Partial Replacement of Fine Aggregates by using Waste Glass

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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 thesis, the issues of economic and environmental 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 5%, 10%, 15% and 20% by weight for M-25 mix. The concrete specimens were tested for consistency, compaction factor and compressive strength 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% by weight for particle size of range 0-1.18mm. We estimate increase in slump value, compaction factor and compressive strength

Keywords – sustainability, waste glass powder, replacement of sand

I. INTRODUCTION

In India, 0.7% of total urban waste generated comprises of glass. Waste glass is crushed into specified sizes for use as aggregate in various applications such as water filtration, grit plastering, sand cover for sport turf and sand replacement in concrete. Concrete is most widely used man made construction material and its demand is increasing day by day. 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. Fine glass powder for incorporation into concrete up to 30% as a pozzolanic material suppressed the ASR. Hence the size of waste glass used was in the range 0-1.18mm. In this research, fine aggregates were partially replaced by waste glass as 5%, 10%, 15%, and 20%by weight. Concrete specimens were tested for compressive strength. The results obtained were compared with results of normal M-25 concrete mix and it was found that maximum increase in compressive strength occurred for the concrete mix containing 10% waste glass as fine aggregate. With increase in waste glass content, water absorption decreased indicating increase in durability. Density of concrete decreased with increase in waste glass content thus making concrete light weight in nature. This paper summarized the behavior of concrete involving replacement of fine aggregates by waste glass as 5%, 10%, 15%, and 20% by weight which may help to reduce the disposal problems of waste glass and enhance properties of concrete.

II. METHODOLOGY

Materials Used and Tests Carried Out On Materials:

Concrete is a composite construction material composed primarily of aggregate, cement and water .There are many formulations that have varied properties. The aggregate is generally coarse gravel or crushed rocks such as limestone, or granite, along with a fine aggregate such as sand. The cement, commonly Portland cement and other cementitious serve as a binder for the aggregate. Water is then mixed with this dry composite which enables it to be shaped (typically poured) and then solidified and hardened into rock-hard strength through a chemical process known as hydration .There are many types of concrete available, created by varying the proportions of the main ingredients below. In this way or by substitution for the cemetitious and aggregate phases, the finished product can be tailored to its application with varying strength, densityor chemical and thermal resistance properties.

Composition of Concrete:

- Cement
- Aggregates
  Coarse aggregate&Fine aggregate
- Water

Compressive strength of standard (1:3) cement sand mixture as PER IS code:
For 3days = 50% strength should be attained
For 7days =70% strength should be attained
For 28days = 100% strength should be attained
EXPERIMENTAL RESULTS OF STRENGTH:
For 3days = 27.66 Mpa
For 7days = 38.66 Mpa
Fineness modulus of the sample of cement taken = 5 %
Bulk density of cement =1415 kg/m^3
REACTION:

Cement chemist notation: $C_3S + H \rightarrow C\text{-}S\text{-}H + CH$

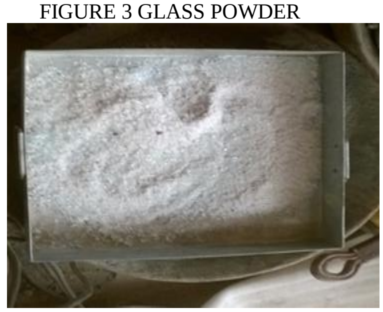
Standard notation: $Ca_3SiO_5 + H_2O \rightarrow (CaO)\cdot(SiO_2)\cdot(H_2O)(gel) + Ca(OH)_2$

Balanced: $2Ca_3SiO_5 + 7H_2O \rightarrow 3(CaO)\cdot2(SiO_2)\cdot4(H_2O)(gel) + 3Ca(OH)_2$

GLASS

FIGURE: 1 WASTE GLASS

FIGURE 3 GLASS POWDER



Glass Powder: Waste glass was collected from autonagar work House, Vijayawada, AP, consisting of waste automobile glass. It was pulverized and then sieved through 1.18mm IS sieve. The specific gravity of waste glass was found to be 2.42. Chemical composition of glass is presented in TABLE 3. Sieved glass powder is sown in fig.3

TABLE 3- Chemical Composition of Glass

Oxides	SiO2	Al2O3	Fe2O3	MgO	Na2O	K2O
Percentage	70.4	1.9	1.2	10.3	14.0	0.4

SIEVE ANALYSIS

TABLE:4 Comparision Of River Standard Glass Powder

IS SIEVE	% OF PASSING (RIVER SAND)	% OF PASSING (GLASS POWDER)	ZONE II (AS PER IS:383)
4.75mm	100	100	90-100
2.36mm	99.7	100	75-100
1.18mm	89	72.3	55-90
600micron	60.9	43.8	35-59
300micron	17.7	28.3	8-30
150micron	3.1	9.9	0-20
75micron	Max 3	Max 15	Max 15
	Zone II		

TABLE: 5 Technical Comparisons of River Sand and Glass Powder:

SL NO	PROPERTY	RIVER SAND	GLASS POWDER	REMARKS
1	Shape	Spherical particle	crystal particle	Good
2	Gradation	Cannot be controlled	Can be controlled	
3	Particle passing 75micron	Presence of silt shall be less than % 3 (IS:383-1970) reaffirmed 2007	Presence of dust particle shall be less than 15%	Limit 3% for uncrushed & limit 15% for crushed sand

4	Silt and Organic impurities	Present (Retard the setting & Compressive Strength)	Absent	Limit of 5% for Uncrushed & 2% for Crushed sand
5	Specific gravity	2.3 – 2.7	2.4 – 2.5	May vary
6	Water absorption	1.5% - 3%	-	Limit 2%
7	Ability to hold surface moisture	Up-to 7%	Up-to 5%	
8	Alkali Silica Reactivity	0.002% -0.01%	0.04%- 0.08%	Limit 0.1% expansion

II. EXPERIMENT AND RESULT

MIX DESIGN FOR M_{25} GRADE CONCRETE

Table 13: FROM TABLE – 6 OF IS: 10262-1982

CHANGE IN CONDITION	WATER ADJUSTMENT (%)	SAND ADJUSTMENT (%)
W/C ratio (-0.1)	0	2.0
Workability (+0.1CF)	+3.0	0
Sand zone (Zone-II)	0	0
Total	+3%	-2%

TABLE: 14 CALCULATED PROPOTIONS:

PARTICULARS	QTY. IN Kg/m^3 OF CONCRETE	MIX PROPORTION BY MASS
Water	202.74	0.4
Cement	506.85	1
Sand	506.04	1
Coarse Aggregates	1081	2

TABLE: 15 QUANTITIES REQUIRED FOR CASTING BY WEIGHT

NS Replaced With GLASS (%)	0%	5%	10%	15%	20%
CEMENT (kg/CUBE)	2.5	2.5	2.5	2.5	2.5
SAND(kg/CUBE)	2.5	2.375	2.25	2.125	2.00
GLASS (kg/CUBE)	0	0.125	0.25	0.375	0.5
COARSE AGG (kg/CUBE)	5	5	5	5	5
WATER (litres)	1.05	1.05	1.05	1.05	1.05

CASTING OF SPECIMENS

The cement and sand were first added and mixed thoroughly in the dry state until homogeneity was achieved. The dry coarse aggregates were added to the mixture and again mixed thoroughly. Water was slowly added and mixed thoroughly for 3 min. After mixing all the ingredients, concrete specimens were cast using steel moulds and compacted with a table vibrator in three layers. For each mix, six 150 x150 x 150 mm cubes were produced for measurement of the compressive strength respectively.

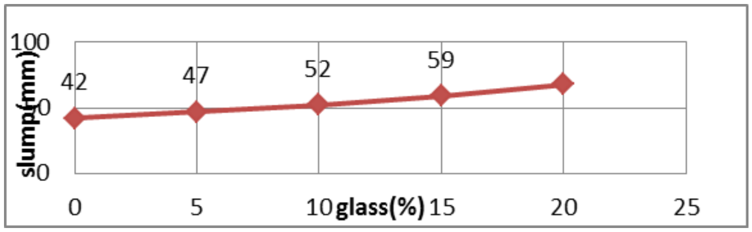
CURING OF SPECIMENS

After 24 h, each specimen was removed from the mould and cured under water at 32 ± 2^oC until testing at age of 7and 28 days for cubes. All specimens were cured in the same water tank to ensure uniform curing conditions.

SLUMP CONE TEST:

TABLE: 16 SLUMP HEIGHT VALUES

TYPE OF AGGREAGRE		SLUMP (mm)
RIVER SAND	GLASS POWDER	
100%	0%	42
95%	5%	47
90%	10%	52
85%	15%	59
80%	20%	68



GRAPH:3 SLUMP TEST GRAPH

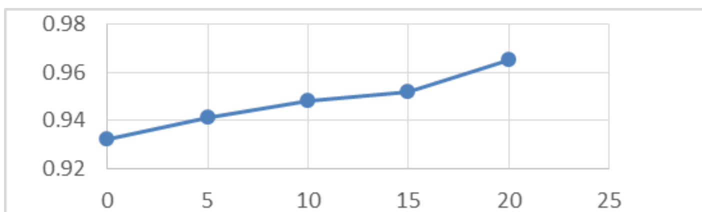
COMPACTION FACTOR TEST PROCEDURE:

Compaction Factor = $\frac{weight of partially compacted concrete}{weight of fully compacted concrete}$

TABLE: 17 COMPACTION FACTOR VALUES

TYPE OF AGGREAGRE		COMPACTION FACTOR
RIVER SAND	GLASS POWDER	
100%	0%	0.932
95%	5%	0.941
90%	10%	0.948
85%	15%	0.952
80%	20%	0.965

GRAPH: 4 COMPACTION FACTOR GRAPH



COMPRESSIVE STRENGTH OF CONCRETE CUBES:

TABLE: 18 COMPRESSIVE STRENGTH OF CUBES AT 7 DAYS:

SL NO	GLASS (%)	LOAD (KN)	COMPRESSIVE STRENGTH AT 7 DAYS (N/mm^2)
1	0	450	20.00
2	5	490	21.77
3	10	555	24.66
4	15	475	21.11
5	20	470	20.88

GRAPH: 6 COMPRESSIVE STRENGTH AT 7 DAYS

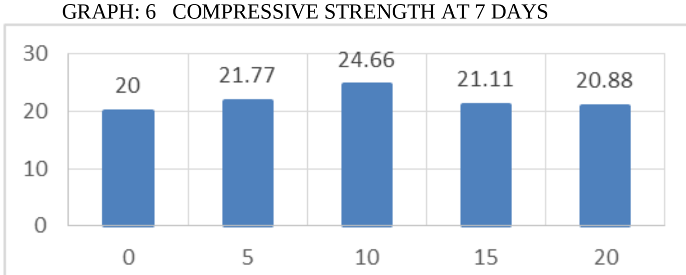
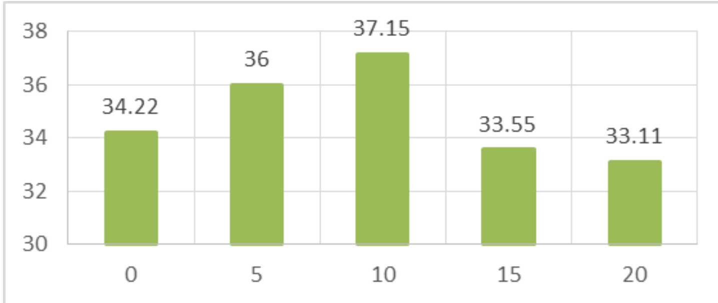


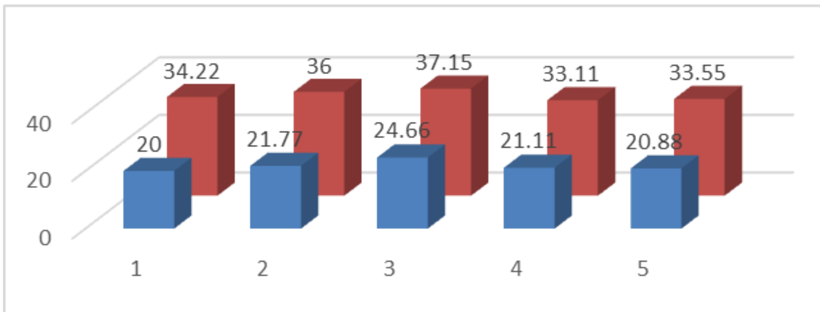
TABLE:19COMPRESSIVE STRENGTH OF CUBES AT 28 DAYS:

S NO	GLASS (%)	LOAD (KN)	COMPRESSIVE STRENGTH AT 28 DAYS (N/mm^2)
1	0	770	34.22
2	5	810	36.00
3	10	835	37.15
4	15	755	33.55
5	20	745	33.11

GRAPH: 7 COMPRESSIVE STRENGTH AT 28 DAYS



GRAPH: 8 COMPRESSIVE STRENGTH COMPARISION



IV.CONCLUSION

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

1. Slump gradually decreased with increase in glass percentage.
2. Compaction factor values gradually increased with increase in glass percentage.
3. 10% replacement of fine aggregates by waste glass showed optimum increase in compressive strength at 7 and 28 days
4. 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
5. Marginal decrease in strength is observed at 15 to20% replacement level of waste glass with fine Aggregate.
6. The optimum replacement level of waste glass as fine aggregate is 10%.
7. With increase in waste glass content, percentage water absorption decreases.
8. Workability of concrete mix increases with increase in waste glass content.
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 eradicate 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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