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RESEARCH ARTICLE

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EVOLUTION OF CONCRETE BY PARTIALLY REPLACING ALL THE INGREDIENT OF CONCRETE

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ABSTRACT

The amount of waste glass has gradually increased over the recent years due to an ever-growing use of glass products. Most of the waste glasses are being 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. On the other hand, with natural sand deposits the world over drying up, there is an acute need for a product that matches the properties of natural sand in concrete. In the last 15 years, it has become clear that the availability of good quality natural sand is decreasing. Environmental concerns are also being raised against uncontrolled extraction of natural sand. The arguments are mostly in regards to protecting riverbeds against erosion and the importance of having natural sand as a filter for ground when waste glasses are reused in making concrete products, the production cost of concrete will come down. Waste glass powder can exhibit characteristics similar to that of sand.

In this report we are going to discuss how the waste glass will have its significant effect on concrete and its properties. Fine aggregate replacement levels by waste glass powder15, 20, and 25 % along with partial replacement of cement and coarse aggregate by fly ash (30%) and recycled aggregates (40%) respectively as known from previous researches. The compressive strength of concrete cubes is tested for 7, 14, 28, days were found and results obtained were compared with that of normal concrete. The results are presented in tables and graphs. The performance of design mixes is good and results are reported in this report. The size of glass powder used is in the range of 90µ to 4.75mm.

KEYWORDS- waste glass powder, compressive strength, fine aggregate, durability.


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INTRODUCTION

In order to make concrete industry sustainable, the use of waste materials in place of natural resources is one of the best approaches. An enormous quantity of waste glass is generated all around the world. In India, 7% of total urban waste generated comprises of glass. UK produces over three million tons of waste glass annually.

In Bhopal there are lots of glass industries in Govindpura Industrial area and Mandideep area, which produces waste glass in a huge amount so there is necessity to use it as construction material.

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. 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. As well, it is found in previous researches the cement can be replaced by 30% by fly ash and coarse aggregate can be replaced by 40% by recycled aggregate without any comparable reduce in compressive strength.

The objective of this paper is to present the results of experimental investigations on Physical and Mechanical properties of concrete made with waste glass powder fine aggregate was partially replaced by 15, 20, and 25percentages along with partial replacement of cement and coarse aggregate by fly ash (30%) and recycled aggregate (40%).

Compressive strength are evaluated and compared with concrete with natural fine aggregates. Fineness modulus, specific gravity, moisture content, water absorption, bulk density are also evaluated of all ingredients.

LITERATURE REVIEW

The second area of studies is for the recycled glass particle (sand) as aggregate for concrete in building construction. The use 30-70% of waste glass as a fine aggregate, up to 100 gm, in concrete has been trialed, showing no deleterious effect at macroscopic level, rather an improvement of the mortar mechanical performance (**Corinaldesi et al. 2005**). **Shehata et al. (2005**) reported that using waste glass as partial volume replacement of fine aggregate resulted in a higher modulus of rupture values for all glascrete mixes compared to reference mix. It was found that using waste glass as a fine aggregate can achieve good interfacial bonding between cement paste and glass aggregates and that the glass aggregates act as crack arrestors, preventing cracks from propagating through them. The presence of recycled glass sand particles (RGS) can also reduce the permeability of the concrete and the amount of water used in concrete (**Taha and Nounu 2008).**

MATERIALS

Materials used to make concrete specimens were fine aggregate, coarse aggregate, cement, fly ash, waste glass powder, recycled aggregate and water.

Table shows results of analysis of the physical properties of natural coarse and fine aggregates; recycled aggregates and waste glass powder.

Table-1. Physical properties of aggregates

Property	Aggregate Coarse	Fine	Recycled	Glass powder
Specific Gravity	**2.87**	**2.75**	**3.20**	**2.37**
Absorption	**0.80**	**0.70**	**1.40**	**0.00**
Moisture Content	**0.30**	**0.10**	**0.20**	**0.00**
Grading Zone	-	2	-	**2**

1. Cement

The cement used for research work was ordinary Portland cement of 43 grade conforming IS-8112.

2. Coarse Aggregate

The coarse aggregate was selected from natural stone, which was maximum 20 mm in size. The stone used had 2.87 specific gravity and 0.80 % water absorption. The grades distribution curves for coarse and fine aggregate are given.

3. Fine Aggregate

Sand of Zone-II as per IS: 383-1970 was used as fine aggregate. It had the specific gravity of 2.75and 0.70% water absorption.

4. Fly Ash

Fly ash used for research work conforming grade IS 3812

5. Glass powder

Waste glass has been collected from Govindpura Industrial area of Bhopal and then it has been converted to powdered form in a range of 90µ to 4.75 mm. The specific gravity of glass powder was 2.37, fineness modulus 3.89, and of grading zone 2.

6. Recycled Aggregate

The recycled aggregate was obtained from the demolished concrete structure, from the remains of beams and columns. It was 20 mm graded aggregates as per IS: 383-1970. It had 3.20 specific gravity in saturated surface state and 1.40 % water absorption.

7. Water

PREPARATION OF TEST SPECIMEN

Concrete mixture proportioning was carried out according to the mix design method. The water to binder ratio was kept constant as 0.4.The total mixing time was 20 minutes then the samples were casted and left for 24 hours. After that, samples were demoulded and placed in the curing tank until the testing time at the age of 7, 14, 28 days. The total numbers of cubes casted were 36. 9 of them were standard cubes with natural fine aggregates while 27 cubes with partial replacement of glass powder as fine aggregate by 15% (9 cubes), 20% (9 cubes)and 25% (9 cubes)along with fly ash (30%) and recycled aggregate (40%) were casted for testing at 7,14, and 28 days. All cubes are of same size, 150 x 150 x 150mm[3].

EXPERIMENTAL INVESTIGATION

MIX PROPORTION

Mix design of the concrete is done strictly as per the specification of the IS 10262: 2009. According to IS code specification mix of M40 grade is designed, 4 different types of mix are prepared with different percentage of Glass powder as Partial Replacement of Fine Aggregate. A standard control mix (CC) was prepared with natural fine aggregates. The other three concrete mixes include G15 that contains 15% of the Glass Powder, While G20, and G25 contains 20 and 25 percentage of Glass Powder respectively. The partial substitution of coarse aggregate by recycled aggregate (40%) and cement by fly ash (30%) was done by volume in the three mixes.

Table-2: Designation of various mixes.

Mix Designation	Percentage replacement of fine aggregate by glass powder
CC (Control Concrete)	0%
G15	15%
G20	20%
G25	25%

Table-3: Composition of various mixes per m^3 of mix.

	CC	G15	G20	G25
Water to cement Ratio	0.4	0.4	0.4	0.4
Size of Coarse Aggregate	4.75 mm-20 mm	4.75 mm-20 mm	4.75 mm - 20 mm	4.75 mm - 20 mm
Size of Fine Aggregate	90 µ-4.75mm	90 µ -4.75 mm	90 µ- 4.75mm	90 µ - 4.75mm
Water	156 l	156 l	156 l	156 l
Cement	390	273 kg	273 kg	273 kg
Fly ash	-	117 kg	117 kg	117 kg
Coarse Aggregate (gravel)	1308kg	775.12 kg	775.12 kg	775.12 kg
Recycled Coarse Aggregate	-	574.44 kg	574.44 kg	574.44 kg
Fine Aggregate (sand)	703.79 kg	302.94 kg	285.12kg	267.3 kg
Glass	-	46.072kg	61.43kg	76.79kg
Ordinary Portland Cement	M43 Grade	M43 Grade	M43 Grade	M43 Grade

*Note- The design of various mixes is done as per IS Code 10262(2009)

WATER CEMENT RATIO

The water cement ratio of all the prepared mixes was kept at an optimum value of 0.4 according to the grade of concrete chosen and mix design that was done.

CASTING AND CURING-

Mixing and casting of cubic test specimens was performed in accordance with IS Code 516-1959. All specimens were wet cure by submersion in water.9 Cubes of 150 x 150 x 150 mm size of each mix were cast for 7-days, 14 days and 28 days testing.

TESTING

1. TEST ON FRESH CONCRETE

Slump Test-The workability of all concrete mixtures was determined through slump test utilizing a metallic slump mould. The difference in level between the height of mould and that of highest point of the subsided concrete was measured and reported as slump. The slump tests were performed according to IS 1199-1959.

2. TEST ON HARDENED CONCRETE

From each concrete mixture, cubes of size 150mm x 150mm x 150mm have been casted for the determination of compressive strength. Cubes were tested for compressive strength at an age of 7, 14, and 28 days from the day of start of curing. A constant loading rate of 150 kN/cm^2/min was employed, and the quoted strength values are the averages of three cubes per test in accordance with IS 516-1959 standard test method.

The recycled aggregate is prepared by crushing the concrete material in Los Angeles Abrasion Test Machine and selecting the aggregate size as per IS standards. The specifications of recycled aggregate are shown in table. The maximum and minimum size of recycled aggregate according to IS codes is taken as 20mm and 4.75mm

Analysis of the physical properties of the natural aggregates was done according to IS standards. All aggregates met the specification of IS standard 383. The slump of the mixes is shown in Table.

Table-4: Slump Values.

Mix	Slump Value
CC	25 mm
G15	25 mm
G20	25 mm
G25	25 mm

RESULTS AND DISCUSSION-

Table shows the compressive strengths of various mixes at 7 days, 14 days and 28 days from the day of curing.

Table-5: Compressive strength test results.

Mix	Compressive Strength (in N/mm2)		
	7 days	14 days	28 days
CC	26.78	28.77	30.04
G15	20.98	27.37	31.50
G20	20.80	25.91	26.32
G25	24.37	28.73	32.78

Compressive strength versus age for all mixes are shown in Figure 1. Comparison of compressive strength according to percentage aggregate substitution is shown in Figure 1.

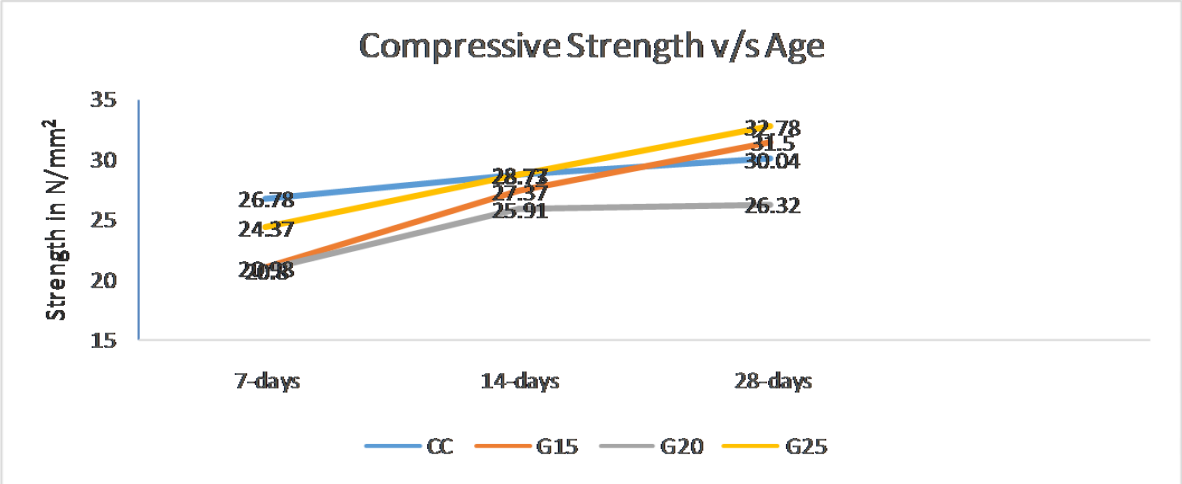

Figure 1: Compressive Strength versus Age.

*Note- Age is from the day of start of curing of concrete cubes.

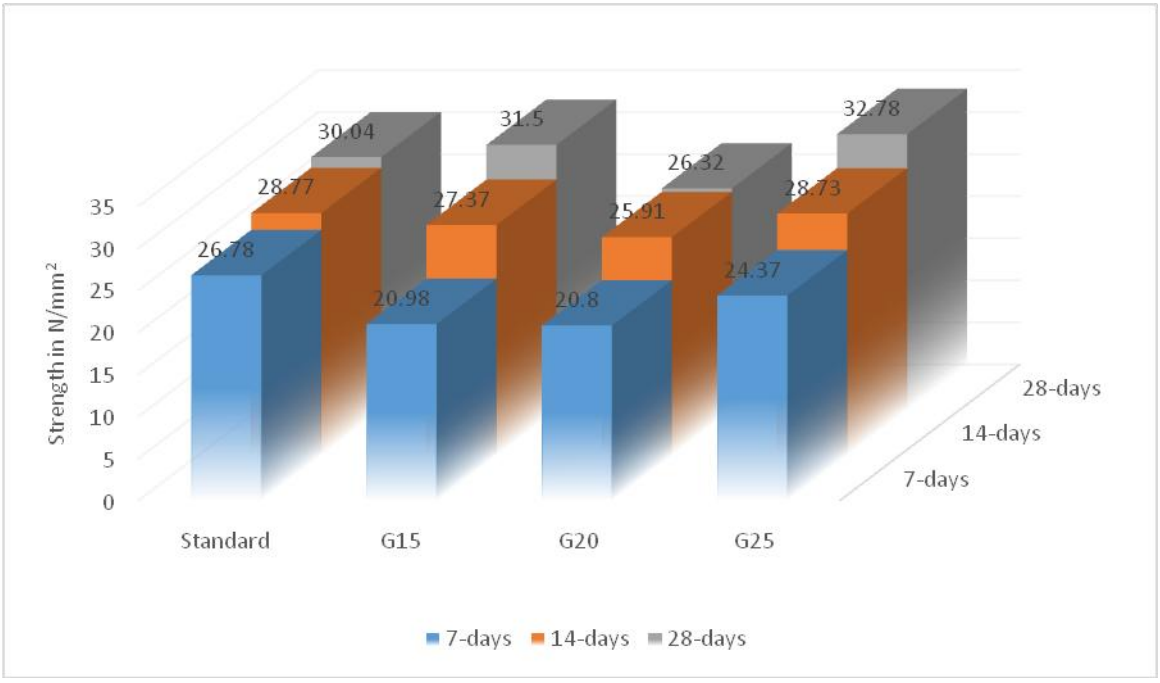

Figure 2: Comparison of compressive strength according to percentage aggregate substitution.

Table 6. Percentage decrease of compressive strength for concrete mixes.

Age (days)	Percentage of glass powder (by volume)		
	15%	20%	25%
7	-21.66	-22.33	-9.00
14	-4.87	-9.94	-0.14
28	+4.86	-12.38	+9.12

Tables 6: Show the percentage change in compressive strength with respect to control mix, by addition glass powder.

CONCLUSION-

(1) The experimental results shows that compressive strength of G15 (15% glass powder as sand replacement) and G25 (25% glass powder as sand replacement) increases by 4.86% and 9.12% respectively as compared to normal standard concrete obtained at 28 days of age.

(2) The slump value doesn't changes with change in glass percentage in concrete means the varied percentage of glass has no effect on workability.

(3) Utilization of waste glass in concrete can turn out to be economical as it is no useful waste and spare of cost.

(4) Utilization of waste glass in concrete will eradicate the disposal problem of waste glass and essay to be environment friendly, thus paving way for greener concrete.

(5) Utilization of waste glass in concrete will keep natural resources, particularly river sand therefore constitute the concrete construction industry sustainable.

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