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EXPERIMENTAL INVESTIGATION ON STRENGTH OF GLASS POWDER REPLACEMENT BY CEMENT IN M_{25} GRADE OF CONCRETE

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ABSTRACT

Every year Million tons of waste glass is being generated annually all over the world. Which is unsustainable as this does not decompose in the environment and one's the glass becomes a waste it is disposed as landfills. Glass is principally composed of silica which is a good Pozzolonic material which should be use in concrete. So in the present case study waste glass is used as partial replacement of cement in concrete and would be a important step toward development of sustainable (environmentally friendly, energy-efficient and economical) infrastructure systems. When waste glass is milled down to micro size particles and use as replacement for cement it is expected to undergo pozzolanic reactions with cement hydrates, forming secondary Calcium Silicate Hydrate (C–S–H). However, the chemical composition and the pozzolanic properties of waste glass are encouraging for the use of this waste in the cement and concrete industries to provide an environmental friendly solution. This project work reviews the different proportion of waste glass can be used in replacement for cement and the effect of the glass properties on the performance and durability of the produce concrete is carried out. The compressive strength test and Tensile strength results indicated that recycled glass concrete gave better strength compared to control samples. A 15% replacement of cement with waste glass was found to giving convincing results compare to other samples in this project we have consider M25 grade of concrete.

Keywords: *Waste glass, Compressive strength, Split tensile strength, Fine aggregates, coarse aggregates*.

I. INTRODUCTION

Concrete is a worldwide composite material consisting of cement, Aggregates (coarse, fine) and water in suitable proportion. The chemical reaction wedged between the cement and water binds the aggregates into a hard mass. Fresh concrete will be plastic, in order that it can be moulded into require size and shape in the moulds. Water have to be applied for few days over the concrete surface soon after its setting because the hydration reactions takes place between the cement and water continue for a long period due to which hardening of concrete takes place. This period when the concrete is kept moist during which concrete gains strength is called curing period. Hence, the strength of concrete increases with age. The process of solidification of concrete from plastic stage is called setting while gaining of strength after setting is called hardening. Usually setting completes within a maximum duration of 10 hours, while about 90% hardening is completed by 28 days. Concrete is a construction material which is mainly used in the world.

The high cost of regular building materials is a central point influencing development in India. In creating nations where plentiful rural and modern squanders are released, these squanders can be utilized for different purposes in development industry. This will have two fold the points of interest and decrease in the cost of development material and furthermore as a methods for transfer of squanders. Subsequently the approach is intelligent, commendable and inferable. In this manner an Endeavour has been made in this investigation to use the waste glass fractional substitution of cement and bond in the improvement of concrete. So an examination on different properties of these materials is carried out. Likewise reasonable measures must be received for achieving the target strength.

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Glass is commonly used in the industries for the production of glass bottles to carry different products and for household appliances like lamps etc glass as the by-product is often dumped as wastes. In India, industries and informal sectors recycle about 15-20% of solid waste in various building material. In developing countries and under developed countries where there is no proper way of recycling the waste glass material can be used as a construction material. It has the advantage of reduction of cost and it also serve as a means of disposal or say recycling of waste. In this paper normal cement is replaced by cement and cubes have been casted to their designed compressive strength.

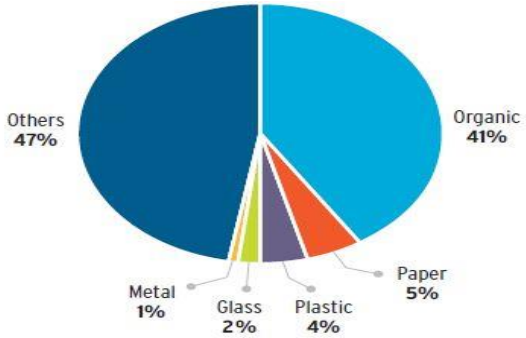

Figure 1. Waste material in India

Table 1. Quantity of various constituents generated per year.

Constituent	% of waste generated in India
organic	41
others	47
Metal	1
glass	2
paper	5
plastic	4

The above shows the percentages of solid waste generated in India the waste material are recycled by using land filling and inclination process but the material like glass cannot be decompose so alternative method should adopt to recycle the waste glass materials.

Scope of the Work

The main aim of this study is to assess the utility and efficacy use of waste glass which are obtained from dumping yard and can be used to produce superior concrete which is no way inferior to Normal concrete and by doing so to recycle the waste products and to decrease the construction cost of buildings.

II. MATERIALS

Cement

Portland cement is the most common type of cement in general usage. It is a basic ingredient of Concrete, mortar and plaster. Of the various ingredients used in concrete, cement is the most energetic and expensive. In the present investigation OPC 53 grade cement is used.

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Table 2. Chemical composition of cement

S.No	Ingredient	Proportion range
1	Lime (cao)	60 to 67%
2	Silica(sio_2)	18 to 25%
3	Alumina(Al_2o_3)	5 to 9%
4	Iron oxide(fe_2o_3)	0.5 to 6%
5	Magnesium Oxide(mgo)	0.1 to 4%
6	Sulphur trioxide(so_3)	1 to 3%
7	Soda or potash	0.5 to 1.3%
8	Alkalies and others	1%
9	Insoluble residues	0.5%
10	Loss an ignition	2%

Table 3. Physical Properties of O.P.C (Ordinary Portland cement)

S.No.	***Property***	**Test Method**	**Value**
1	Fineness modulus	Sieve analysis (IS 2386-1963 Part 2)	4.23
2	Specific gravity	Pycnometer (IS 2386-1963 Part 3)	2.70
3	Bulk density (kg/m3)	(IS 2386-1963 Part 3)	1340

Water

Combining water with a cementations material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and makes it flow more freely. Lower water to concrete ratio yields a stronger, more durable concrete, while more water gives a free flowing concrete with a higher slump.

Impure water used to make concrete can cause problems when setting or in causing premature failure of the structure.

Fine aggregate

It is the aggregate most of which passes 4.75 mm IS sieve and contains only so much coarser as is permitted by specification According to size the fine aggregate may be described as coarse sand, medium sand and fine sand. IS specifications classify the fine aggregate into four types according to its grading as fine aggregate of grading Zone-1 to grading Zone-4. The four grading zones become progressively finer from grading Zone-1 to grading Zone-4. 90% to 100% of the Fine aggregate passes 4.75 mm IS sieve and 0 to 15% passes 150 micron IS sieve depending upon its grading zone.

Table 5. Physical properties of Fine Aggregate

S.No.	Property	Test Method	Test Result
1	Initial Setting time	Vicat apparatus (IS 4031-Part 5)	42 min
2	Normal Consistency	Vicat apparatus (IS 4031-Part 4)	33 %
3	Fineness	Sieve test on sieve no.9 (IS 4031-part11)	7% Residue
4	Specific Gravity of Cement	Specific gravity bottle (IS 4031-Part 11)	3.05
5	Final setting time	Vicat apparatus	308min

Coarse Aggregates

Crushed stone aggregates of 20mm size obtained from local quarry site were used for the experiment. The physical properties of coarse aggregates are shown in table below.

Table 6. Physical properties of Coarse Aggregate

S. No.	***Property***	**Test Method**	**Value**
1	Fineness modulus	Sieve analysis (IS 2386-1963 Part 2)	3.13
2	Specific gravity	Pycnometer (IS 2386-1963 Part 3)	2.6
3	Bulk density (kg/m^3)	(IS 2386-1963 Part 3)	1830

ISSN 2348 – 8034
Impact Factor- 5.070

4	Water absorption	(IS 2386-1963 Part 3)	1.02%

Glass Powder

Glass powder is obtained from the waste glasses bottle and pieces from the dump yard. The collected waste glasses are to be crushed in to powder to get the particle mix passing through 75 micron sieve to get the grading of cement.

Table 7. Chemical constituents of glass powder

Minerals	Percentage
Silica (Sio2)	50-80%
Alumina(Al_2O_3)	1-10%
Iron oxide(Fe_2O_3)	< 1%
Calcium oxide(Cao_3)	5-15%
Magnesium oxide	<1.5%
Sodium oxide	1-1.5%

III. MIX DESIGN

MIX DETAILS FOR M_{30} CONCRETE (1:1.97:2.87)

Cement	Fine aggregate	Coarse aggregate	w/c ratio
394 kg	779 kg	1134 g	0.50

Table 8. Showing the Workability results of sample

S.N o	Sample	Slump value in mm
1	Normal concrete	104
2	Glass reinforced Concrete 1	102
3	Glass reinforced Concrete 2	102

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Impact Factor- 5.070

4	Glass reinforced Concrete 3	99
5	Glass reinforced Concrete 4	94
6	Glass reinforced Concrete 5	94

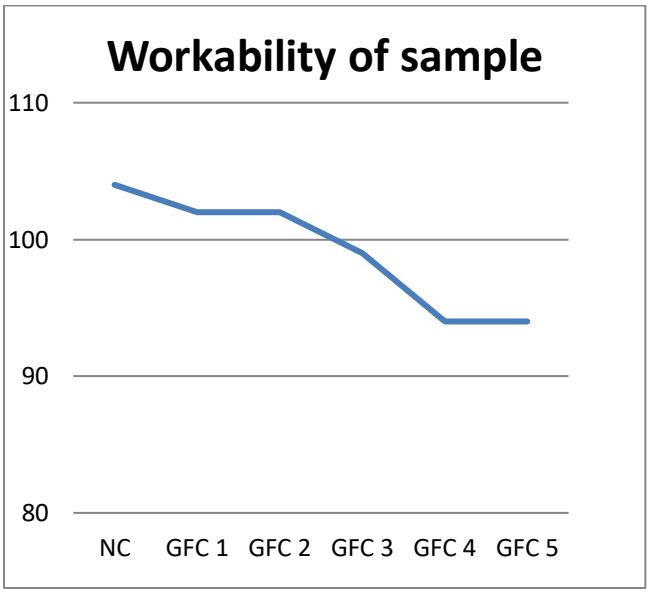

Figure 1. Graph Shows the Workability results of test samples

IV. EXPERIMENTAL RESULTS

1. Compression test results of cubes

All the cubes have been tested under the compression testing machine at the age of 7 days and 28 days of curing. The cube is loaded till it fails and the crushing strength is noted. The crushing strength is calculated by using the following formula.

Compressive Strength of concrete = Maximum compressive load / Cross Sectional Area

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Figure 2.Cubes after testing

Compression test of concrete

Nominal concrete (NC) = Cement + Sand + CA

Table 9.Compressive Strength of Concrete with 0 % Replacement for 7 and 28 days

Sample	7days	Avg compressive strength (KN/m^2)	28 days	Avg compressive strength (KN/m^2)
NC	19.16	20.19	26.75	26.66
	20.89		28.03	
	20.52		25.22	

Result: Average value of the 3 samples for 0% replacement is for 28 days is 26.66 KN/m^2. This is near to our target mean strength 31.60 KN/m^2

Compressive Strength of glass powder replaced Concrete Following are the mixes considered for the study

NC - 100% Cement
GFC1 - 5% glass powder + 95 % cement
GFC2 - 10% glass powder + 90% cement
GFC3 - 15% glass powder + 85 % cement
GFC4 - 20% glass powder + 80 % cement
GFC5 - 25% glass powder + 75 % cement

Weigh batching is done for all materials. All aggregates used in the mix were weighed under surface dry conditions.

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Table 10. Compressive Strength of concrete for different proportional's of replacement for 7 and 28 days

Sample	7days compressive strength (KN/m^2	Avg compressive strength (KN/m^2)	28 days compressive strength (KN/m^2	Avg compressive strength (KN/m^2)
NC	19.16	20.19	26.75	26.66
	20.89		28.03	
	20.52		25.22	
GFC1	20.31	20.91	25.92	27.57
	19.45		28.54	
	22.97		28.27	
GFC2	21.64	21.85	28.17	28.02
	21.03		27.76	
	22.88		28.14	
GFC3	21.79	22.73	28.01	30.44
	23.14		30.97	
	23.26		32.34	
GFC4	18.54	19.25	26.56	25.94
	19.89		25.42	
	19.34		25.86	
GFC5	16.63	16.64	22.37	23.13
	17.23		22.58	
	16.08		24.46	

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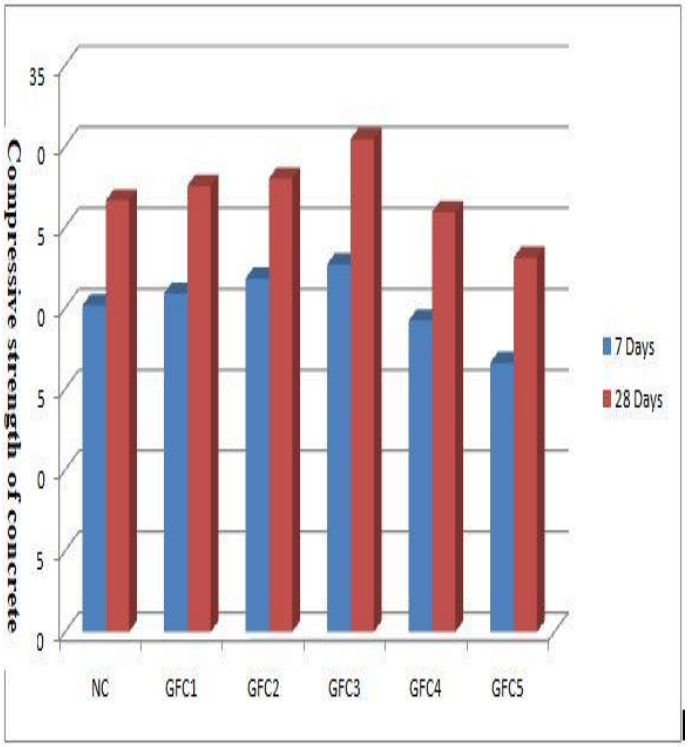

Figure 3. The Above Graph shows the test results after 7 & 28 Days of testing

The following bar chart showing the values of normal and different replaced proportions of Compressive strength of concrete for 7 & 28 days and it shows that sample GFC3 which is 15 % Glass replaced for cement gives high strength when compare with the rest of the samples.

2. Split Tensile Strength

Tensile strength is one of the basic and important properties of concrete. Knowledge of its value is required for the design of concrete structural elements subject to transverse shear, torsion, shrinkage and temperature effects. Its value is also used in the design of pre stressed concrete structures, liquid retaining structures etc. The cylindrical specimen shall have diameter not less than four times the maximum size of the coarse aggregate and not less than 150 mm. The length of the specimens shall not be less than the diameter and not more than twice the diameter.

Table 11 .Split Tensile Strength of different proportional's of concrete for 7 and 28 days

Sample	7days	Avg compressive strength (KN/m^2)	28 days	Avg compressive strength (KN/m^2)
NC	1.06	1.29	2.91	3.18
	1.69		3.39	
	1.14		3.26	
GFC1	1.82	1.64	3.04	3.28
	1.41		3.46	
	1.70		3.35	
GFC2	2.36	2.27	3.59	3.48
	2.25		3.45	

	2.2		3.42	
GFC3	2.70	2.62	4.24	4.23
	2.64		4.06	
	2.52		4.40	
GFC4	1.84	1.84	2.98	3.02
	1.85		3.03	
	1.82		3.06	
GFC5	1.36	1.44	2.53	2.48
	1.46		2.47	
	1.52		2.49	

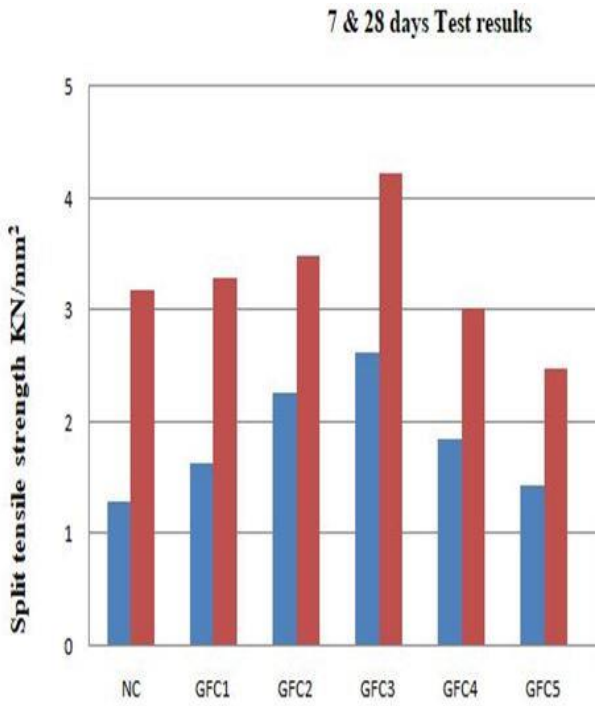

Figure 3. The Above Graph shows the test results after 7 & 28 Days of testing

The following bar chart showing the values of normal and different replaced proportions of Split Tensile strength of concrete for 7 & 28 days and it shows GFC3 sample which is 15% of waste glass powder replaced for cement gives high strength when compare with the rest of the samples.

V. CONCLUSION

The purpose of the research is to determine the mechanical properties of concrete specimens in which and cement is replaced with waste glass powder. So that to utilise the waste product and to reduce the construction cost of buildings.

The following conclusions are made based on the above study:

- The 7 days and 28 days compressive strengths of concrete increase initially as the replacement percentage of cement with glass powder increases, and become maximum at about 15% sample and later decreases.
- The split tensile strength of concrete increases initially as the replacement percentage of cement with glass powder increases, and becomes maximum at about 15 % glass powder replaced sample and later decrease.

The present study shows that there is a great potential for the utilization of glass powder in concrete as partial replacement of cement. About 15 % of cement may be replaced with glass powder and fly ash size less than 70 µm without any sacrifice on the compressive strength.

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