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Partial Replacement of Waste Glass as a Fine Aggregate in Concrete

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ABSTRACT: 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 in energy saving. 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 to further explore the use of waste glass as coarse and fine aggregates for both ASR (Alkali-Silica-Reaction) alleviation as well as the decorative purpose in concrete. The recycling of waste glass as a component in concrete makes waste glass a sustainable alternative to land filling and so makes it economically viable.

Concrete industry is one of the largest consumers of natural resources due to which sustainability of concrete industry is under threat. The environmental and economic concern is the biggest challenge concrete industry is facing. In this paper, the issues of environmental and economic concern are addressed by the use of waste glass as partial replacement of fine aggregates in concrete. Fine aggregates were replaced by crushed waste glass as 10%, 20%, and 30% by weight for M20mix. The concrete specimens were tested for compressive strength at 7 and 28 days of age and the results obtained were compared with those of normal concrete. Waste glass when grounded to a very fine powder shows some pozzolanic properties as it contains high SiO_2 and therefore to some extentit replaces the cement and contributes for strength development.

I. INTRODUCTION

Concrete is most widely used man made construction material and its demand is increasing day by day. The use of river sand as fine aggregate leads to exploitation of natural resources, lowering of water table, sinking of bridge piers and erosion of river bed. If fine aggregate is replaced by waste glass by specific percentage and in specific size range, it will decrease fine aggregate content and thereby reducing the ill effects of river dredging and thus making concrete manufacturing industry sustainable. The amount of waste glass produced has gradually increased over the recent years due to an ever growing use of glass products. Most waste glass has and is being dumped into landfill sites. The land filling of waste glass is undesirable because waste glass is non-biodegradable which makes them environmentally less friendly. Utilization of this waste is the need of the hour. 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. This move will serve two purposes; first, it will be environment friendly; second, it will utilize waste in place of precious and relatively costlier natural resources.

The using of waste glass as coarse aggregate in concrete creates a problem in concrete due to ASR (Alkali Silica Reaction). The reaction between alkalis in Portland cement and silica in aggregates forms silica gel. This gel is prone to swelling. It absorbs water and the volume of the gel increases. Under confinement by cement matrix and aggregate, the swelling of the ASR gel generates hydrostatic pressure. If the reaction continues and internal pressure exceeds the tensile strength of the matrix, cracks will form around the reactive aggregate particles. Ground waste glass was used as fine aggregate in concrete and no reaction was detected with fine particle size, thus indicating the feasibility of the waste glass reuse as fine aggregate in concrete. In addition, waste glass seemed to positively contribute to the mortar micro-structural properties resulting in an evident improvement of its

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mechanical performance. Larger the particle size of waste glass more is the chance of ASR occurrence.

This report summarized the behaviour of concrete involving replacement of fine aggregates by waste glass as 10%, 15% and 20% by weight which may help to reduce the disposal problems of waste glass and enhance properties of concrete.

II. EXPERIMENTATION

In this research, fine aggregates were partially replaced by crushed waste glass as 10%, 15% and 20% by weight in a concrete. Concrete specimens were tested mainly for compressive strength test, for different waste glass percentages. The test results obtained were compared with results of normal M-20 concrete mix.

Materials Used: materials used in the preparation of concrete specimens are- cement, water, coarse aggregate, sand and crushed glass waste.

Glass: The waste glass is collected from locally based glass bottle manufacturing factory. It is crushed in fine particles and sieved through 4.75mm size sieve. Following table has chemical composition of glass.

Composition of glass

Composition (% by mass)/property	Glass powder
Silica ($Si0_2$)	72.5
Alumina (Al_2O_3)	0.4
Iron oxide (Fe_2O_3)	0.2
Calcium oxide (CaO)	9.7
Magnesium oxide (MgO)	3.3
Sodium oxide (Na_2O)	13.7
Potassium oxide (K_2O)	0.1
Sulphur trioxide (SO_3)	-
Loss on ignition	0.36
Maximum sieve size	4.75mm

Fig.: Crushed glass for replacement as sand.

Cement: In this work, Portland Pozzolana Cement (PPC) of 53 grade which is available in local market was used.

Fine aggregate: Fine aggregate/sand used this experiment was locally supplied natural river sand. It was first sieve through 4.75mm sieve to remove particles greater than 4.75 mm.

Coarse Aggregate: Crushed stone conforming toIS 383 - 1970 is used in this study.Locally available coarse aggregate having maximum sizes of (10-20mm) were used.

Water: Potable water which is available in college campus is used for mixing and curing of cubes.

Mix Proportion: The mixture proportion used is of M20 grade concrete with the standard ratio of 1:1.5:3 to cast the cubes. The mixture is to be prepared with the water cement ratio of 0.5 as per IS 10262- 2009.

III. METHODOLOGY

In this experiment, all mixes were proportion in order to achieve a M20 grade of concrete, corresponding water-cement ratioused is 0.5 as per standards. A control mix was produced containing only natural aggregate, with four resulting mixes incorporating waste glass as a partial replacement for fine aggregates in proportions of 0%, 10%, 15%, and 20%. Batching was done by weighing the calculated amount of each constituent of concrete according to the standard mix ratio of 1:1.5:3 forM-20 grade concrete. The constituents were then thoroughly mixed until a uniform mix was achieved. After that, water was added and the process was repeated for different specimens. Different cubes of size 15cm x 15cm x 15cm are casted using the fresh concrete mix with compacting each layer and left for 24 hours before demoulding. The specimens after demoulded are cured and were

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tested for compressive strength at 7 and 28 days of age.

Given below is a flow chart of methodology:

EXPERIMENTAL PROGRAMME STEPS

a) Measurement of ingredients
b) Mixing of concrete
c) Workability
d) Compaction
e) Curing
f) Remoulding of specimen

Fig.: Mixing of concrete by hand in pan

IV. RESULT AND DISCUSSION

The concrete mixes such as conventional concrete mix and partially added waste glass concrete mix with 10%, 15% and 20% of replacement have been cast as per mix design. The effect on compressive strength of concrete at age of 28 days has been evaluated. The conventional concrete results are compared to result of three mixes. The result are presented in following table.

Compressive strength of concrete for 15cm cube specimen

(7 days curing)

Composition	Specimen	Compressive Strength (N/mm^2)	Mean (N/mm^2)
Conventional	C1	14.41	14.39
	C2	14.83	
	C3	13.94	
10% of glass	10G1	15.22	15.75
	10G2	15.46	
	10G3	16.57	
15% of glass	15G1	17.60	16.83
	15G2	16.31	
	15G3	16.58	
20% of glass	20G1	14.73	14.78
	20G2	15.19	
	20G3	14.42	

(28 days curing)

Composition	Specimen	Compressive Strength (N/mm^2)	Mean (N/mm^2)
Conventional	C1	21.15	21.38
	C2	22.06	
	C3	20.92	
10% of glass	10G1	22.87	23.14
	10G2	23.11	
	10G3	23.44	
15% of glass	15G1	25.28	25.10
	15G2	24.96	
	15G3	25.16	
20% of glass	20G1	21.34	21.59
	20G2	22.13	
	20G3	21.29	

Fig.: failure of block due to compression.

V. CONCLUSION

As a conclusion, all the objectives of this study are achieved. We can efficiently utilised

crushed glass waste as partial replacement of fine aggregate in concrete. It is economical and efficient where glass waste is available.

On the basis of results obtained, following conclusions can be drawn:

1) 15% replacement of fine aggregates by waste glass showed maximum increase in compressive strength.
2) Fine aggregates can be replaced by waste glass up to 20% by weight with slightly increase in compressive strength.
3) With increase in waste glass content, percentage water absorption decreases.
4) With increase in waste glass content, average weight decreases for mixture with waste glass content thus making waste glass concrete slightly light weight.
5) Workability of concrete mix increases with increase in waste glass content.
6) Use of waste glass in concrete can prove to be economical as it is non useful waste and free of cost.
7) Use of waste glass in concrete will eradicate the disposal problem of waste glass and prove to be environment friendly thus paving way for greener concrete.
8) Use of waste glass in concrete will preserve natural resources particularly river sand and thus make concrete construction industry sustainable.

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