Study on Mechanical Properties of Glass Sand Concrete (GSC)

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Abstract- The World's infrastructure is mostly composed of concrete. It plays vital role in construction industry and major contribution in depletion of environment. Exploration of river sand for manufacturing of concrete is a major environmental concern. Many researchers are working to identify the better replaceable material for natural river sand. The present study focuses on feasibility of glass sand obtained from waste glass as an alternative for natural river sand.River sand is replaced with glass sand at various proportions varying from 50 to 100%. The workability of concrete is decreased with an increase in proportion of glass sand. On the contrast, the average compressive strength increased with an increase in proportion of glass sand. However, workability is observed to increase with use of PLSTOL341 super plasticizer.

Key Words: Glass Sand(GS), River Sand(RS), Glass Sand Concrete-GSC, Compressive Strength, Tensile Strength, Workability

1. INTRODUCTION

Concrete is most widely used material in construction industry. In India, the consumption of concrete is increasing day to day along with construction rate. River sand is one of the constituentof conventional concrete whichis obtained from rivers.The procurement of sand from rivers seriously affects the ground water recharge. Natural formation of river sand in river beds takes a long time, which eventually results in scarcity of river sand in peak construction periods. This situation alarms the need of substitute material for river sand.Glass is one the major solid waste which is of serious concern to environment. The disposal of waste glass is one of the prominent solid waste management problem in urban areas.The major component of glass and sand being Silica makes it the most suitable material for replacement of Sand in concrete. This study emphasizes on use of waste glass as fine aggregate. It is achieved by pulverizing the waste glass to particles of size less than 4.75 mm as shown below figure 1. Table 1 illustrates the mechanical properties of glass.

Figure 1.Glass Sand

Table 1: Mechanical Properties of Glass

S.No	Property	Values
1	Density	2500 kg/m^3
2	Hardness	470 HK
3	Compressive resistance	800 – 1000 MPa
4	Modulus of Elasticity	70000 MPa
5	Bending Strength	45 MPa
6	Specific Gravity	2.6

Background Study

Bajid et.al (2011) investigated mechanical properties of concrete by replacing Glass powder. The replacement of cement by 20 % of glass powder yielded 30 % increase in compressive strength and 22% increase in flexural strength.

Mizi fan (2014) conducted studies on replacement of fine aggregate with glass sand. It was observed that 5 % increase in compressive strength was obtained with 20 %replacement of sand. Also, the degree of workability reduced with gradual increase of glass sand.

Kiang Hwee Tan (2014) statedthat complete replacement of fine aggregate with glass sand has no significant effect on the mechanical properties of concrete. On the contrary, it led to an increase in compressive strength, splitting tensile strength & flexural strength. The drying shrinkage was slightly reduced with the use of glass sand in lower strength concrete.

Bhat & Bhavanishankar Rao(2014) concluded that an increase of 27% compressive strength was achieved with 20% replacement of cement by glass powder. However, the water cement ratio has significant effect on compressive strength.

2. MATERIALS & METHODOLOGY:

2.1Cement: Ordinary Portland cement (53 grade) of single batch was used throughout project. The physical properties of cement are determined according to IS. Table 2 summarizes the physical properties of cement.

Table 2. Physical properties of Cement

S. No	Property	IS Code	Value
1	Specific gravity		3.15
2	Fineness		8.5%
3	Consistency		30%
4	Initial setting time		35min
5	Final setting time		5hr 35min

2.2Fine Aggregates: Waste glass obtained from local source was thoroughly washed and pulverized to size lessthan 4.75 mm. The particle size distribution (Figure 2, Figure 3) illustrates the properties of river sand and glass sand confirming to zone-II according to IS:383-1970 and specific gravities are 2.62 & 2.67 respectively.

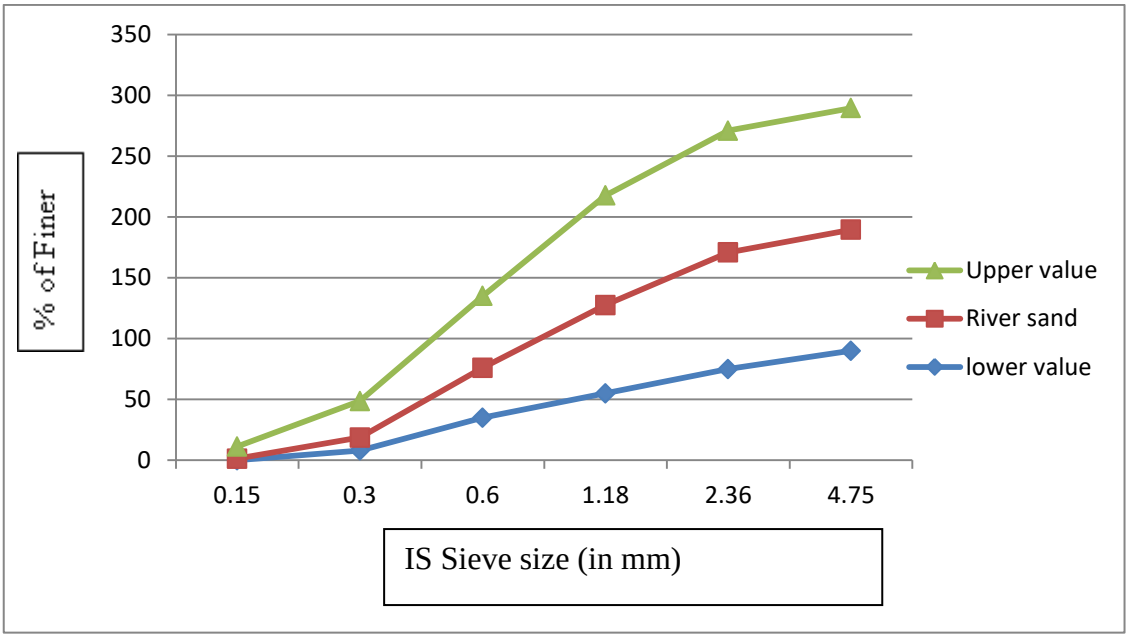

Figure 2. Sieve analysis of river sand

2.3 Coarse Aggregates: Aggregates of irregular shape and size varying between 10 mm –20mm were used in 2:3 proportion throughout the project to ensure the uniformity of the results. The specific gravity of 10mm, 20mm aggregate resulted as 2.67 and 2.70 respectively.

2.4 Admixture: Superplasticizer (PLASTOL341) is a polycarboxylate based mid-range/ high-range water reducing & plasticizing admixture. PLASTOL341 was used in a proportion of 0.5% of cement weight in the present study to ensure required workability.

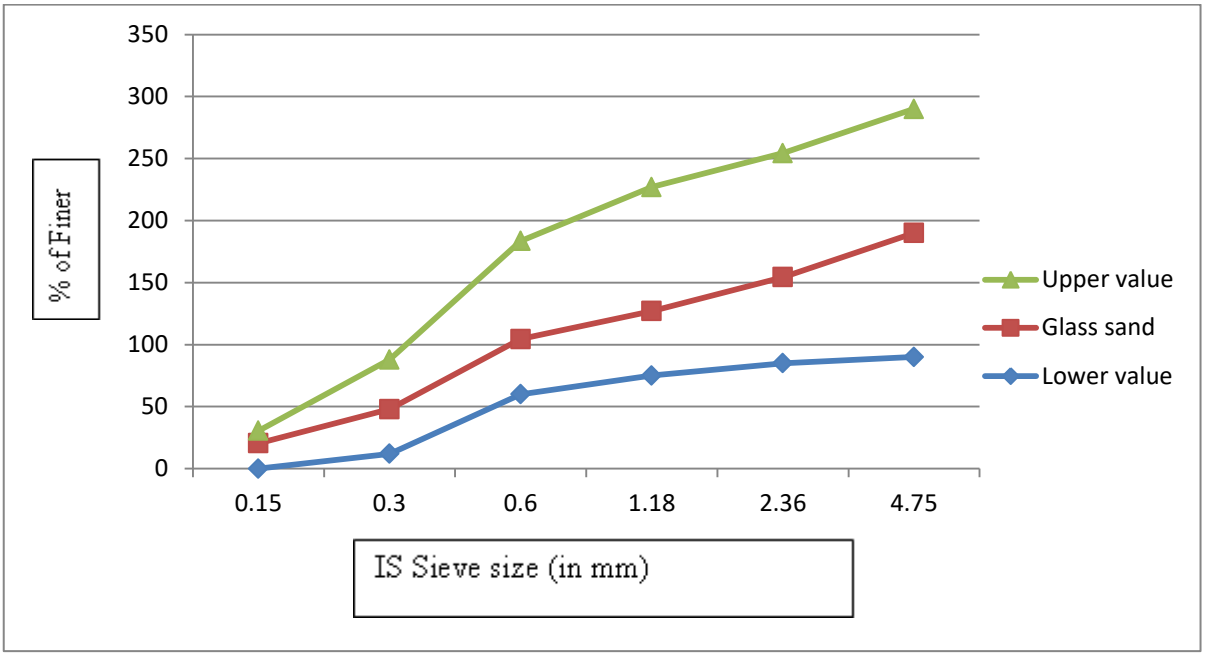

Figure 3. Sieve analysis of glass sand

2.5 Water: Fresh Water (confirming to IS standards) was used for testing of materials, mixing of concrete and curing of concrete specimens.

3. EXPERIMENTAL PROCEDURE

The concrete mix design of M40 was adopted as per IS: 10262-2009 & IS:456-2000. The materials confirming to IS standards are adopted for the mix design. The properties of materials (coarse aggregate, cement, glass sand and river sand) used in the present study are illustrated in Table 3 below.

Table 3. Properties of materials

S. No	Property	Value
1	Maximum aggregate size (MAS)	20mm
2	Shape of aggregates	Angular
3	Degree of quality control	Good
4	Type of exposure	Moderate
5	Specific gravity of cement	3.15
6	Specific gravity of river sand	2.62

7	Specific gravity of glass sand	2.67
8	Specific gravity of coarse aggregate	2.70
9	Zone of river sand	Zone II
10	Zone of glass sand	Zone II

3.1Estimation of quantities

IS:456-2000 (table 5) suggests maximum water/cement ratio of 0.50. Hence, water cement ratio of 0.4 is chosen for present study. IS:10262-2009 (table 2)suggests water content of 186 liters for MAS20mm for a slump of ___. Hence, 197 liters of water is estimated to attain a slump value of 100mm. Cement content of492.5 Kgwas obtained according to adoptedwater cement ratio of 0.4. Further,the estimation of quantities for proportioning were carried out according to design mix(M40) 1:0.4:1.30:2.16 with 0.5% of admixture content. IS:10262-2009 suggests the selection of final mix proportion based on three trial mix results by varying water cement ratio and slump. The results of various trial mix adopted in the present study are listed in Table 4. The results indicate that T1 mix (1:0.4:1.30:2.16) yielded satisfactory values of strength & workability.

Table 4. Trial mix results

S. No	Mix Design	Compressive strength (MPa), 28 days	Split tensile strength (MPa), 28 days	Workability (mm)
1	T-1 (1:0.4:1.79:2.98)	53.82	3.26	150
2	T-2 (1:0.3:1.27:2.12)	52.72	3.12	135
3	T-3 (1:0.4:1.79:2.98)	50.70	3.10	120

3.2Mix proportions in glass sand: The variation of proportion of glass sand was decided based on physical properties of glass sand. The proportions of glass sand varried in the T1 mix (1:0.4:1.30:2.16) and the corresponding notations along are indicated in table 5 below.

Table 5. Glass sand concrete results

S. No	Notation	Proportion of glass sand	Compressive strength (MPa), 28 days	Split tensile strength (MPa), 28 days	Workability (mm)
1	GS - 1	60 %	53.87	3.40	150
2	GS – 2	70 %	54.72	3.42	140
3	GS – 3	80 %	56.51	3.47	130
4	GS – 4	90 %	57.72	3.54	120

5	GS –5	100 %	58.72	3.64	100

4. RESULTS

4.1Compressive strength

The compressive strength is considered as a prominent factor to determine the strength of hardened concrete. Concrete specimens of (150x150x150) mm were casted as per IS: IS:516-1959. The results indicated maximum compressive strength of concrete corresponding to 100% replacement (GS – 5) of glass sand in river sand, refer Table No:5

4.2 Split tensile strength

The tensile strength of concrete is determined indirectly with split tensile strength. Cylindrical specimens of dimensions 100 mm diameter and 300mm length were used to measure split tensile strength. The specimens were cast and cured for 28 days. The testing of specimens was conducted as per IS:516-1959. It can be inferred that, with an increase in proportion of glass sand in concrete, tensile strength of concrete increased along with compressive strength, refer Table No:5

4.3 Workablity

The workability of concrete tested by using slump cone equipment. Initially T1 mix got 150mm slump at 0.5% of admixture content. Glass sand content varying in riversand, observed workability of concrete reduced gradually at same admixture content. When 100% replacement of glass sand in riversand achieved good workability of 100mm slump, refer Table No:5

5.CONCLUSIONS

1. The increase in glass sand percentage in riversand, resulted in increase of compressive strength gradually.The 100% replacement of glass sand in riversand achieved 45% more characterstic compressive strength than conventional concrete.
2. The increase in glass sand percentage in riversand, resulted in increase of split tensile strength gradually.The 100% replacement of glass sand in riversand achieved 13% more split tensile strength than conventional concrete.
3. The workability of concrete influenced by addition of glass sand in fine aggreagte. The increased in percentage of glass sand in concrete, increased the fines percentage there by moisture content has decreased.Hence resulted in reduction of workability of concrete. Which can be improved by the addition of super plasticizer (PLASTOL 341) at 0.5% weight of cement.

4. The improved in results from the above three conclusions have satisfied the codal provisions. So the construction industry can use glass sand as a substitute material of riversand and thereby reduces the disposal problem of waste glass in urban areas.

REFERENCES