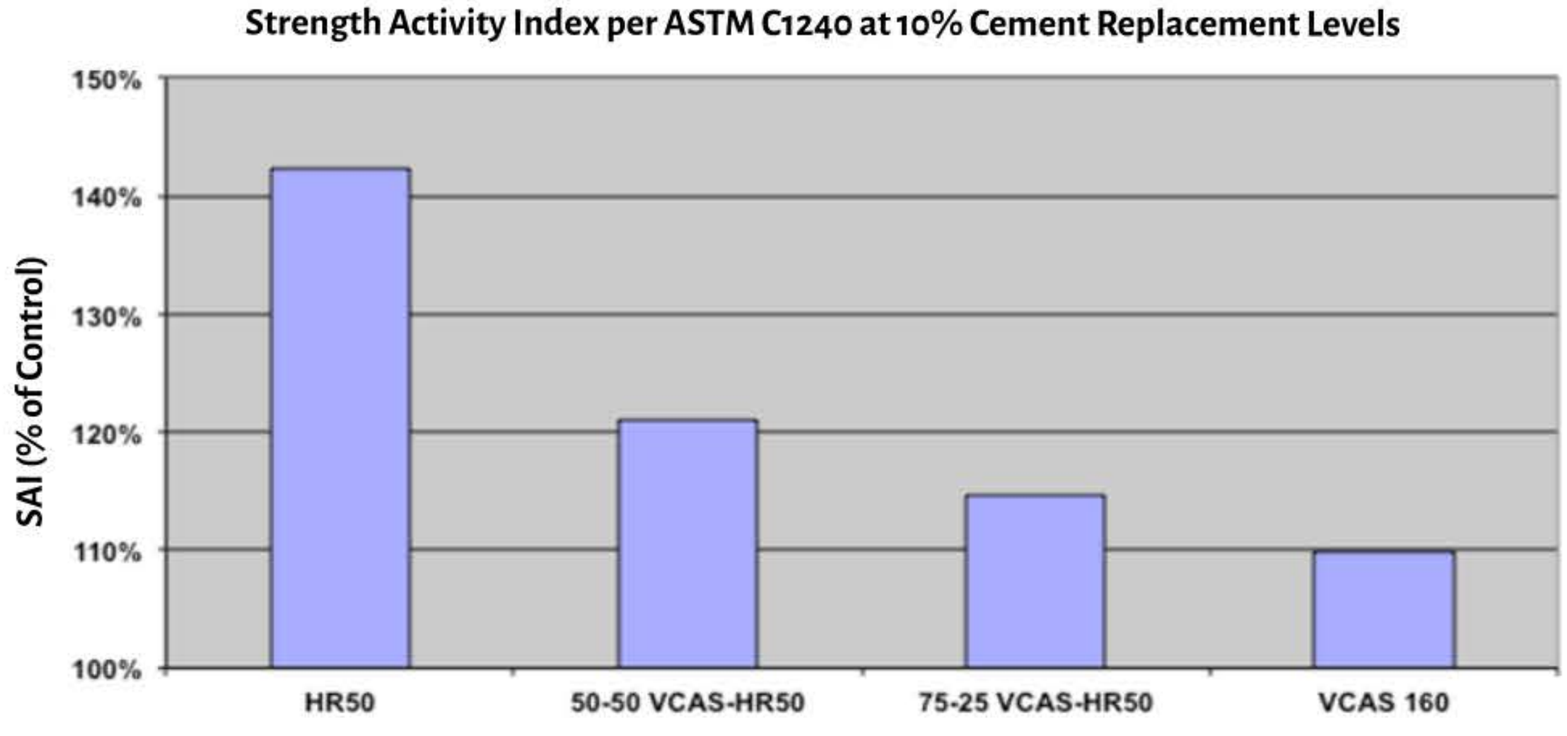
Figure 2

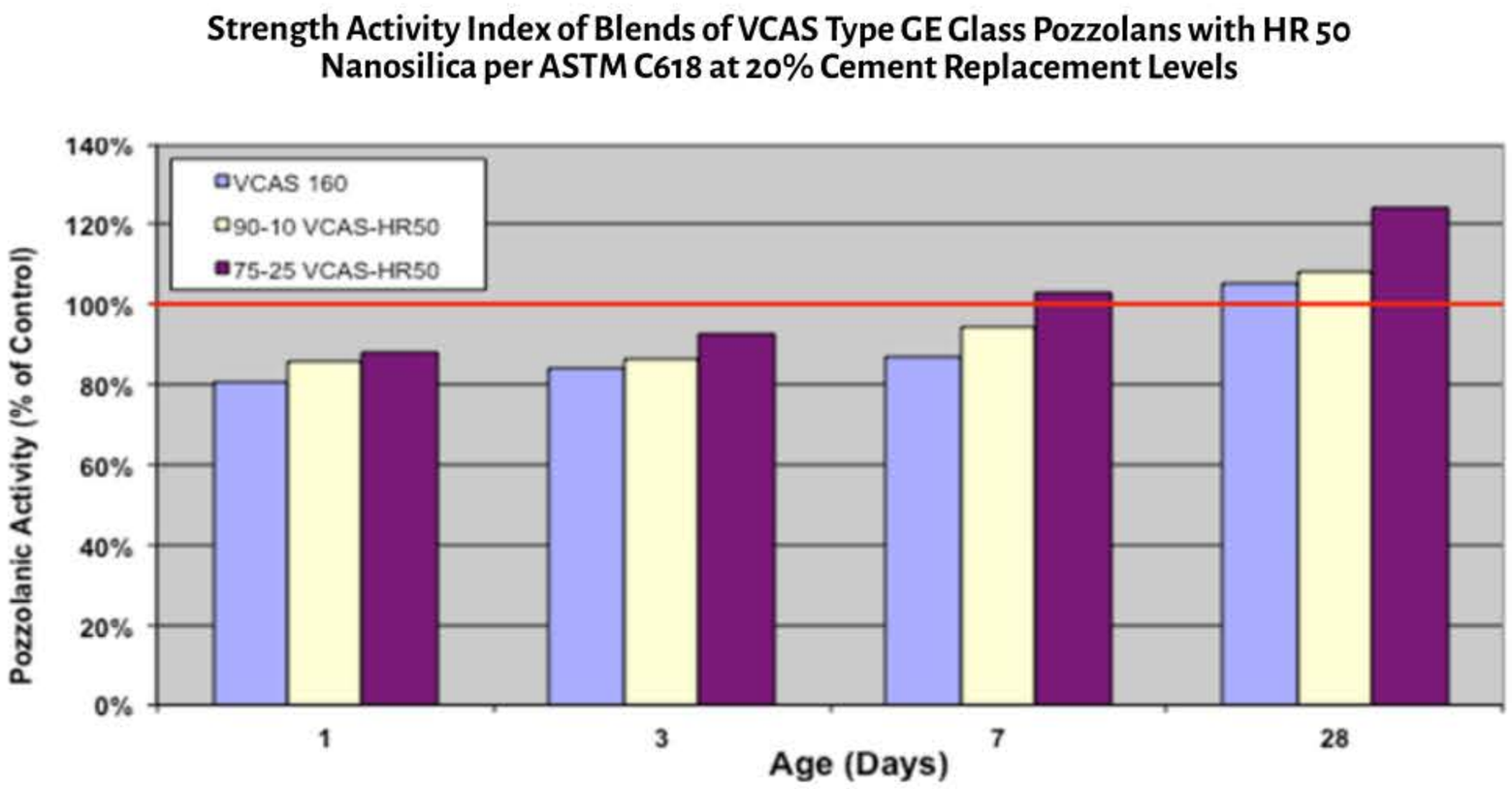
Type GS Glass: Strength development and strength activity index (SAI) for different Blaine finenesses (3,000-6,000 cm2/g)



Both Type GE and GS pozzolans show excellent pozzolanic properties.
The main differences are ASR mitigation and impact on concrete color.

Figure 3 Strength Development- HR50 Nanosilica Blended with Type GE Glass Pozzolans



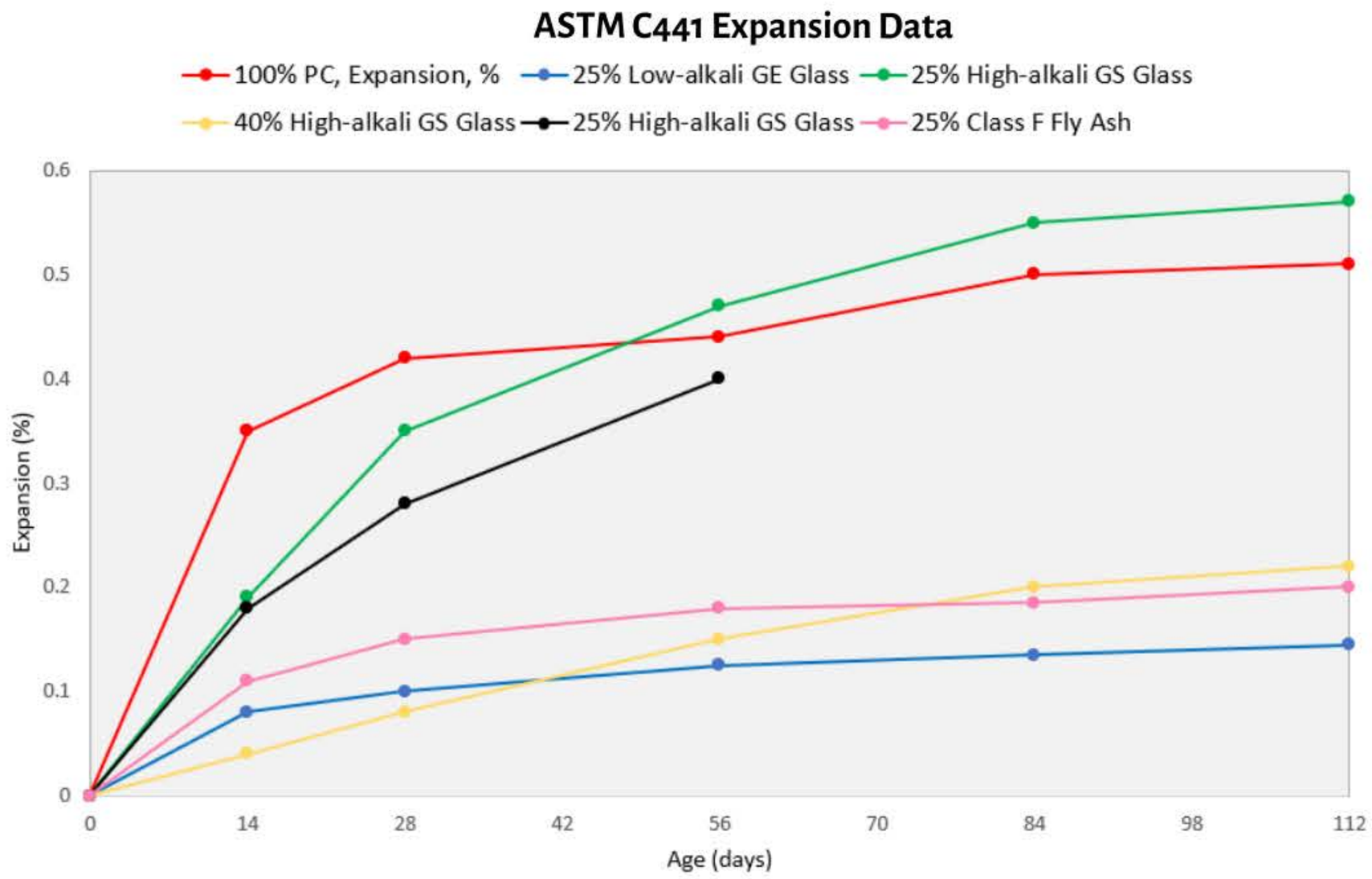


Different blend ratios of HR 50 Nanosilica and Type GE pozzolans all show greater than 110% strength activity index when tested according to ASTM C1240, the silica fume standard at 10% cement replacement.

Early strength can be enhanced by blending VCAS Type GE pozzolans with Nanosilica.

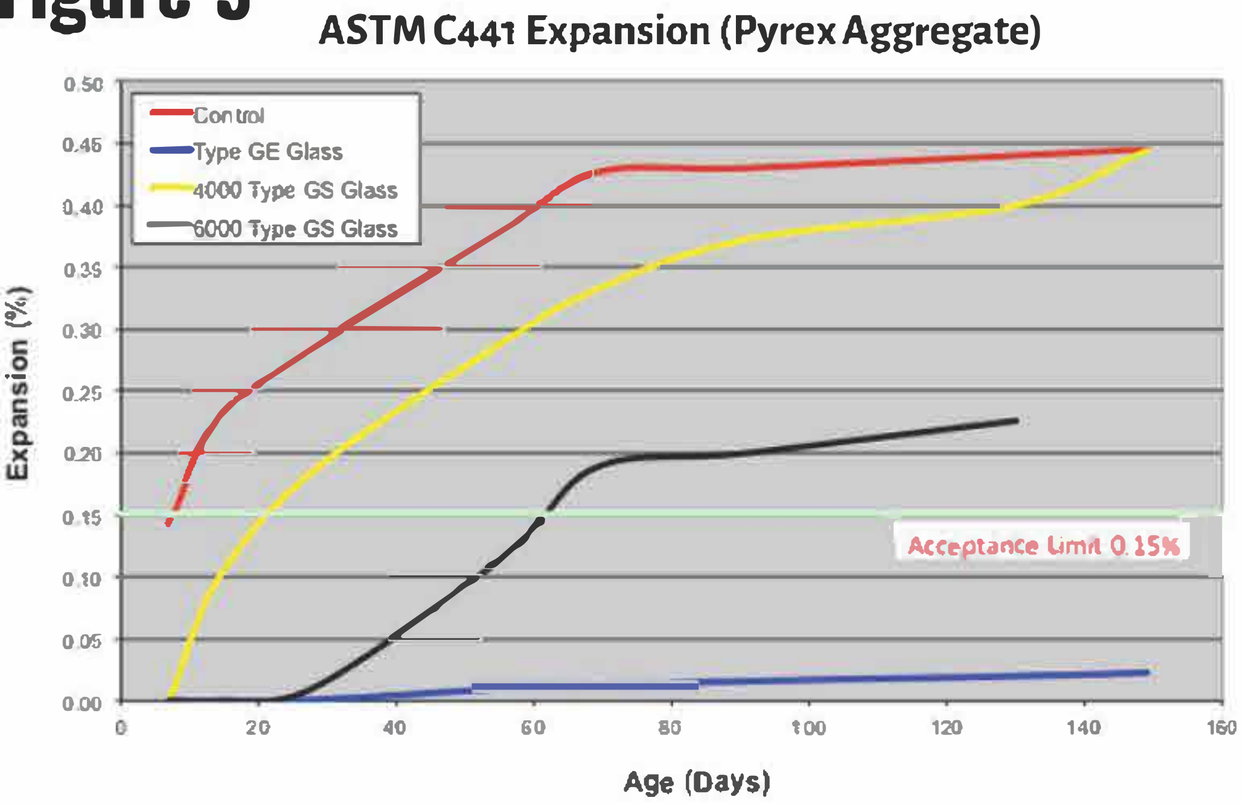
Figure 4

Expansion data for ground pozzolans, Type GS (High Alkali) vs. Type GE (Low Alkali) vs. Class F Fly Ash. Courtesy of Mahipal 2019.



ASTM C441 is an excellent screening tool to determine how different types of pozzolans and dosages will affect expansion in concrete. Type GS pozzolans have minimal impact on reducing expansion caused by reactive aggregates. Type GE VCAS pozzolans effectively mitigate ASR from any reactive aggregate.

Figure 5



Comparison of ASTM C441 expansion data for mortars prepared with Pyrex aggregate and 20% cement replacement with glass pozzolans: Type GE Glass; Type GS Glass (4,000 cm2/g); and Type GS Glass (6,000 cm2/g). Finer particle sizes are more effective at reducing expansion.

Figure 6

Influence of Type GE Pozzolans Dosage on Concrete Prism Expansion Containing Reactive Spratt Gravel Aggregate in CPT (ASTM C1293). Courtesy of Thomas et al.

ASTM C1293 is a standard test to measure expansion in concrete prisms. Comparisons of GE Glass, GS Glass, and Fly Ash cement replacement are consistent with ASTM C441 data. Type GE glass is very effective for ASR mitigation.

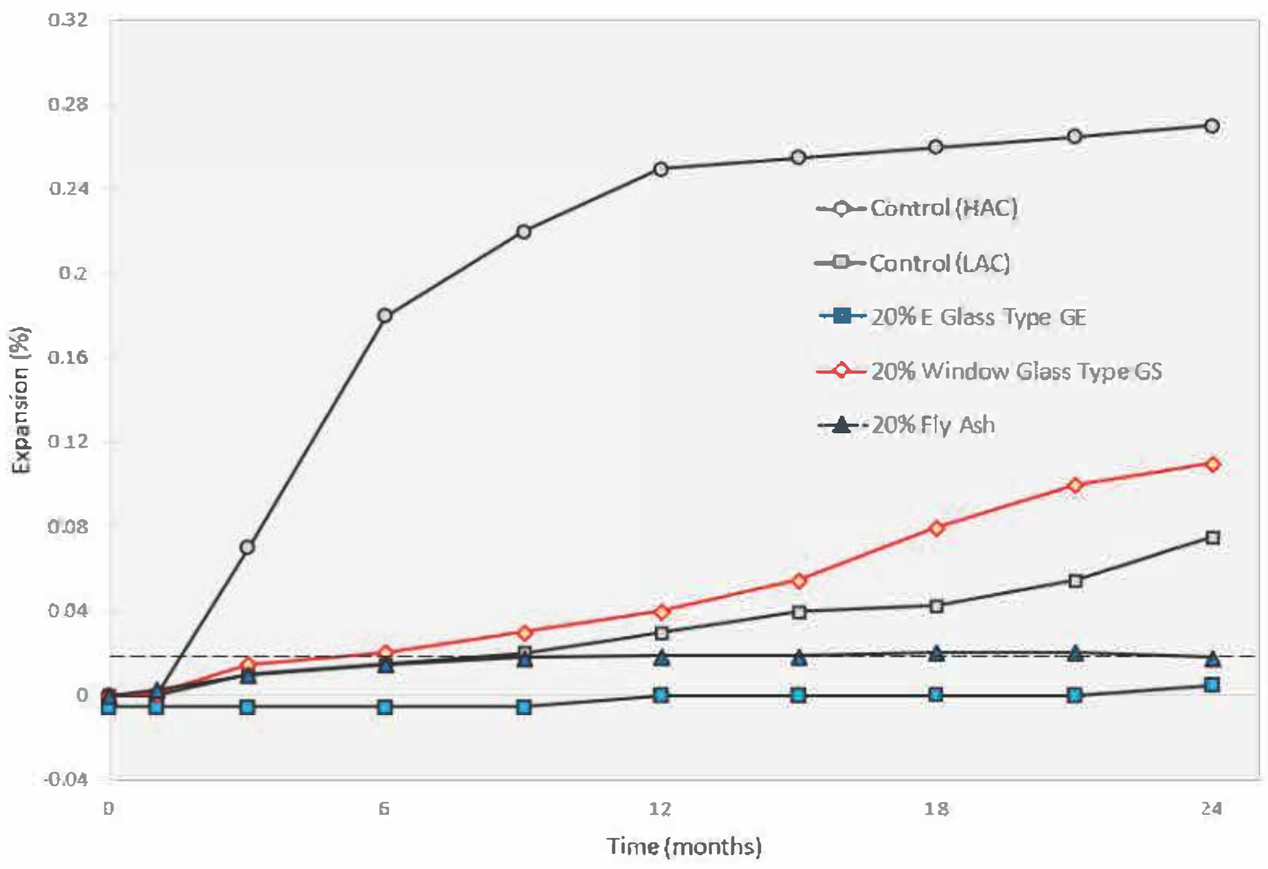
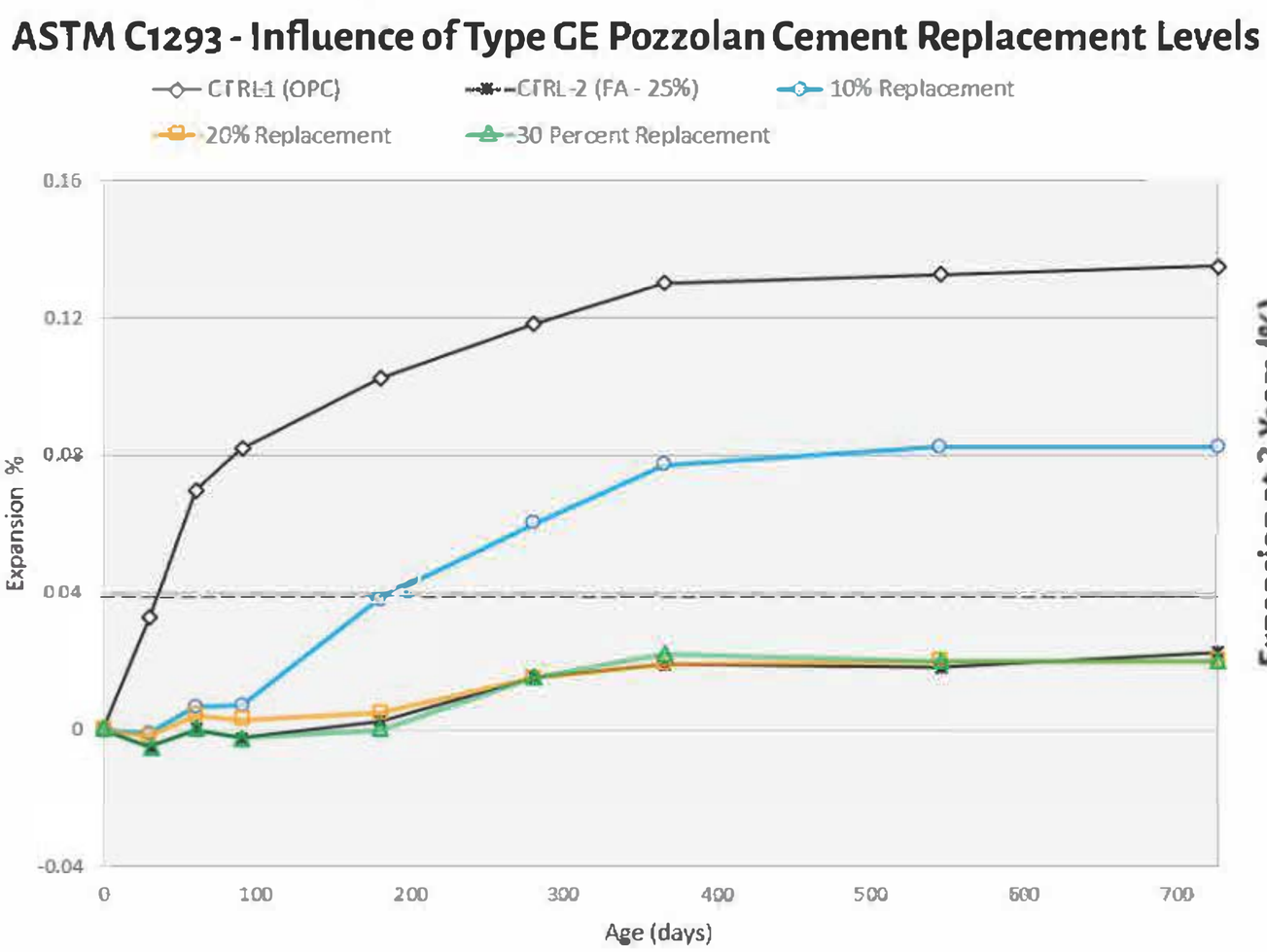


Figure 7

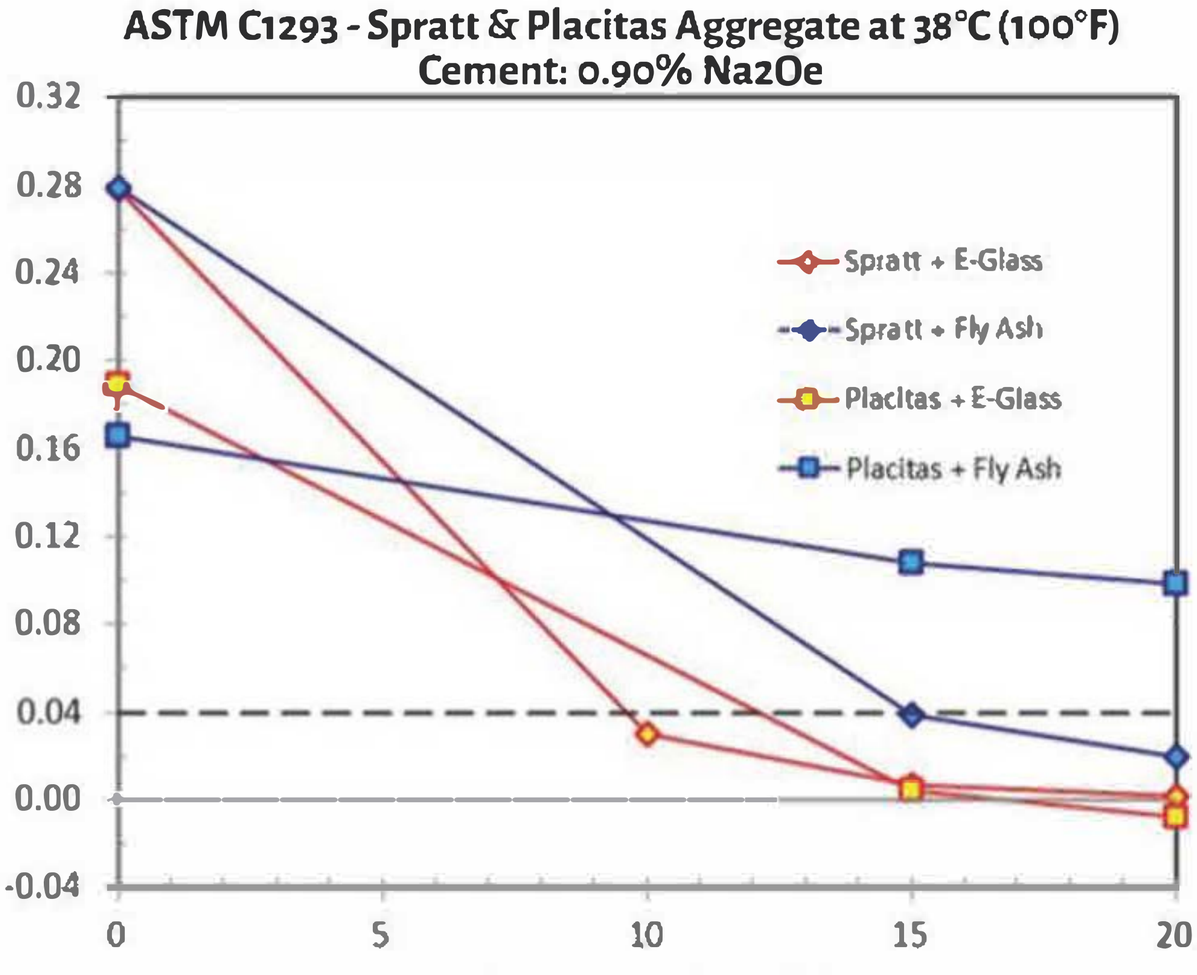
Influence of Type GE Pozzolans Dosage on Concrete Prism Expansion Containing Reactive Las Placitas Gravel Aggregate in CPT (ASTM C1293). Courtesy, Rangaraju et al, Clemson.



[Type GE Pozzolan Properties: LOI – 1%; Avg. Dia. 4 microns; Sp. G = 2.60; Blaine Fineness = 10,200 cm2/g]

Figure 8

ASR mitigation data on cement replacement levels needed for Spratt and New Mexico aggregates. Courtesy Mike Thomas.

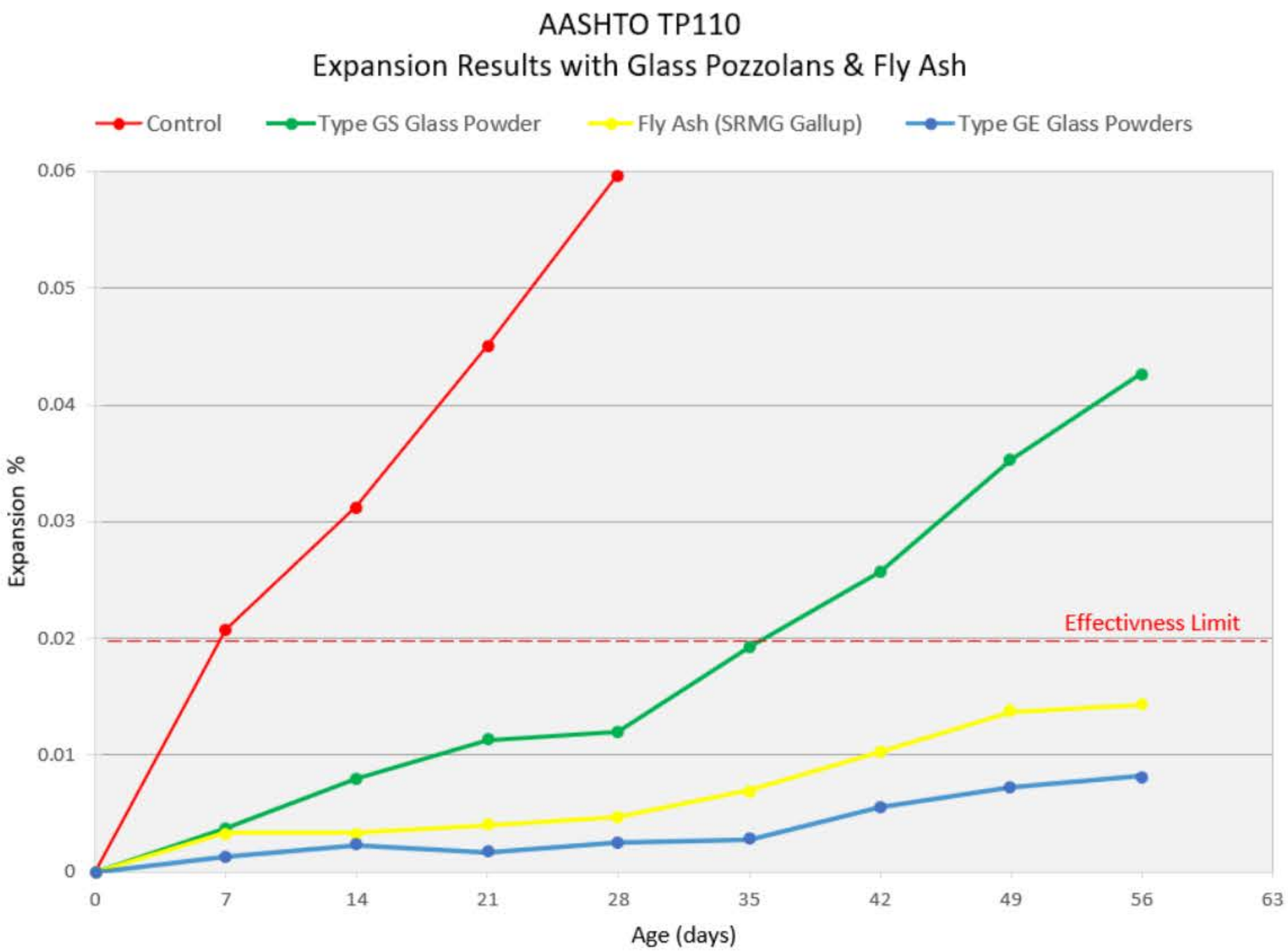


Depending on the reactive aggregate, various cement replacement levels of Type GE glass pozzolans are required.

In all cases, Type GE pozzolans can mitigate ASR at lower replacement ratios than Fly Ash.

Figure 9

Comparison of ASR mitigation using AASHTO TP110 Concrete Prism test with New Mexico aggregates. Type GE pozzolans and fly ash both successfully mitigate ASR at 25% cement replacement, whereas Type GS glass pozzolans do not adequately mitigate ASR. Courtesy AMEC Foster Wheeler/Hemmings.



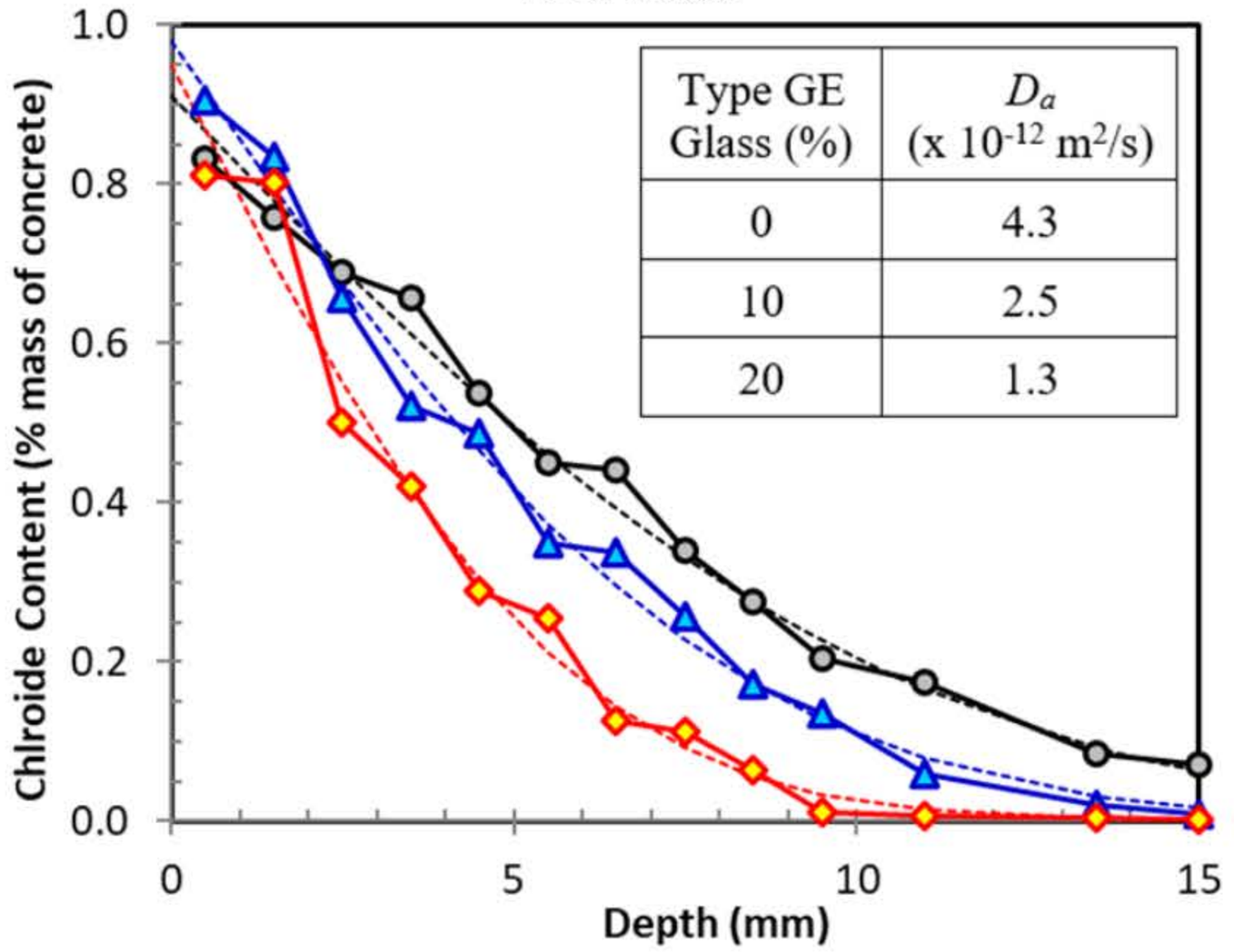
The ASTM C1293 test takes two years to render a result, so we have found that AASHTO TP110, which is a concrete prism test, takes 60 days and is a good proxy. Also, ASTM C441 has always been an excellent screening test for the efficacy of pozzolans to prevent expansion in reactive borosilicate glass (Pyrex).

Figure 10

Rapid Chloride Permeability (ASTM C1202)

Age (Days)	Control	Coulombs 80:20 VCAS
28	>6000	1600
56	9300	920
150	7500	400

Charge Passed	Chloride Ion Penetrability
>4000	High
2000-4000	Moderate
1000-2000	Low
100-1000	Very Low
<100	Negligible

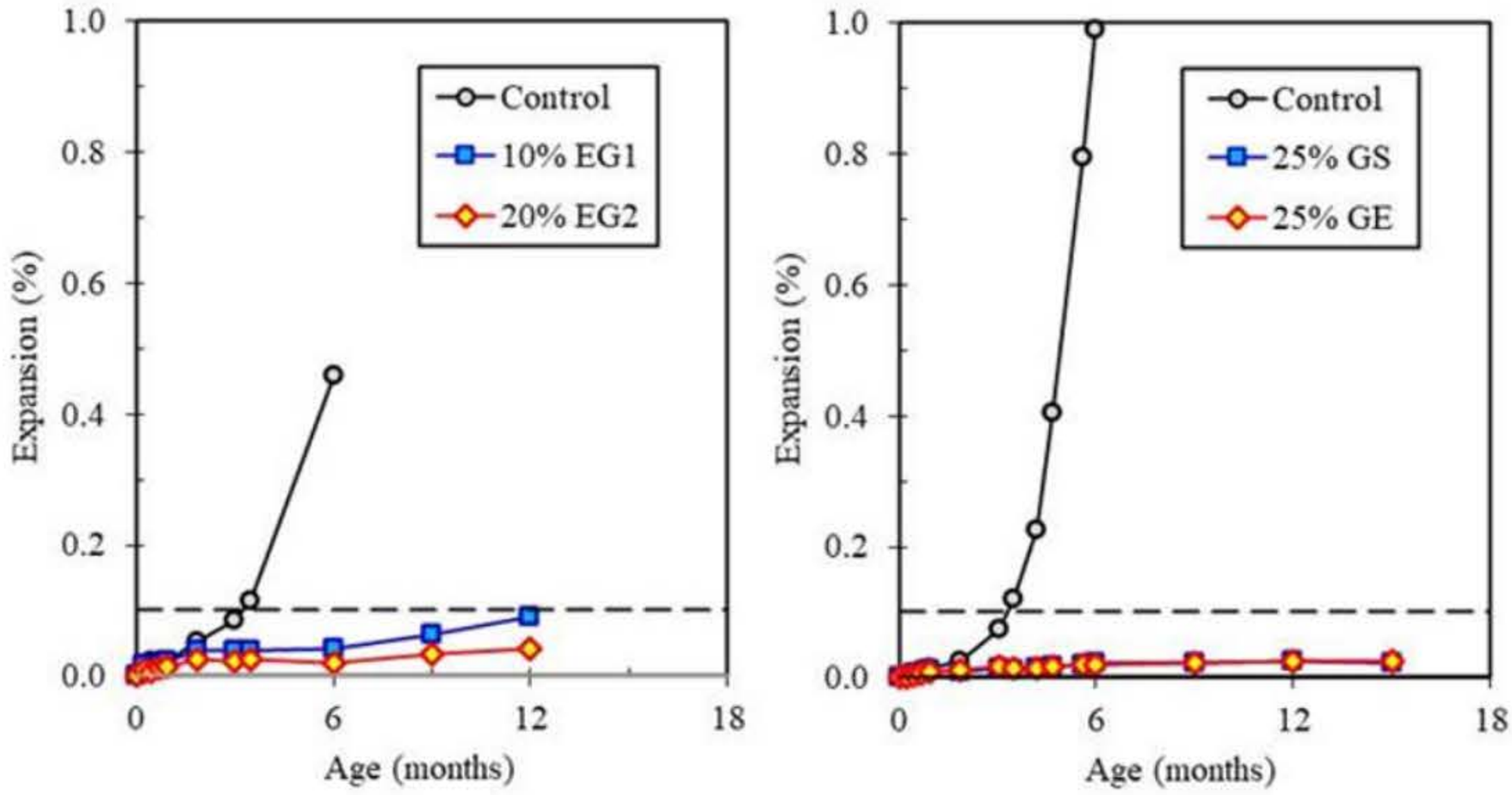


Glass pozzolans are quite effective at significantly reducing chloride ion permeability. The left graph shows ASTM C1202 at 20% cement replacement. The graph on the right indicates that Type GE pozzolans, when tested with ASTM C1556, the Chloride Diffusion test, are extremely effective at cement replacements of 10%, and that 20% replacement almost completely stops chloride diffusion at depth. As a practical matter, time to corrosion of embedded steel rebar is increased 2-3 times by the use of Type GE Glass. Courtesy Thomas and Hemmings.

Figure 11

Improved Sulfate Resistance

Evaluation of sulfate resistance testing for Type GS and Type GE Glass Pozzolans per ASTM C1012. Courtesy Mike Thomas.



The results from testing (ASTM C1012) to evaluate sulfate resistance are shown in Figures 11 for two separate studies.

The first of these studies, on the left, was concerned with the use of ground E-glass, and data are shown for replacement levels of 10% and 20%. Both levels of replacement were successful in reducing the expansion of a high-C3A Portland cement (control mix expansion 0.459% at 6 months) to below the limits for Type HS cement (0.05% at 6 months and 0.10% at 1 year), when blended with a high-C3A Portland cement.

The second study, on the right, was part of a wider study on the use of pozzolans in concrete (Kasaniya, 2019) and the data show the expansion of mortar bars with either 25% ground GS or GE glass, both of which were capable of reducing expansion to acceptable levels (meeting limits for Type HS cement) when blended with a high-C3A cement (control mix expansion 0.99% at 6 months)."

Summary

Both Type GS and GE glass powders are excellent reactive pozzolans contributing to reducing the carbon footprint of concrete structures. Type GS pozzolans can be used indoors and where reactive aggregates are not a consideration. Type GE pozzolans are more effective than fly ash in mitigating ASR with the further advantage of being as white as white cement. Type GE pozzolans are also excellent in preserving colorfastness in pigmented concrete precast, GFRC, and flooring. Nanosilica HR 50 works well in situations where a white, highly reactive replacement for silica fume is required.

Appendix

ASTM C109/C 109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)

ASTM C311/C311M Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete

ASTM C441 Standard Test Method for Effectiveness of Pozzolans or Ground Blast Furnace Slag in Preventing Excessive Expansion of Concrete due to Alkali-Silica Reaction.

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

ASTM C1012 Standard Test Method for Length Change of Hydraulic Cement Mortars Exposed to a Sulfate Solution

ASTM C1069 Test Method for Specific Surface Area of Alumina or Quartz by Nitrogen Adsorption

ASTM C1202 Standard Test Method for Electric Indication of Concrete's Ability to Resist Chloride Penetration

ASTM C1240 Standard Specification for Silica Fume Used in Cementitious Mixtures

ASTM C1293 Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction

ASTM C1556 Standard Test Method for Determining the Apparent Chloride Diffusion of Cementitious Mixtures by Bulk Diffusion.

ASTM C1567 Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)

ASTM C1778 Guide for Reducing the Risk of Deleterious Alkali- Aggregate Reaction in Concrete

AASHTO TP110 Standard Method of Test for Potential Alkali Reactivity of Aggregates and Effectiveness of ASR Mitigation Measures (Miniature Concrete Prism Test MCPT)