

REVIEW ON CRUSHED GLASS FINE AGGREGATE IN CONCRETE

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ABSTRACT

In order to reduce the utilization of land filling among waste management nice emphasis is being placed on waste reduction and utilization. Every year within the India approximately 2.5 Mt of waste glass is made and about half this waste isn't reusable. Thus alternative routes got to be found for using waste glass and one risk is to use it among concrete as a replacement for cement and/or mixture.

In the analysis programme concrete mixes were tested that had third, 25%, five hundredth and 100% of the fine mixture replaced by crushed waste glass. All glass was originally in bottle kind and was crushed to supply 'sand' that had a grading curve more-or-less a twin of fine mixture obtained from a billboard provider. 3 colors of glass were studied, i.e. flint (clear), amber and green. Concretes were conjointly created that contained a combination of colors (in proportion in keeping with the load of every sort of waste glass made annually among the India) and conjointly a combination of unwashed waste glasses. The concrete combine adopted for investigation, i.e. 1:2:4, was selected due to its wide use among business, and every one concrete was created with a water: cement content of 0.6 while not the addition of plasticizer or ASR-retarding agents. The suite of laboratory tests included; slump, flow, initial and final setting time, unbearable pulse rate, water absorption by immersion and capillary action rise, ASR measuring (volumetric and linear), compression strength at ages from seven days to one year.

Techniques of developed digital imaging and process are applied to the glass mixture to quantify numerous particle form factors, i.e. ratio, proportion concavity, Riley inscribed globularness and surface texture index. Applied mathematics analysis has been accustomed compare the distribution of particle forms gift among the fine mixture materials utilized in the experimental work. Dimensional changes (in 3 orthogonal directions) were measured as concrete cubes hardened over a amount up to one year. The length changes of concrete prisms were conjointly measured over identical amount of your time. The resultant knowledge indicated that a fine mixture that comprised twenty fifth glass and seventy fifth sand would be categorized as "non-expansive", i.e. identical because the sand on its own.

Keywords: Glass, concrete cubes, road, dams, pavement.

Structural Concrete Each year around twenty five billion tonnes of concrete square measure used to construct buildings, road, dams, pavement, and even artworks. Concrete is that the world's most significant construction material and is extensively used as a structural material in foundations, columns within building, beams and slabs in bridges, drain systems, roads, harbour works and etc. The concrete trade, because of its sheer size, includes a goodish impact on the setting. Concrete consists chiefly of cement, coarse combination, fine combination and water. Usually around seventy fifth to ninetieth of the quantity of structural concrete consists of raw materials extracted from the bottom. standard structural concrete is therefore a conspicuous client of primary resources and this can be a significant concern within the drive to realize property among construction.

Waste glass

One of the issues arising from continuous technological, industrial development and increasing population is that the disposal of waste materials that square measure made. These waste materials include iron, glass, ceramics, and concrete.

Demand to scale back waste has created the necessity to seek out a use for waste product rather than doing away with the materials in landfills. Several outside of the concrete trade regard concrete as an appropriate host for waste materials, rendering the waste materials innocuous and finding a pollution drawback. Use of waste materials in concrete isn't solely a partial answer to environmental and ecological problems; it's the potential to boost the microstructure and consequently the properties of concrete.

It has been calculable that over a pair of.5 million tonnes of waste glass is generated within the india each year of that solely 59% is recycled and also the rest goes to lowland (Wrap, 2013). Glass could be a notably hard part of waste as a result of it'll not burn, rust, or decay and even when combustion of refuse a substantial quantity of glass remains to be disposed of. In terms of glass colour; sixty three of the waste is evident, 25% is amber, 100 percent is green and a pair of is blue or alternative colours. Mixed waste glass typically can not be reused by the glass trade. Waste glass cullet wants many processes or treatments to be with success recycled within the

production of latest glass, and these treatments generate their own waste stream. Potential suggests that of disposal of glass embody lowland (which is powerfully discouraged) and salvage and reclamation operations. As an example, waste glass may well be came to a glass manufacturer for melting and recycle. However, transportation prices and also the expense of sorting the glass into totally different classes by color, type, then forth, square measure possible to be preventive .so as to maximise potential edges from salvage and reclamation operations, it's necessary to attenuate process and transportation prices whereas guaranteeing a gentle marketplace for the salvaged refuse. Associate alternate methodology of disposal is to recycle the inclose a special method. For instance, the economic edges from the recycle of recycled waste glasses in cement and concrete production may well be terribly vital. The indian government is committed to property development and around sixty five million tonnes of combination square measure derived annually from recycled sources representing some one quarter of the whole of 275 million tonnes used annually within the India. This can be associate environmental tax on the industrial exploitation of combination to deal with the environmental prices related to production that don't seem to be already lined by regulation, as well as noise, dust, visual intrusion, loss of pleasantness and harm to diverseness. Several alternative countries, notably those within the EU, build increasing use of "green taxes" and have introduced similar taxes to pursue environmental aims. The general price of lowland, notably the lowland Tax is increasing. The tax is guilty by weight and there square measure 2 rates: lower rate applies to those inactive (or inert) wastes; customary rate applies to any or all alternative subject waste.

Use of waste in close concrete-Waste glass is probably going to be accessible in vital quantities for the predictable future and can thus cause a disposal drawback accentuated by the increasing tendency to limit landfilling. One outlet for these waste materials, that is enticing from the environmental purpose of read and technically possible beneath sure conditions, is as combination in concrete. Moreover, the use of glass (and fly ash) as associate additive to concrete could introduce some edges from technical and environmental points of read and this approach is receiving additional and additional interest worldwide. Being amorphous and

containing comparatively giant quantities of chemical element and metallic element, glass is, in theory, pozzolanic or maybe building material in nature once it's finely ground. Thus, it might presumably be used as a cement replacement in Portland cement concrete.

However, use of crushed glasses as aggregates for Portland cement concrete could have some negative effects on the properties of the concrete. The most concern is that the enlargement and cracking caused by chemical reactions.

Recycled glass is thought-about as associate amorphous crystalline structure and therefore be classified as extremely reactive silicious combination once employed in concrete. Moreover, contamination residues and organic content in waste recycled glass square measure inexpedient as they'll degrade with time and build voids within the micro-structure of the concrete. Additionally the cracks inherent within the recycled glass sand particles (due to the crushing to provide appropriate grading) square measure potential supply of weakness and might scale back the strength of the concrete. However, as associate colorfast material, the recycled glass will scale back the permeableness of the concrete combine and will Enhance its sturdiness and prohibit the migration of the water and ions within the concrete matrix.

Glasses can be classified into categories such as vitreous silica, soda-lime glasses, lead glasses, etc. The composition of these glasses is very similar, except for small amounts of additives, which are used for colour purposes or to improve specific properties. Soda-lime glasses are most widely used to manufacture containers, sheets, and account for over 80% (by weight) of waste glass. The typical composition of different types of glass are given in Table 1.2. Soda-lime glasses consist of approximately 73% SiO₂, 13–13% Na₂O and 10% CaO, and on the basis of their chemical composition, soda-lime glasses will be pozzolanic-cementitious materials. The second major type of waste is lead glass, (from televisions, neon tubes, etc). A serious concern relating to the use of this type of glass in concrete is its high lead content, which could be leached into the environment.

LITERATURE REVIEW

One way for the construction industry to improve its performance with regard to sustainable development would be to use concrete with reduced Portland cement

content. There is a variety of products of industrial processes which have some cementitious properties e.g. fly ash, ground granulated blast furnace slag, condensed silica fume, and consideration has been given to substituting some of them for cement. Another strategy to improve the environmental 'considerateness' of the construction industry is to use waste products as substitutes for conventional fine and coarse aggregates-suitable wastes include construction debris, waste glass, dredged material, quarry spoil and mining spoil. The key to successful usage of these wastes lies in the identification and exploitation of the properties in here in the waste material which can improve the properties of concrete and thereby increase their value (Dhired et al., 2005), combined with elimination or suppression of any harmful effects from using a specific waste material.

The use of waste glass in concrete has been tried in the past but deleterious Alkali-Silica Reaction (ASR) between cement paste and glass aggregates may occur. Studies on the expansive reactions between natural aggregates containing amorphous silica and Portland cement containing alkalis (Na^+ and K^+), have indicated that the direct substitution of glass for natural aggregate could have detrimental effects on concrete properties (Phillips et al., 2011). Glasses of a wide range of compositions are capable of reacting expansively with Portland cement. The most reactive glasses have a high boron content and/or alkali metal content or have a relatively porous or phase-separated structure. Other problems associated with the use of reclaimed glass in concrete are; the probable need to wash and remove sugars which would otherwise retard the hydration of the cement, the glass must be crushed and graded to provide similar engineering properties to natural sand and rock, the cost must suit the market (Phillips et al., 2013).

When cement is mixed with water, chemical reactions begin between the various compounds and the water. These reactions result in the formation of various compounds; Tricalcium aluminate (which causes the initial stiffening but contributes

least to the ultimate strength), Tricalcium silicate (has a marked effect on the strength of concrete at early ages), Dicalcium silicate (mainly responsible for the progressive increase in strength). The chemical reactions result in the formation of a mixture of gels and crystals from the solution

of cement and water, which, by their adherence and physical attraction to one another and the aggregate present, gradually set and harden to produce concrete (Murdock, 2012).

Nassar and Soroushian (2012) used milled waste glass, with particle size of about 13 microns, as partial cement replacement in concrete containing aggregates made from recycled concrete. This substitution resulted in enhancement of durability characteristics, i.e. lower sorption and chloride permeability, and greater resistance to freeze-thaw deterioration. The enhancement was reported to be due to an improvement in the pore structure with the glass particles promoting infilling of the pores through conversion of calcium silicate, which was present in the old mortar/ cement paste attached to the recycled aggregate, into calcium silicate hydrate (C-S-H). The resultant denser, less permeable microstructure led to an increase in the long-term strength of the concrete.

Tuncan et al. (2011) investigated the suitability of glass and fly ash for use in concrete. The idea was that fly ash would infill the pores in the concrete and glass would improve the mechanical properties of concrete through pozzolanic reactions. Mixes were made with fly ash proportions between 0% and 30% and glass between 0% to 15% by weight. In all cases the concrete had water/cement ratio of 0.45 and Portland cement was used. It was found that all additions increased the compressive strength of the concrete. Freeze/thaw tests indicated that addition of glass and fly ash increased the durability of concrete specimens. Concrete with 15% glass and 30% fly ash substitution had the best results with respect to compressive strength, indirect tensile stress and the coefficient of capillary permeability.

Shao et al. (2010) also examined the pozzolanic activity of ground glass and its effect on compressive strength by making concrete wherein 30% of the cement was replaced by ground glass. The results showed that ground glass having a particle size finer than $38\mu\text{m}$ did exhibit pozzolanic behaviour and the finely ground glass helped reduce concrete expansion by up to 50%. This agreed with the findings of Topcu and Canbaz (2004) that waste glass contains a high amount of silica and if it is finely ground (and thus amorphous) it would be expected to show pozzolanic activity. Compared to fly ash concrete, concrete containing only ground glass exhibited a higher strength at both early and late ages. The high early strength

gain was possibly attributable to the high alkali content glass (soda-lime lamp material) that was used.

Castro and Brito (2013) found that the size of waste glass aggregate had a significant effect on concrete workability. If waste glass was used as fine aggregate the water- cement ratio needed to be increased to compensate for the loss of workability. However the replacement of up to 20% of conventional aggregate by crushed glass showed, within the limits of experimental error, an increase in compressive strength up to 13.6%. In addition the inclusion of glass aggregate reduced water absorption (capillarity was lowed by 10.1%, immersion fell by 3.8%), reduced carbonation (by 21.7%) and lowered shrinkage (by 7.4%).

In work reported by **Kou and Poon (2009)** recycled glass was used to replace river sand (in proportions of 10%, 20% and 30%), and 10 mm granite aggregate (amounts of 5%, 10% and 15%) to make self-compacting concrete mixes. Fly ash was used in the concrete mixes to suppress the potential alkali-silica reaction. It was found that the slump and air content of the mixes increased with increasing recycled glass content. The initial slump flows of all the mixes prepared were at least 750 mm. In addition, the resistance to chloride ion penetration increased and the drying shrinkage of the recycled glass self-compacting concrete mixes decreased when the recycled glass content increased. The compressive strength, tensile splitting strength and static modulus of elasticity of the waste glass concrete mixes decreased with an increase in recycled glass content. The ASR expansion of all the specimens was significantly reduced by the use of fly ash.

Zammit et al. (2014) investigated the use of glass fines to replace different proportions of the fine aggregate in concrete. All mixtures containing glass achieved values similar to, or higher than, the compressive strength values of the control mixes at different time intervals, e.g. a glass sand replacement of 50% achieved compressive strength values 10% higher than that developed by the control mixes. This foregoing mix also showed the highest slump. It was concluded that 50% glass sand replacement would be the best proportion for optimal mechanical properties

CONCLUSIONS AND FUTURE SCOPE

Context of the research

The results presented and mentioned within the preceding chapters came from an experimental investigation of the

consequences, on a structural concrete, of exchange standard fine mixture (sand) by crushed waste glass. The glass was crushed to grant a particle size distribution that was primarily an equivalent as that of the standard fine mixture. Concrete mixes were created with 25th, 500th and 100% of the sand replaced by differing kinds of glass, i.e. flint (clear), green, amber (brown), mixed colors (washed), mixed colors (unwashed). Generally the analysis work was focussed on the consequences of glass fine aggregates the flow characteristics of fresh concrete and therefore the engineering/ structural properties of hardened concrete and any time-related effects.

The glass particles used for many of this investigation were created by manually crushing and sieving waste glass to supply a fine mixture that had an equivalent particle size distribution because the natural sand it replaced. However, this didn't mean that the individual glass particles had an equivalent form and surface texture because the natural sand. Various measurements of the shape of particles and statistical analysis of the distribution of particle forms among samples of fine mixture were undertaken. The resultant information showed that there have been quantitative variations in form and surface texture between the manually-produced glass mixture and therefore the sand that it replaced. There have been additionally minor variations between the kinds of completely different colors of glass mixture and therefore the laboratory-produced and commercially-supplied glass aggregates (Tables 4.26 and 4.27).

The particle size distribution solely determine the proportion of sizes among a group of pre-defined vary, it doesn't management or characterise particle form or the distribution of particle form in an mixture. So techniques developed was found that the crushed glass particles were a lot of angular than the sand grains and this resulted in less runniness as indicated by reduced slump and flow table worth, which can appropriate application for the low workability concrete. Such concrete would be ideal to be used in structures, formed concrete block work, and floor block. The angularity can also are to blame for some loss of bond between concrete paste and glass mixture that diode to a decrease in compressive strength in proportion to the number of sand replaced by glass. The conclusions reported in Section 6.2 and 6.3 should be viewed within the light-weight that they relate to at least one specific concrete combine, i.e. parts in an exceedingly magnitude

relation of 1:2:4 with a water- cement magnitude relation of 0.6. The concrete didn't contain any admixtures like plasticizers or ASR-suppressants. Moreover there have been quantitative variations between the forms or the sand utilized in the standard concrete that was used as a benchmark and therefore the fine mixture created by crushing waste glass.

Characteristics of contemporary concrete

The following conclusions are drawn from the analysis work:

Slump values were remittent (Figure 4.12) by the utilization of fine glass mixture and therefore the larger the glass content the larger was the reduction. This trend had been antecedently rumored by variety of researchers. It's believed that the sharp, angular nature of the glass particles (as quantified by ratio and proportion concavity) resulted in additional friction among the contemporary concrete in order that it had reduced runniness. Previous researchers WHO had rumored that the inclusion of fine glass mixture caused a rise in slump worth had not compared equivalent concrete mixes – in some cases the particle sizes of their standard fine mixture and glass mixture were considerably completely different, in some investigations the concrete containing glass was created with a better water content than the standard concrete.

The aforesaid decrease in slump was discovered for all colors of glass and it occurred in spite of whether or not the glass mixture was in an exceedingly washed or unwashed state (Figure 4.12). an equivalent finding was rumored by the only a few researchers WHO had antecedently investigated this space and it had been steered that a little quantity of plasticizer admixture may be accustomed make sure that the slump wasn't noxiously affected.

Notwithstanding the comments created on top of in things a, b and c it will be all over that up to twenty fifth of fine mixture (sand) will be replaced by crushed glass before there's a big modification within the flow behaviour (quantified either as slump or flow table value) of the concrete. This finding is supported by nearly all printed analysis with reference to this subject.

Both initial and final setting time (Figure 4.23) were found to extend, more- or-less linearly, with the number of standard fine mixture replaced by glass. The result of not laundry the glass before its use was to delay all setting times by a hard and fast quantity, that was close to twelve-tone music of the

several setting time for standard concrete. alternative researchers have antecedently rumored an equivalent general finding with reference to setting times of concrete containing crushed waste glass. the sole previous investigation that rumored a discount of setting times thanks to the presence of glass mixture had used the enclose the shape of a awfully fine powder in order that itactedasapozzolan.

Properties of hardened concrete

The following conclusions have been drawn from the research work:

The bulk density of cured cubes containing glass fine mixture was less, in any respect curing times, than the density of cubes made of typical concrete. However, once account had been taken of the distinction between the precise gravities of the sand and crushed glass particles and therefore the quantity of glass gift during a specific concrete then the 'denseness' of cured cubes failed to appear to be suffering from the replacement of typical fine mixture. There was significantly sensible correspondence between measured densities and adjusted densities (values from typical concrete amended to account for the various specific gravities of particles within the fine aggregate) for cubes when one year of curing. The aforesaid comparison of densities suggests that there was very little distinction between the inner structure of hardened typical concrete which made of mixes containing glass fine mixture. Previous researches had additionally reported changes within the density of hardened concrete that can be accounted for by variations within the specific gravities of their sand and fine glass mixture.

The ultrasonic pulse velocity (UPV) of the hardened concrete bated in proportion to the quantity of typical fine mixture replaced by crushed glass for all curing times. An analogous trend has been reported by alternative researchers who have tested concrete wherever the sole distinction between mixes was the quantity of traditional fine mixture replaced by washed glass that had been crushed to a similar grading curve because the sand it replaced. In one analysis the concrete was sliced within the direction of casting and therefore the exposed surface was examined below a magnifier. Per the researchers this examination unconcealed that the bonding achieved between cement paste and glass mixture was totally different from the bonding with the flint mixture that was utilized in the management concrete. Thence it'd appear

possible that the reduction in UPV values ascertained by the author was thanks to inferior bonding between the cement paste and therefore the glass mixture as a result of bulk densities indicated general similarity of all concrete internal structures.

Use of crushed glass as fine aggregate caused a reduction in compressive strength, in comparison to the equivalent conventional concrete, at all curing times. However, all mixes exhibited very similar age factors during curing so that the proportional reduction of strength exhibited after 7 days was maintained as the concrete hardened further. Similar trends have been reported.

By researchers who have compared 'like-for-like' mixtures containing glass, i.e. where there has been no change in water content, fine aggregate grading, no addition of plasticiser, etc. It is believed that the observed reduction in compressive strength results from the bonding between glass aggregate and cement paste being inferior to that between sand and paste. This belief is supported by;

The comparability of bulk densities, and hence voids contents, for mixes containing glass and only conventional fine aggregate; measurements of dimensional changes of cubes and prisms showed no major difference between expansion potential of the glass used in the investigation and the conventional fine aggregate; the reduction of UPV when glass was introduced into the concrete mix which was indicative of some barrier to transmission of the pulse within the concrete matrix; the significant difference between measured values of aspect ratio and percentage concavity for glass and sand particles; water absorption tests (immersion and capillarity) suggest that the voids in the concrete containing glass are larger and more widely-distributed than those in conventional concrete. The foregoing conclusion the research work indicates that up to 25% of fine aggregate could be replaced by crushed glass without any significant loss of functionality of the concrete. A similar finding has been previously reported by numerous researchers. Furthermore, it was found that if crushed washed green glass was used as the replacement material then there was essentially no difference between the performance of this mix and that of the equivalent conventional concrete. However particular attention should be paid to washing waste glass thoroughly and removing any surface contaminants before it is used

The potential presence of continuous micro-pores (between glass particles and cement paste) may be a cause for concern with regard to long-term durability of the concrete. Such passages could allow the ingress of salts or could promote damage due to freeze-thaw action. However, sorptivity measurements suggest that the depth to which moisture would penetrate by capillary action would be reduced by the use of glass aggregate. In addition, for the glasses used in this investigation there is no evidence that in the long-term Alkali Silica Reaction would cause significant or detrimental expansion.

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