VITROHUE® Glass Aggregates

Technical Bulletin VH-002:

Using Recycled Glass with Portland Cement

Background

There is considerable interest in the use of recycled glass with portland cement in making a variety of different types of cement products. This interest has been motivated by the large quantity of recycled glass available through municipal recycling programs--which far exceeds the demand for such glass from conventional markets like container manufacturers. If glass could be incorporated in cement products, it would greatly reduce the disposal of recycled glass and/or its use in lower valued markets such as fill and road base material.

Unfortunately soda lime glass is classified as a reactive aggregate in portland cement, and thus requires special types of cement and the use of pozzolans to suppress the alkali-silica reactivity (ASR). Considerable research has been done on this problem as summarized by Diamond, 1992 and Stark, et.al. 1993. In 1997 and 1998, the process of using recycled glass for concrete masonry blocks and precast concrete was refined in work sponsored by The New York State Energy Research and Development Authority (NYSERDA).

Today, a variety of approaches have been developed to deal with the ASR problem, and considerable development work is being done worldwide to incorporate recycled glass into concrete products.

This bulletin will attempt to summarize some of these methods and recommend procedures that can be used to make stable mixtures of glass and portland cement.

Alkali-Silica Reactivity

Glass is normally unstable in the alkaline environment of concrete, resulting in the formation of gels that expand and weaken the cement-aggregate bond. Unless appropriate precautions are taken to minimize the chemical reaction between the silica-rich aggregate and the cement, the concrete may become unstable.

Such preventative actions may be achieved by the addition of pozzolonic material such as fly ash, silica fume, ground blast furnace slag, or ground recycled glass into the concrete mix in appropriate proportions. Certain chemicals such as Li oxides and hydroxides added to the concrete have also been found to minimize the ASR; however, the cost of these chemicals is relatively high compared to pozzolonic materials.

The reports of NYSERDA in 1997 & 1998 and Stark, et.al. in 1993 describe extensive tests with pozzolonics and lithium additives to glass-concrete mixtures. Shayan, 2002 has tested pozzolonic additions to glass-concrete mixtures and found that certain mixtures of fine ground glass, fly ash and glass powder added in the right proportions can effectively minimize the ASR. His work shows that excellent strengths can be achieved in reasonable setting times, but no work has been done on freeze thawing of the glass-concrete mixtures.

These studies indicate that with the proper additions of glass and other additives, glass can be added to concrete mixtures that will give satisfactory results for at least certain types of concrete products.

Much more experimentation would need to be done to establish a high degree of credibility of glass-concrete mixtures in structural applications and indeed that may never be achieved to the satisfaction of building engineers. For a wide variety of concrete products such as concrete pavers, masonry blocks, tiles, counter tops, panels, containers, and statuary, the use of glass should present no structural concerns.

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Glass Concrete Formulations

Based on Shayan's work in 2002, a variety of pozzolonic additives can be added to minimize the ASR in concrete. (Reference is made to a pdf file of Shayan's paper on our web site under Technical Bulletins-Glass Aggregates "Paper").

Not more than 50% of the normal rock aggregate can be replaced with a mixture of coarse and fine glass aggregate. It is this coarse glass aggregate that can react with the cement binder if no precautions are taken.

Up to 25% of the cement binder should be replaced with a pozzolonic material such as fly ash or finely ground glass powder such as bag house dust. The glass powder appears to work equally well as the fly ash, but there are a variety of types of fly ash available. Class F fly ashes are probably more effective than Class C fly ashes, but test work would need to be done to evaluate a specific source of fly ash.

There is little chemical difference between sources of ground glass powder if it is recovered from bag house dust in processing a mixture of type of recycled glass.

Work by NYSERDA 1998 seems to indicate that ground glass powder made from green bottles works best, which is attributed to the chrome content of green glass, but no explanation of this effect is offered.

A typical formulation of glass-concrete is presented in the next column:

Typical Formulation of Glass-Concrete

- Aggregate:75% + Binder:25%
- Glass Aggregates: Coarse + Fine = 25% to 50% of the total aggregate
- Binder: Replace up to 25 % of the binder with Fly Ash or Glass Powder <250 mesh
- Add water as required
- Water reducers or superplasticisers may be added to improve strength if necessary
- Air entrainment is usually required
- Cure times close to maximum strength in 28 days
- PSI strengths of 4,000 to 5,000 achieved @ 28 days

Freeze-Thaw Resistance

At this time there has been no testing of the stability of glass-concrete products in freeze-thaw testing. Until sufficient data is obtained on freeze-thawing, products made with the above formulations should be restricted for use in areas of relatively mild winters. These formulations are to be used as guidelines and users are encouraged to do their own testing and experimentation to achieve results desired. Trivitro Corporation does not warrant that the formulas will work in all applications and users must satisfy themselves with their own testing.

References

Diamond, S. 1992. *Alkali-aggregate reactions in concrete: an annotated bibliography 1939-1991*. Washington, D.C.: National Research Council, Strategic Highway Research Program, SHRP-C/UWP-92-601:470

NYSERDA. *Use of Recycled Glass for Concrete Masonry blocks.* Report 97-15, Nov. 1997

NYSERDA. *Use of Recycled Glass and Fly Ash for Precast Concrete.* Report 98-18, Oct. 1998

Shayan, A. *Value-added Utilisation of Waste Glass in Concrete.* IABSE Symposium Melbourne 2002