Experimental Investigation on Partial Replacement of Waste Glass Powder by Fine Aggregate in Concrete

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***Abstract* - 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 waste glass powder as 10%, 20% and 30% by weight for M-25 mix. The concrete specimens were tested for compressive strength, durability (water absorption) and density at 28 days of age and the results obtained were compared with those of normal concrete. The results concluded the permissibility of using waste glass powder as partial replacement of fine aggregates up to 20%.**

Keywords - Waste glass powder, concrete, compressive strength and Workability.

1. 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.

Normally glass does not harm the environment in any way because it does not give off pollutants, but it can harm humans as well as animals, if not dealt carefully and it is less environment friendly because it is non- biodegradable Glasses and its powder have been used as a construction material to decrease environmental problems. Glass material contents contribute greater strength and better thermal insulation due to its better thermal properties of the glass aggregate. When waste glasses are reused in making concrete products, the production cost of concrete will go down. Using crushed glass material for the replacement of natural sand can be justified both as a remedial for waste disposal and also for reducing environmental degradation.

The main factor limiting the replacement of waste glass in concrete is Alkali-Silica Reaction (ASR). The silica in the glass reacts with the alkalis in the cement and form a gel like structure (ASR gel). This gel can absorb water and swell inside the microstructure of the concrete. This swelling causes internal stresses. When these internal stresses exceed the strength limit of concrete, then severe cracking and damage can occur. Reduction of the size of glass aggregates, witnessed no alkali-silica reaction. The susceptibility of glass to alkali implies that coarse glass or glass fibres could undergo ASR in concrete, possibly with deleterious effects. However, the fine ground glass is an effective ASR suppressant, preventing ASR damage to the concrete.

1.1 Crushed Waste Glass

The waste glass used in this project is crushed waste glass which are collected from the scrap. After collecting, all the unwanted materials, like labels are removed. Then it is washed and crushed into required sizes.

1.2 Objectives

The primary objectives of this study are to improve the strength properties of partial replacement of fine aggregate to waste glass powder in concrete so as to make it suitable for construction of any civil engineering structures.

The specific objectives of this work include:

- To study the workability of concrete using crushed waste glass powder as partial replacement for fine aggregate.
- To study the compressive strength of concrete

using waste glass powder as partial replacement for fine aggregate.

- To study the density of concrete using crushed waste glass powder as partial replacement for fine aggregate.
- To compare the cost of concrete using crushed waste glass powder as partial replacement for fine aggregate with normal conventional specimen.
- To attain more strength while comparing to the normal concrete.

2. LITERATURE REVIEW

We have referred the data from the international journal of innovative research in science, engineering and technology. Following are the literature reviews over Partial replacement of fine aggregate by waste glass powder in concrete.

1) M.Vijaya Sekhar Reddy(2015) In this paper, the issues of environmental andeconomic concern are addressed by the use of waste glass as partial replacement of fine aggregates in concrete. Fine aggregates were replaced by waste glass powder (GP) as 10%, 20%, and 30% by weight for M20 mix. The concrete specimens were tested for compressive strength at seven and 28 days of age and the results obtained were compared with those of normal concrete. The study indicated that waste glass can effectively be used as fine aggregate replacement (up to 20%) without substantial change in strength.

2) B.V. Kavyateja(2016) The study provides details regarding exploratory examination on the suitability of squashed glass as partially replaced for fine total in solid generation. The control blending proportion of 1: 1.5: 3 grouped by volume with water – bond proportion of 0.5 were utilized. The compressive qualities of cured solid 3D shapes of sizes 150mm x 150mm x 150mm were assessed at 3days, 7days, 28 days, 56 days, and 90 days.

To obtain the test results the workability is increased, compressive strength is increased up to 20% replacement level and at 30%, 40% replacement level it goes to decreasing, and Splittensile strength is slightly decreasing as compared to normal concrete.

3) G.Vijayakumar(2013) Cement manufacturing industry is one of the carbon dioxide emitting sources besides deforestation and burning of fossil fuels. The global warming is caused by the emission of green house gases, such as CO_2, tothe atmosphere. Glass powder was partially replaced as 10%, 20%, 30% and 40% and tested for its compressive, Tensile and flexural strength up to 60 days of age and were compared with those of conventional concrete.

4) Kumar Animesh(2017) Concrete is the mixture of various materials coarse aggregate, fine aggregate, cement & water, each of them is mixed in various proportions to achieve specific strength. Cement being the most important material plays an important role in the manufacturing of concrete. Waste glass in the form of fine aggregate & coconut shell as coarse aggregate can be used. The Proportion of the mineral and mixture is applied in testing cubes for their workability, compression strength and flexural strength. This paper briefly discusses the effects of addition of glass powder & coconut shell on the properties of mortar concrete mix of M25 at 28 days four concrete mix with fibre dosages 0%, 5%, 10% & 20% of the weight concrete mix. The result of glass powder & coconut shell concrete for 7 days, 28days, curing of concrete. The testing of concrete according to Indian standard specification to identify the effect of workability and mechanical strength properties due to doses glass powder & coconut shell.

5) Kamal Ranout (2018) To find out compressive strength, flexural strength and tensile strength of concrete by using waste glass as a fine aggregate and to check internal structure of concrete by SEM test and XRD test. Waste glass is the better idea to use in concrete as fine aggregate as India produce 22 million metric ton of waste glass per year and recycles only 45% of it. Fine aggregate replaced by glass with 3%, 6%, 9%, 12%, 15% in M40 mix. In this research also Alccofine 1203 used to provide additional strength to concrete. Alccofine addition to glass as additive helps to improve the strength properties of glass concrete due to its micro sixe.Strength increases as replacement of 5%, 7%, to 9% due to angular shape of glass molecules.

3. MATERIALS

The following materials have been used in this investigation.

1. Cement
2. Fine Aggregate
3. Coarse Aggregate
4. Waste Glass Powder

3.1 Cement

The Ordinary Portland cement 53 Grade is used.

3.2 Fine Aggregate

Ordinary river sand is used as fine aggregate. The sand is sieved in 2.36mm sieve as the sand passing through this sieve is use as fine aggregate.

3.3 Coarse Aggregate

The ordinary coarse aggregate is sieved in 20mm sieve and the aggregate passing through the 20mm sieve is used as coarse aggregate.

3.4 Waste Glass Powder

The waste glass used in this project is crushed waste glass which are collected from the scrap. After collecting, all the unwanted materials, like labels are removed. Then it is washed and crushed into required sizes.

4. METHODOLOGY

First we conducted test on materials. Next we prepared M25 mixture based on mix design as per IS 10262-2009.

4.1 TESTS ON MATERIALS

CEMENT:

- Setting Time Of Cement
- Normal Consistency Of Cement
- Specific Gravity Of Cement
- Compressive Strength Of Cement
- Fineness Of Cement

FINE AGGREGATE:

- Specific Gravity
- Sieve Analysis (Gradation)

COARSE AGGREGATE:

- Crushing Value
- Water Absorption
- Sieve Analysis Test (Gradation)

GLASS POWDER:

- Specific Gravity
- Sieve Analysis

Fig 1: Glass Powder

Table 4 Chemical Composition of Waste Glass

Components	Percentage (%)
Silica (SiO2)	70.4
Alumina (Al2O3)	1.9
Iron Oxide (Fe2O3)	1.2
Magnesium Oxide (MgO)	10.3
Sodium Oxide (Na2O)	14.0
Potassium Oxide (K2O)	0.4

5. MIX PROPORTION

The tests are carried out on water-cement ratio of 0.5. The control mix (M25) is designed in accordance with IS 10262-2009 guidelines.

For making the mixes containing glass powder, the amount of powder is calculated by using the weight of powder in place of the weight of sand. Based on the physical properties of the materials used in the concrete mix design was done.

Table 5 Mix Proportion for M25 Mixes

Mix Designation	CC	Mix 1 (10%)	Mix 2 (20%)	Mix 3 (30%)
Cement (kg)	2.11	2.11	2.11	2.11
Fine Aggregate (kg)	2.11	1.899	1.688	1.477
Coarse Aggregate (kg)	4.22	4.22	4.22	4.22
Water Cement ratio	0.5	0.5	0.5	0.5
Crushed Waste Glass (kg)	0	0.211	0.422	0.633

6. EXPERIMENTAL WORK

6.1 Workability

Each batch of concrete shall be tested for consistency immediately after mixing by one of the methods described in IS 1199-1959 provided that care is takento ensure that no water or other material is lost, the concrete used for the consistency tests may be remixed with the remainder of batch before making the test specimen. The period of remixing shall be short as possible yet sufficient to produce ahomogenous mass.

6.2 Slump Test

The test is carried out using a mould known as a slump cone or Abram's cone. The cone is placed on a hard non-absorbent surface. This cone is filled with fresh concrete in 3 stages, each time it is tamped using a rod of standard dimensions. At the end of the third stage, concrete is struck off flush to the top of the mould. The mould is carefully lifted vertically upwards, so as not to disturb the concrete cone Concrete subsides. This subsidence is termed as slump and is measured into the nearest 5mm if the slump is <100mm and measured to the nearest 10mm if the slump is greater than 100mm.

6.2 Compressive Strength of Concrete

The compression strength of any material is defined as the resistance of failure under the action of compression forces. The compressive strength is the capacity of a material or structure to withstand loads tending to reduce size. The compression test was conducted on concrete specimen cured for 7 days and 28 days**.** The top and bottom bearing plates of the compression testing machine were wiped and cleaned before the placement of the specimens. After ensuring the connection between the specimen was placed on the lower bearing plate keeping the centre alignment by the screwed guides of the bearing plate. The load is applied until the specimen fails and the ultimate load is noted and the results were recorded.

6.3 Preparation of Test Specimen

The ingredients for the various mixes were weighed and prepared the mixes by tilting drum type concrete mixture machines. Precautions were taken to ensure uniform mixing of ingredients. The specimen were cast in steel mould and compacted by a tamping rod. The specimens of 150mm × 150mm × 150mm size of cubes and 150mm diameter 300mm high cylinder specimens were casted for the determination of compressive strength

and split tensile strength at different ages respectively.

Fig 2: Concrete Mixing

Fig 3: Casting of

Specimen

Fig 4: Curing of Specimen

6.4 Water Absorption Test

This test is to determine the susceptibility of an unsaturated concrete to the penetration of water. This test is to determine the rate of absorption of water by measuring the increase in the mass of a specimen resulting from absorption of water as a function of time when only one surface of the specimen is exposed to water.

Fig 5: Water Absorption Test

7. RESULT AND DISCUSSION

7.1 Workability Test

Slump test is used to determine the workability of fresh concrete. The test was followed as per IS 1199-1959. The result of the slump test was represented in table.

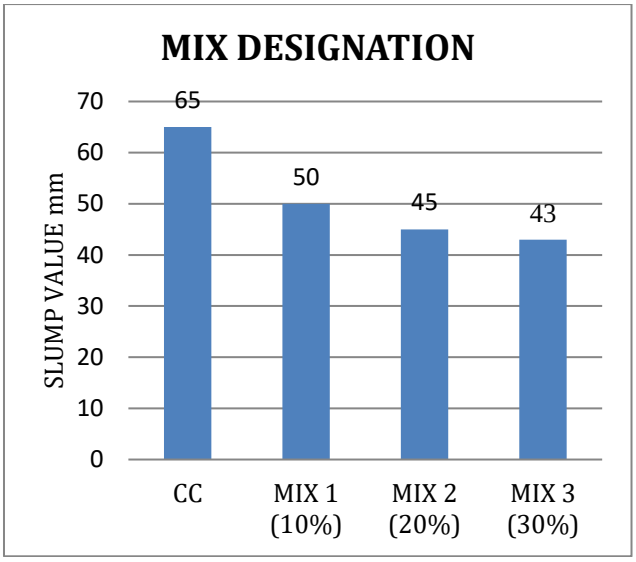

Fig 6: Slump Test

7.2 Compressive Strength Test

Average compressive strength for 7 days and 28 days obtained by taking average of specimens for each day are compiled below.

Fig 7: Compressive Strength

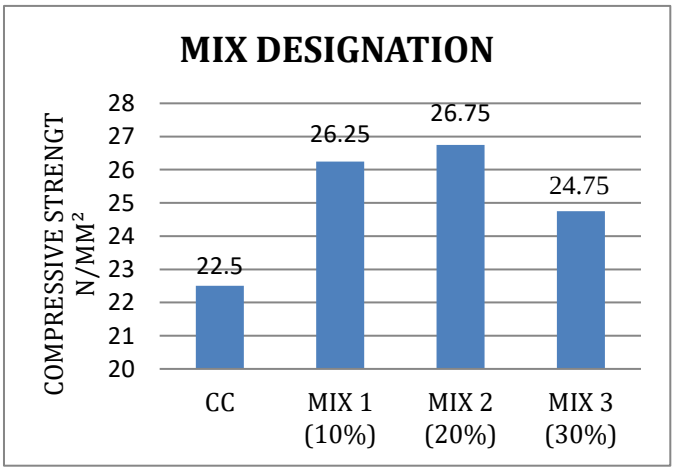

Fig 8: Compressive Strength Test for 7 Days

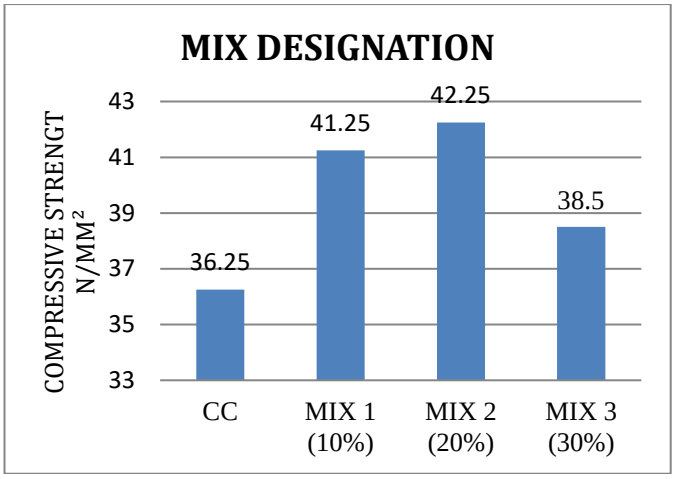

Fig 9: Compressive Strength Test for 28 Days

8. CONCLUSION

- Replacement is done in concrete with crushed waste glass in fine aggregate with different percentages of 10%, 20% and 30% respectively.
- To find the mechanical properties of concrete mix design for M25 had been carried out and cubes were casted.
- Maximum compressive strength for 7 and 28 days is obtained in conventional mix is of 22.50 N/mm^2 and 36.25 N/mm^2.
- Maximum compressive strength for 7 and 28 days is obtained in replacement mix is of 26.25 N/mm^2 and 42.25 N/mm^2.
- There exist high potential for the use of crushed glass as fine aggregate into the concrete for the saving of natural aggregate.
- With increasing of crushed glass particle into the concrete the workability should be increased gradually as compared to normal concrete.
- Crushed glass replaced as fine aggregate into the concrete the compressive strength should be increased up to 20% replacement level and after 30% replacement level it goes to decreasing.

9. REFERENCES

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