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PARTIAL REPLACEMENT OF FINE AGGREGATE BY WASTE GLASS POWDER 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 0%, 5%, 10%, 15%, 20% and 25% by weight for M-20 mix. The concrete specimens were tested for compressive strength, splitting tensile 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 15%.

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 of Present Study

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, Split tensile strength and flexural 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 understand the effectiveness of glass powder in strength enhancement.

2. LITERATURE REVIEW

We have referred the data from the international journal of innovative research in science, engineering and technology (an ISO 3297:2007 certified organization). Following are the literature reviews over Partial replacement of fine aggregate by waste glass powder in concrete.

1) Wang(2015) stated that the re-use of rejected liquid crystal display (LCD) glass & adding it in the concrete (LCDGC) for the replacement of the usual river sand by the sand prepared from rejected LCD glass. Three different mix designs were planned with the 0%, 15%, 20%, 25%, 30% and 40% LCD glass sand replacement investigated; after that their engineering properties were determined. The main results shows that with the partial addition of 20% LCD glass sand to concrete satisfy the requirements of the slump and also improved the engineering properties and the durability of concrete. For Compressive Strength results maximum variation of 3.9% was achieved for 20% replaced specimen.

2) Zainab and Enas(2013) investigated the properties of concrete containing waste glass as fine aggregate. The strength properties and the alkali silica reaction (ASR) expansion were analyzed in terms of waste glass content. Then the total quantity of 80 kg of crushed waste glass was partially swapped with sand at 10%,15%, and 20% in the concrete mix. The result shows 80% of pozzolanic strength activity and 4.23% & 10.99% increase in compressive strength and flexural strength respectively when fine aggregate is replaced by 20% waste glass.

3) Manthar ali keerio & saleem khoso(apr-2017) materials used during this research activity consist of cement, fine aggregate, coarse aggregate, waste glass & water. waste glass was washed, grinded and passed from sieve 325µ. Total 60 specimens were casted keeping cement, fine aggregate and coarse aggregate in ratio 1:1.5:3 water binder ratio is 0.5. Mixture of modified concrete prepared with 5%,10%,15%,20%&25% replacement of fine aggregate by waste glass. On the basis of conducted research it can be concluded that workability of concrete increases as the dosage of waste glass increases, the maximum increase in workability was observed at 25% substitution of fine aggregate with waste glasses.

4) Jangid jitendra and Saoji(2014) In this research the flexural and compressive strength will increase when 20% of fine aggregates are replaced by waste glass powder and the compressive strength so obtained is 34.4 MPa and flexural strength is 3.9MPa.

5) M Iqbal Malik & Muzaffar Basher(7july-2013) In this research fine aggregate were partially replaced by waste glass as 10%,20%,30%&40% by weight. Concrete specimens were tested for compressive strength, split tensile test, durability, workability. The result shows 20% replacement of fine aggregates by waste glass increased by 15% (24.73MPa) & 25% (35.11MPa) for compressive strength at 7 days & 28 days respectively. Split tensile test results shows decrease of 9.80% (2.30MPa) for 20% replacement.

6) Mannava Anusha(2016) Glass powder (GP) used in concrete making leads to greener environment. In shops, damaged glass sheets & sheet glass cuttings are go to waste, which are not recycled at present and usually delivered to landfills for disposal. This project examines the possibility of using GP as fine aggregate replacement in concrete. Natural sand was partially replaced (0%-30%) with GP in concrete. For 10% replacement of fine aggregate result shows increment of 9.66% (57.45MPa), 15.45% (3.95MPa) and 69.39% (7.86MPa) for Split Tensile strength, Compressive strength and Flexural strength respectively for 28 days of curing.

7)Dr.Haider Ammash & Ali Nahhab(june-2009) Reported that the addition of waste glass as a partial

replacement of fine aggregate leads to decrease 7.56%(34.2 Mpa) in compressive strength & split tensile strength 18.9%(3.00MPa) compare to conventional concrete. The acceptable expansion has been achieved upto 20% replacement by the result of present study.

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 43 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. Nex twe prepared M20 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
- Finess 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

5. RESULTS AND DISCUSSION

COMPRESSIVE STRENGTH TEST

To determine the Compressive strength of given concrete cubes.
Observation:
Size of cube = 15cm×15cm×15cm
7 days compressive strength:

Sl.No	Replacement by Glass Powder in %	C/S Area in mm2	Load at failure in (Ton)	Compressive strength in N/mm²
1	0%	22500	40	17.33
		22500	39.5	
2	5%	22500	48	21.148
		22500	49	
3	10%	22500	55.71	24.29
		22500	55.2	
4	15%	22500	56.7	24.73
		22500	56.5	
5	20%	22500	51.30	22.37
		22500	51.2	
6	25%	22500	41.4	18.07
		22500	41.2	

Table 1: 7 days Results of compressive strength test

28 days compressive strength:

Sl.No	Replacement by Glass Powder in %	C/S Area in mm2	Load at failure in (Ton)	Compressive strength in N/mm^2
1	0%	22500	57.5	25.425
		22500	59.15	
2	5%	22500	64.38	28.07
		22500	64.2	
3	10%	22500	77.27	33.69
		22500	76.5	
4	15%	22500	80.52	35.11
		22500	78.80	
5	20%	22500	70.65	30.82
		22500	70 .20	
6	25%	22500	58.90	25.69
		22500	60.05	

Table 2: 28 days Results of compressive strength test

GRAPH

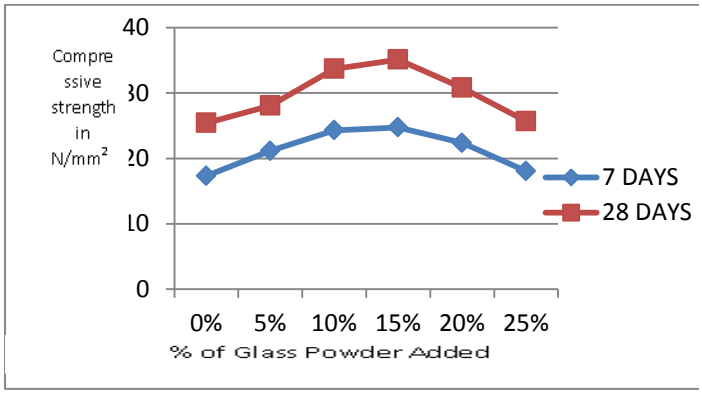

Fig 2: Graph on Replacement by Glass Powder v/s Compressive strength

Discussions:

It is observed that,

- The compressive strength of the concrete at 7 days for 10% replacement of the coarse aggregate with expanded clay is 5.33% more than the normal cement concrete cube.
- The compressive strength of the concrete at 28 days for 10% replacement of the coarse aggregate with expanded clay is 3.83% more than the normal cement concrete cube.

SPLIT TENSILE TEST

To find the Vertical Compressive stress and Shearing Stress by Split Tensile Test for the given concrete.

Observation:

Length of the specimen = 30cm

Dia of the specimen = 15cm

Horizontal stress = $\frac{2P}{\pi LD}$

Where, P= Compressive load at failure

L= Length of specimen

D= Dia of Cylinder

Sl.No	Replacement by Glass Powder in %	Load at failure in (Ton)	Horizontal Stress in N/mm^2
1	0%	9.45	2.01
		9.2	
2	5%	9.72	2.12
		9.5	
3	10%	9.54	2.08
		9.45	
4	15%	9.26	2.02
		9.1	
5	20%	9.90	2.16
		8.65	
6	25%	8.76	1.91
		8.67	

Table 3: 7 days Results of split tensile test

Sl.No	Replacement by Glass Powder in %	Load at failure in (Ton)	Horizontal Stress in N/mm^2
1	0%	19.02	4.16
		18.75	
2	5%	20.1	4.38
		20.09	
3	10%	19.75	4.31
		19.7	
4	15%	22.60	4.94
		22.55	
5	20%	18.45	4.02
		18.5	
6	25%	17.60	3.72
		17.58	

Table 4: 28 Days Results of Split Tensile Test Graph:

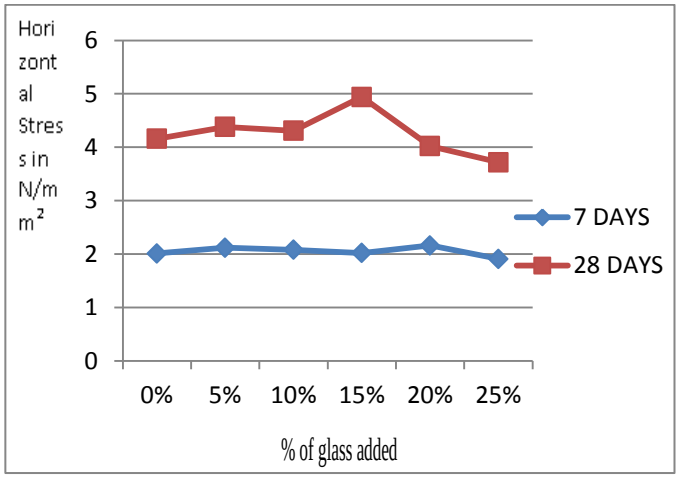

Fig 3: Graph on Replacement by Glass Powder v/s Split tensile strength

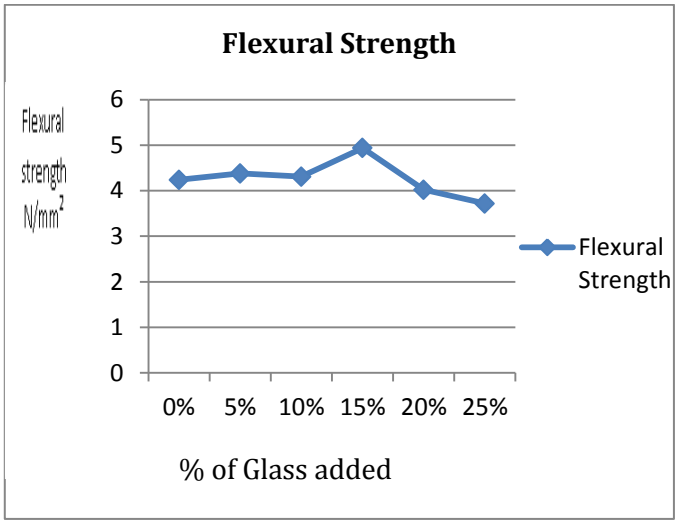

Fig 4: Graph on Replacement by Glass Powder v/s flexural strength

Discussions:

It is observed that,

- The Horizontal stress of the concrete at 7 days for 10% replacement of the coarse aggregate with expanded clay is 7.46% more than the normal cement concrete cylinder.
- The Horizontal stress of the concrete at 28 days for 10% replacement of the coarse aggregate with expanded clay is 12.78% more than the normal cement concrete cylinder

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FLEXURAL STRENGTH TEST

28 days strength:

Sl.No	Replacement by Glass Powder in %	Flexural strength N/mm²
1	0%	4.24
2	5%	4.38
3	10%	4.31
4	15%	4.94
5	20%	`4.02
6	25%	3.72

Table 5: 28 days results of flexural strength test

6. CONCLUSIONS

Based on the results it has been concluded that,

- The concrete with waste glass powder is proved to be better than conventionally cured concrete by all means.
- The addition of waste glass powder increases the degree of hydration, producing a denser microstructure leading to better curing.
- The compressive strength for the waste glass powder concrete resulted in values 42.70% higher for 7days &38.70% for 28days when compared to the plain concrete with a replacement of waste glass powder by 15%.
- The split tensile strength for the waste glass powder concrete resulted in values 3.48% for 7days higher when compared to the plain concrete with an replacement of waste glass powder by an 10%. The split tensile strength for the waste glass powder concrete resulted in values 18.75% for 28days higher when compared to the plain concrete with an replacement of waste glass powder by an 15%.
- For 15% replacement by the waste glass powder is the optimum percentage to yield the strength.
- The flexural strength for the waste glass powder concrete resulted in values 16.50% for 28 days

higher when compared to the plain concrete with an replacement of waste glass powder by an 15%.

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