Partial Replacement of Sand with Waste Glass in Concrete

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Abstract— Aggregates, both fine and coarse are the most important components of concrete. The cost of these aggregates is on the increase. The waste glass disposal becoming a major issue for the communities worldwide. These factors are major thrusts of this study the investigation of crushed waste glass as partial replacement of fine aggregate in concrete, with a view to protecting the environment and also reducing the cost of concrete. The properties of concretes containing waste Glass Powder as partial substitution for natural sand were investigated in this study. Glass dust waste was used as a partial replacement for sand at 5%, 10%, 12% and 20% by weight for M-25 concrete mix. The concrete specimens were tested for, workability and compressive strength at 7 days and 28 days of age and the results obtained were compared with those of conventional concrete.

Keywords: Compressive Strength, Concrete, Crushed Waste Glass

I. INTRODUCTION

Concrete is most commonly used man made construction material and its demand is increasing day by day. Both Sand and gravel are the most commonly used fine and coarse aggregates. The resources of these materials are unsustainable in the long run and they are getting exhausted. During the last few decades the aggregates utilization increased rapidly due to urbanization and industrialization the use of river sand as fine aggregate leads to exploitation of natural resources, lowering of water table and erosion of river bed. If fine aggregates are replaced by waste glasses in specific size range and percentage then, it will decrease the fine aggregate content and thereby reducing the ill effects of river dredging and thus making concrete manufacturing industry sustainable. Due to progressively more use of glass products the amount of waste glass produced has gradually increased over the recent years.

Most waste glass is dumped into landfill sites. The land filling of waste glasses are unwanted because they are non-biodegradable which makes them environmentally less friendly. Utilization of this waste is the need of the hour. There is enormous prospective for using waste glass in the concrete construction sector. When the waste glasses are reused in concrete making, 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.

II. EXPERIMENTAL STUDY

A. Materials

1) Coarse and Fine Aggregate

The aggregates used in this empirical study, were sourced from Indian suppliers and were readily available in the country. The coarse aggregate was of angular nature with a nominal maximum aggregate size of 20 mm. The fine aggregate was in the form of river sand, originating from the Raipur region. The physical properties of both aggregates can be seen in Table 1. Both coarse and fine aggregates used in this project conformed to requirements specified in IS: 383-1970, (Indian Standard).

TYPES	PHYSICAL PROPERTY	RESULTS	REFERENCE
COARSE	Specific gravity	2.83	IS 2386-part III
	Fineness modulus	7.57	
	Water absorption	0.15%	
FINE	Specific gravity	2.62	IS 2386:1963 part III clause 2.4.2
	Sieve analysis zone	Zone II Grading	Table 4 IS 383:1970
	Fineness modulus	2.76	IS 2386:1963 part I
	Water absorption	0.60%	

Table 1: Properties of aggregates

2) Waste Glass

Waste glass for this experiment was obtained from Shankar glasses situated at power house bhilai Chhattisgarh. Now the material is subjected to crushing and milling process in order to create a fine aggregate. The glass was further subjected to a mechanical sieving process, with fractions in excess of 1.18 mm being discarded in order to avoid excessive ASR. This also allowed for the removal of organic impurities, which separated to the top during the sieving process. Table 2 emphasizes the properties of crushed glass material.

PROPERTY	RESULT
SPECIFIC GRAVITY	2.39
FINENESS MODULUS	2.52

Table 2: Properties of Crushed glass material

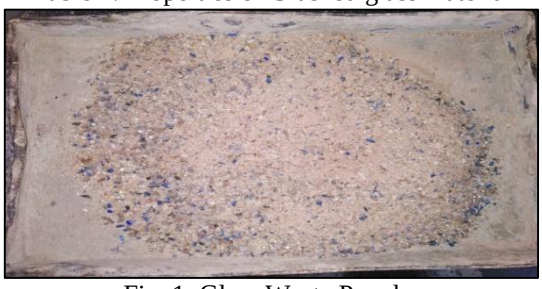


Fig. 1: Glass Waste Powder

3) Cement

The cement used in the production of all concrete for this project is ordinary Portland cement of Grade 53 (Birla A1 premium). The cement conformed to the requirements set out within IS (Indian Standard), ensuring its suitability for

structural applications. The properties of cement used are given below in Table 3.

PHYSICAL PROPERTY	RESULT	REFERENCE
Standard Consistency	33%	IS4031(part4):1988
Specific Gravity	3.21	IS 8112-1989
Fineness Modulus	1%	IS4031(part1):1996
Compressive Strength 7-days	34.6N/mm²	IS 8112-1989
Compressive Strength 28-days	53.06N/m²	IS 8112-1989

Table 3: Properties of cement

B. Project Design

1) Mixture Design

Concrete mix designs adopted throughout this study were undertaken in accordance with the procedure specified in Indian standards. All mixes were proportioned in order to achieve a design compressive strength of 31.5MPa after28 days. Corresponding water-cement ratio was calculated as 0.45. As per our mix design calculation the ratio of M-25 grade of Cement concrete is 1:1.8:2.5. 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 5%,10%, 12%, and 20%. A summary of the individual mix designs is presented

Mix proportions	% of replacement	Crushed glass material	Fine aggregate
		kg/m³	
Conventional concrete	0%	-	765.76
Mix 1	5%	38.29	727.47
Mix 2	10%	76.58	689.18
Mix 3	12%	91.89	673.87
Mix 4	20%	153.15	612.61

Table 4: Concrete mix design summary.

The quantity of water, cement and coarse aggregate used in this mix proportions remains same and are given by,

S.NO.	MATERIALS	PROPORTIONS
1	Water (L)	191.58
2	Cement (kg)	425.73
3	Coarse aggregate(kg)	1083.11

The main objective of designed concrete mix is to determine the most economical and practical combination of readily available materials to produce concrete which will satisfy the performance requirement under particular conditions of use. The mix design is based on the quantity, quality and grading of the materials, any variation in quantity, quality and gradation will result changes in the mix design.

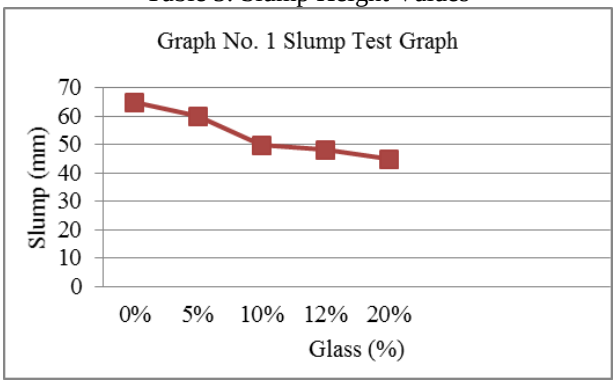
III. RESULTS AND DISCUSSION

The cement concrete cube of size 150mm*150mm*150mm were casted. These specimens are subjected to compression test after 7 and28 days of curing. Henceforth, the results are tabulated accordingly. These are compared with the conventional concrete results to find out the optimum value of replacement for natural sand with crushed glass material.

A. Slump Cone Test:

TYPE OF AGGREAGRE		SLUMP (mm)
RIVER SAND	GLASS POWDER	
100%	0%	65mm
95%	5%	60mm
90%	10%	50mm
88%	12%	48mm
80%	20%	45mm

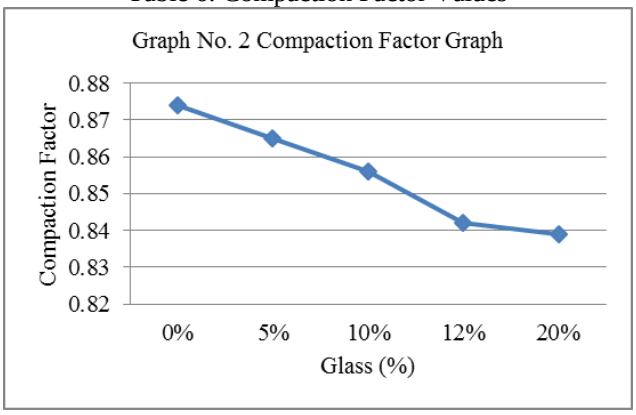
Table 5: Slump Height Values



B. Compaction Factor Test:

TYPE OF AGGREAGRE		COMPACTION FACTOR
RIVER SAND	GLASS POWDER	
100%	0%	0.874
95%	5%	0.865
90%	10%	0.856
88%	12%	0.842
80%	20%	0.839

Table 6: Compaction Factor Values

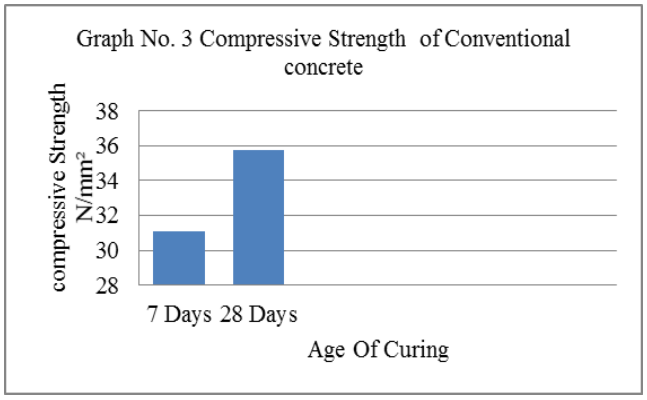


1) Conventional Concrete

Conventional concrete was also known as normal concrete, which has ingredients such as aggregates, water and cement.

Tests	Curing days	Strength (N/mm²)
Compression test	7	31.12
	28	35.745

Table 7: Test results for conventional concrete

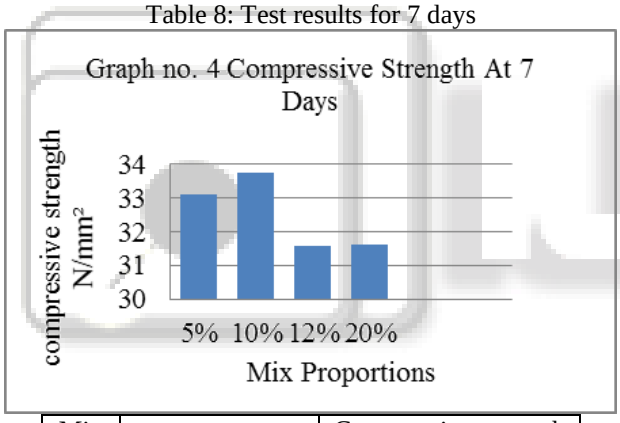


2) Designed Concrete for Various Mixes

The fundamental object in proportioning concrete mixes is the production of a durable material of requisite strength, water tightness, and other essential properties at minimum cost. To achieve this careful attention must be taken to selection of cement, aggregate, and water.

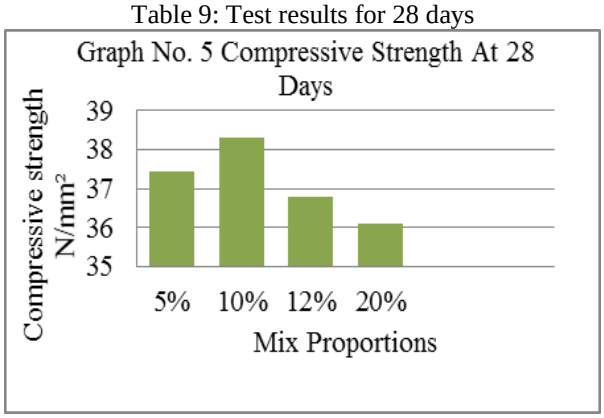
Mix	Age of concrete	Compressive strength (N/mm²)
5%	7	33.13
10%	7	33.74
12%	7	31.595
20%	7	31.63

Table 8: Test results for 7 days



Mix	Age of concrete	Compressive strength (N/mm²)
5%	28	37.45
10%	28	38.31
12%	28	36.785
20%	28	36.115

Table 9: Test results for 28 days



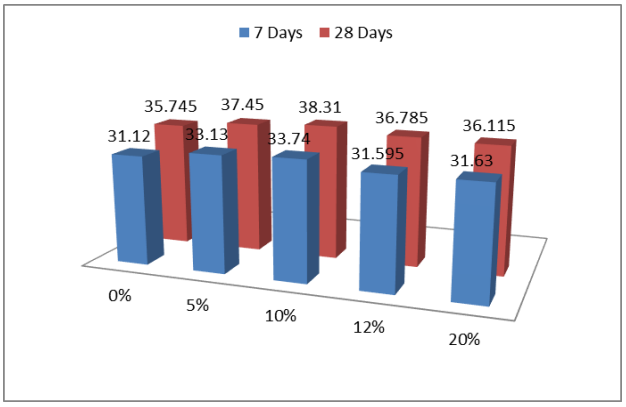


Fig. 7: Compressive Strength Comparison

IV. CONCLUSION

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

1) This experimental study required to identify the effects of using waste glass as a partial replacement for fine aggregate in concrete
2) With increasing proportion of waste glass powder in the concrete mix the workability of the fresh concrete decreases, due to the angular nature of the glass particles.
3) Slump gradually decreased with increase in glass percentage.
4) Compaction factor values gradually decreased with increase in glass percentage.
5) Compressive strength was found to increase with the addition of waste glass to the mix up until the optimum level of replacement. This can be attributed to the angular nature of the glass particles facilitating increased bonding with the cement paste.
6) 10% replacement of fine aggregates by waste glass showed optimum increase in compressive strength at 7 and 28 days.
7) By using waste glass as partial replacement of fine aggregate, compressive strength increases up to 10% by 7.18%, but after that, it starts decreasing for 12% & 20%.
8) Fine aggregates can be replaced by waste glass up to 20% by weight as there is no much difference between 20% replacement level & 0% replacement level.
9) Use of waste glass in concrete can prove to be economical as it is non useful waste and free of cost.
10) Use of waste glass in concrete will remove the disposal problem of waste glass and prove to be environment friendly thus paving way for greener concrete.
11) Use of waste glass in concrete will preserve natural resources particularly river sand and thus make concrete construction industry sustainable.

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