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Glass Wastes as Coarse Aggregate in Concrete

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Abstract

Waste glass is a major component of the solid waste stream in many countries. It can be found in many forms, including container glass, flat glass such as windows, bulb glass and cathode ray tube glass. At present, although a small proportion of the post-consumer glass has been recycled and reused, a significant proportion, which is about 84% of the waste glass generated, is sent to landfill. Glass is a 100% recyclable material with high performances and unique aesthetic properties which make it suitable for wide-spread uses. Glass is widely used in our lives through manufacturedtract products such as sheet glass, bottles, glassware, and vacuum tubing. Glass is an ideal material for recycling. The use of recycled glass helps save of energy. The increasing awareness of glass recycling speeds up inspections on the use of waste glass with different forms in various fields. One of its significant contributions is to the construction field where the waste glass was reused for concrete production. The application of glass in architectural concrete still needs improvement. Laboratory experiments were conducted in the SHIATS to further explore the use of waste glass as coarse aggregates replacement in concrete. The study indicated that Waste glass can effectively be used as coarse aggregate replacement (upto 50%) without substantial change in strength.

Keywords: *Coarse aggregate; Compressive strength; Concrete; Waste glass.*

1. INTRODUCTION

Glass is a transparent material produced by melting a mixture of materials such as silica, soda ash, and $CaCO_3$ at high temperature followed by cooling during which solidification occurs without crystallization. Glass is widely used in our lives through manufactured products such as sheet glass, bottles, glassware, and vacuum tubing. Glass is an ideal material for recycling. The use of recycled glass helps save of energy. The increasing awareness of glass recycling speeds up inspections on the use of waste glass with different forms in various fields. One of its significant contributions is to the construction field where the waste glass was reused for concrete production. The application of glass in architectural concrete still needs improvement. Several study have shown that waste glass that is crushed and screened is a strong, safe and economical alternative to using sand in concrete. During the last decades it has been recognized that Sheet Glass waste is of large volume and is increasing year by year in the Shops, construction areas and factories. Using waste glass in the concrete construction sector is advantageous, as the production cost of concrete will go down. The amount of waste glass is

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gradually increased over the recent years due to an ever-growing use of glass products. Most waste glasses have been dumped into landfill sites. The land filling of waste glasses is undesirable because they are not biodegradable, which makes them environmentally less friendly. There is huge potential for using waste glass in the concrete construction sector. When waste glasses are reused in making concrete products, the production cost of concrete will go down (Topcu and Canbuz, 2004). Crushed glass or cullet, if properly sized and processed, can exhibit characteristics similar to that of gravel or sand. When used in construction applications, waste glass must be crushed and screened to produce an appropriate design gradation. Glass crushing equipment normally used to produce a cullet is similar to rock crushing equipment. Because glass crushing equipment in glass sector has been primarily designed to reduce the size or density the cullet for transportation purposes and for use as a glass production feedstock material, the crushing equipment used is typically smaller and uses less energy than conventional aggregate or rock crushing equipment (Egosi, 1992). Waste glasses are used as aggregates for concrete (Johnson, 1998, Masaki, 1995 and Park, 2000; Vikas Srivastava *et al*. 2013). However, the applications are limited due to the damaging expansion in the concrete caused by ASR between high-alkali pore water in cement paste and reactive silica in the waste glasses. The chemical reaction between the alkali in Portland cement and the silica in aggregates forms silica gel that not only causes crack upon expansion, but also weakens the concrete and shortens its life (Swamy, 2003). Ground waste glass was used as aggregate for mortars and no reaction was detected with fine particle size, thus indicating the feasibility of the waste glass reuse as aggregate in mortars and concrete. Estimated cost for housing is more and some construction materials like natural aggregates are also becoming rare. Waste glasses are used as aggregates for Concrete. In the present study en extensive experimental work was carried out and carried out to find the suitability of use of waste glass in concrete and it was proposed:-

i. To study the workability of concrete mode using glass waste as partial replacement of coarse aggregate
ii. To study the compressive strength of concrete mode using glass waste as partial replacement of coarse aggregate.

2. MATERIAL & METHODOLOGY

In order to study the effect of waste glass as partial replacement of coarse aggregate on the strength of concrete, fine aggregate, coarse aggregate 60 cubes and 6 cubes 0% waste glass for a mix have been cast in the laboratory.

Cubes, ($100mm \times 100mm \times 100mm$) were cast.

An effort has been made here to compare the strength of cubes made up with different percentage of demolished waste to the respective strength of conventional concrete at the end of 7 and 28 days of moist curing and to have an idea about the optimum percentage of demolished waste which does not affect the strength of recycled concrete considerably. Similarly fine aggregate and coarse aggregates was also partially replaced by demolished waste and only cubes were cast and tested after 7 and 28 days for mix of 1:1.67:3.33 at a w/c of 0.50.

Cement

In this work, Ordinary Portland cement (OPC) of Birla (43 grade) brand obtained from a single batches trough out the investigation was used. The physical properties of OPC as determined is Table 1.

Fine Aggregate

Fine aggregate / sand is an accumulation of grains of mineral matter derived from the disintegration of rocks. It is distinguished from gravel only by the size of grain or particle, but is distinct from clays which contain organic minerals. Sands that have been sorted out and separated from the organic material by the action of currents of water or by winds across arid lands are generally quite uniform in size of grains. Usually commercial sand is obtained from river beds or from sand dunes originally formed by the action of winds. Much of the earth's surface is sandy, and the sand are usually quartz and other siliceous materials. Sand is used to make mortar and concrete and for making molds in foundries.

Coarse Aggregate

Coarse aggregate are the crushed stone used for making concrete. The commercial stone is quarried, crushed and graded. Much of the crushed stone used is granite, limestone and trap rock. Crushed angular granite metal of 10 mm size from a local source was used as coarse aggregate. The specific gravity of 2.6 and fineness modulus 6.05 was used.

The coarse aggregate are granular materials obtained from rocks and crushed stones. They may be also obtained from synthetic material like slag, shale, fly ash and clay for use in light-weight concrete.

Water

Potable water is used for mixing and curing. On addition of higher percentage of demolished waste the requirement of water increases for the same workability. Thus a constant slump has been the criteria for water requirement but the specimens having 0% demolished waste, w/c of 0.50 has been used.

Concrete

The concrete mix design is done in accordance with IS:10262 (1982). The cement content in the mix design is taken as 380 kg/m^3 which satisfies minimum requirement of 300 kg/m^3 in order to avoid the balling effect. Good stone aggregate and natural river sand of zone- II were used as coarse aggregate and fine aggregate respectively. Maximum size of coarse aggregate was 12.5 mm. a sieve analysis conforming to IS: 383-1970 was carried out for both the fine and coarse aggregate .Concrete may be produced as a dense mass which is practically artificial rock and chemicals may be added o make it waterproof or it can be made porous and highly

Table 1. Properties of Cement

S.No.	Properties	Experimental Value	Codal requirement (IS 8112-1989)
1	Normal Consistency	30%	
2	Initial setting time	104 Min	(Not less than 30 min)
3	Final setting time	310 Min	(Not more than 600 min)
4	Soundness of Cement	6mm	(Not more than 10 mm)
5	Fineness of Cement (%age retained on 90 micron IS sieve)	2.5%	<10%
6	Specific gravity of Cement	3.15	3.15
7	Compressive Strength		
8	3 Days	23.33	23 N/mm^2
9	7 Days	33.66	33 N/mm^2
10	28 Days	43.66	43 N/mm^2

permeable for such use as filter beds. An air-entraining chemical may be added to produce minute bubbles for porosity. Normally, the full hardening period of concrete is at least 7 days. The gradual increase in strength is due to the hydration of the tri calcium aluminates and silicates. Sand used in concrete was originally specified as roughly angular, but rounded grains are now preferred. The stone is usually sharply broken. The weight of concrete varies with the type and the amount of rock and sand.

Table 2. Properties of Aggregates

Property	Sand	Coarse Aggregate	
		20 mm	12.5 mm
Specific Gravity	2.62	2.71	2.70
Bulk Density (kg/m3)	1573	1477	1489

Fig. 1: Test set up for compressive strength test of concrete

3. RESULT & DISCUSSION

Results of observations are given in table 3 and fig. 2.

Table 3. Compressive strength

S.No.	Cube designation	Compressive strength (N/mm^2)		% age of Glass
		7 days	28 days	
1	A	13.66	29.67	0
2	B	15.67	31.00	10
3	C	14.11	29.67	20
4	D	15.33	25.33	30
5	E	14.67	27.33	40
6	F	15.67	29.67	50

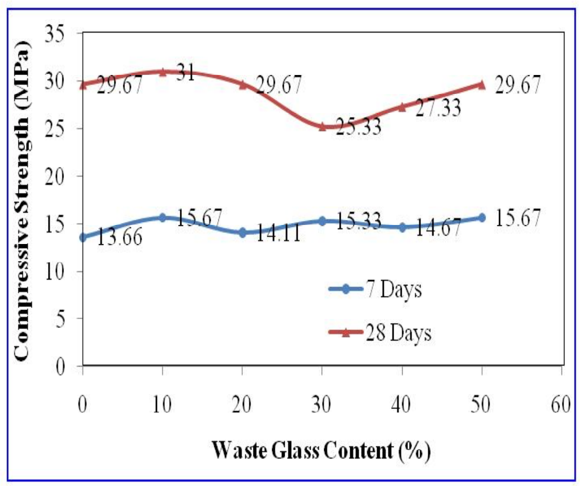

Fig. 2: Variation in compressive strength of glass waste concrete

It is observed that when coarse aggregate is replaced by 10% glass waste, the compressive strength at 7 days is found to increase by about 14.63% on average. However, it is evident that increase in compressive strength at 28 days is only 4.49% at same replacement level. It is observed that on replacing coarse aggregate by 20% glass waste on average there is an increase in compressive strength at 7 days by 3.24% however, at 28 days, compressive strength is same as that of referral concrete. It is seen that there is an increase in compressive strength at 7 days by about 12.17% and 7.31% respectively whereas at 28 days compressive strength is decreased marginally at 30 and 40% replacement level.

4. CONCLUSIONS

1. While using waste glass as coarse aggregate replacement, 28 days strength is found to marginally increase up to 20% replacement level.
2. Marginal decrease in strength is observed at 30 to 40% replacement level of waste glass with coarse aggregate.
3. Waste glass can effectively be used as coarse aggregate replacement.
4. The optimum replacement level of waste glass as coarse aggregate is 10%.

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