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Experimental Investigation On The Properties And Durability Of Partially Replaced Recycled Aggregates, Glass Powder Concrete For Cost Effective Construction.

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Abstract:
Waste glass powder was used as a secondary cementitious material towards the production of recycled aggregate concrete with improved strength and durability attributes. Experimental investigation of the novel concept of using waste glass powder, as partial replacement for cement, to overcome the drawbacks of recycled aggregate and the resulting concrete showed that waste glass, when milled to micro-scale particle size, is estimated to undergo pozzolanic reactions with cement hydrates, forming secondary calcium silicate hydrate (C–S–H). Waste glass powder was also found to suppress alkali-silica reactions. These reactions bring about favorable changes in the structure of the hydrated cement paste and the interfacial transition zones in recycled aggregate concrete. The encouraging test results are viewed to facilitate broad-based use of recycled aggregate and diversion of large quantities of landfill-bound mixed-color waste glass for a value-added use to produce recycled aggregate concrete incorporating waste glass powder. An attempt has been made to provide concise information of strength of concrete containing waste glass powder and recycled aggregate when subjected to sulphate attack.
Key words*: Waste Glass Powder, Calcium silicate hydrate, Recycled aggregate concrete, Compressive Strength, Spit tensile strength, cost effective and sulphate attack.*

1. INTRODUCTION

Concrete is comprised of cement, fine aggregates, coarse aggregates and water. Milled waste glass was used as secondary cementitious material towards production of recycled aggregate concrete with improved strength and durability attributes. [1], [3]
This study aims at utilization of such industrial by product for value added application. The recycled glass has been used in the form of powder. The glass powder was tested with concrete , where 20% cement was replaced by the glass powder and also with 0%, 25%, 50% and 75% proportions of the replacement of recycled aggregates with the virgin aggregates was done for certain concrete mix.

The compressive strength and split tensile strength were conducted for the above replacements. The result showed glass powder improves the mechanical properties [10], [4].

Experimental investigation of the novel concept of using milled waste glass, as partial replacement for cement, to overcome the drawbacks of recycled aggregate and the resulting concrete showed that waste glass, when milled to micro-scale particle size, is estimated to undergo pozzolanic reactions with cement hydrates, forming secondary calcium silicate hydrate (C–S–H).[1]. These reactions bring about favorable changes in the structure of the hydrated cement paste and the interfacial transition zones in recycled aggregate concrete. Use of milled waste glass, as partial replacement of cement, is estimated to produce significant gains in strength and durability of recycled aggregate concrete. Milled waste glass was also found to suppress Alkali-silica reactions. [11]

2. Aim of the study

2.1 Parameters

2.1.1 Grade of concrete: M30

2.1.2 Water cement ratio: 0.4

2.1.3 Type of aggregate:

- Fine aggregate: confirming to zone II

- Coarse aggregate: Graded aggregates with 20mm downsize.

2.1.4 Size of the cube specimens- 150mmX150mmX150mm

2.1.5 Size of cylinders- 150mm diameter and 300mm height

2.1.6 Type of cement

- J K – 43 Grade confirming to IS: 8112 – 1989 in case of concrete with waste glass powder and normal concrete.

2.1.7 Waste glass powder from Enviro Safety Glasses, Mysore.

2.1.8. Recycled coarse aggregate- 20mm downsize.

2.2 Curing period.

For compressive strength test - The specimens were cured for 7 days, 28 days and 56 days.

For splitting tensile test - The specimens were cured for 7 days, 28 days and 56 days.

2.3 Percentage replacement of virgin coarse aggregates with recycled coarse aggregates and cement by waste glass powder.

In this experiment we have replaced 25%, 50%.75% and 100% of virgin coarse aggregates with recycled coarse aggregates and 20% of cement by waste glass powder.

Considering the above parameters the experimental investigations have been carried out and the results obtained with discussions are reported in subsequent pages.

2.4 Cost Effective Concrete.

2.5 Durability test

2.6 Compressive strength when immersed in $MgSO_4$ for 28 days and 56 days.

2.7 Split tensile strength when immersed in $MgSO_4$ for 28 days and 56 days of curing.

3. Materials and Methodology

3.1 Testing of materials

3.1.1 Cement

- Tests on cement: As per IS 4031 (part 4, 5) – 1988(6)

The cement is tested as per IS 4031- 1988 and the test results are tabulated below. For this experimental investigation we used JK cement with 43 grades.

TABLE 3.1

TEST RESULTS OF CEMENT

Characteristics	Unit	Value
Fineness (Retained on 90 Micron IS sieve)	%	2.20
Setting time • **Initial set** • **Final set**	 min min	 105.00 250.00
Standard Consistency	%	31.00
Specific Gravity	-	3.13

3.1.2 Fine aggregates

3.1.2.1 Tests on Fine aggregates: Natural sand / River sand

The different test conducted on fine aggregates and the results obtained are tabulated below. The tests are conducted as per IS: 2386.

TABLE 3.2

TEST RESULTS OF FINE AGGREGATES

Specific gravity	2.64
Fineness modulus	2.72
Water absorption	1.2%
Zone	Belong to grading zone II of IS 2386 (part 3) - 1963 (7)

TABLE 3.3

TESTS ON GRADING OF FINE AGGREGATE

IS Sieve Size	% Passing for Zone II fine aggregates as per IS 383: 1970	% Passing obtained
4.75mm	90 – 100	100
2.36mm	85 – 100	93.996
1.18mm	75 – 100	72.153
300µ	12 - 40	9.109
150 µ	0 – 10	0.62
75 µ	0	0.206
Pan	0	0

3.1.3 Coarse Aggregates

In this investigation we have used 20mm down size aggregates as coarse aggregates and they are tested as per IS 2386 and the results are tabulated below

TABLE 3.4
TEST RESULTS OF COARSE AGGREGATES

Specific gravity	2.63
Fineness modulus	7.11
Moisture content	0.23%
Loss on abrasion	22.8%

3.1.4 Glass powder

Glass powder is collected from Enviro Safety Glasses, Mysore. It was a waste discarded glass, where it was milled thoroughly and bought down in the form of powder.

Fig 3.1: Glass powder

TABLE 3.5
TEST RESULTS OF GLASS POWDER

Physical properties of glass Powder	Results
Specific gravity	2.73
Median particle size	90μ

3.1.5 Recycled coarse aggregates

Recycled coarse aggregate of 20mm downsize are collected from a demolished building in Mangalore.

Fig 3.2 Recycled coarse aggregates

TABLE 3.6
TEST RESULTS OF RECYCLED COARSE AGGREGATES

Specific gravity	2.4
Moisture content	0.21%
Loss on abrasion	31.6

Table 3.7
Mix Proportions for normal concrete

Grades	Cement (kg/m^3)	Fine aggregates (kg/m^3)	Coarse aggregates (kg/m^3)	Water (lit/m^3)
M30	480	626	1151	192
	1	1.30	2.39	0.4

3.2 Mix Design

Mixing of ingredient of concrete is done as per design mix proportion designed based on 10262-2009.

TABLE 3.8
AMOUNT OF WASTE GLASS POWDER AND RECYCLED AGGREGATES USED IN CONCRETE

Grade	**M30**			
Target Strength	Fck + 1.65 (s) = 38.25 N/mm^2			
Cement (kg/m^3)	480			
Fine aggregates (kg/m^3)	626			
Coarse aggregates (kg/m^3)	1151			
Replacement of cement by Glass Powder (%)	20			
Glass Powder (kg/m^3)	96			
Replacement of Coarse aggregates by Recycled aggregates %	0	25	50	75
Recycled aggregates (kg/m^3)	0	287.75	575.5	863.25

TABLE 3.9
COST ANALYSES FOR MATERIALS OF CONCRETE MADE USING RECYCLED AGGREGATES

	Material	**Quantity/m^3**	**Rate/unit**	**Cost (Rs)**
For partially replaced glass powder and recycled aggregate concrete M30 Concrete (for 1m^3)	Cement	8 bags	370/bag	2960
	Fine aggregate	0.24 m^3	2300/m^3	552
	Coarse Aggregate	0.315	1950/m^3	615
	Recycled Coarse Aggregate	0.06	1300/m^3	78
	Glass Powder	100 Kg	6	600

Total Cost for the materials of M30 Concrete made by the replacement of glass powder and Recycled Aggregates: **4805 Rs**

Therefore saving made by using Recycled Coarse Aggregates = 4%

4 Durability Study

4.1 Sulphate Attack

Sulphate attack denotes an increase in the volume of cement paste in concrete due to chemical action between the products of hydration of cement and solution containing sulphates. Of all the sulphates, magnesium sulphate causes maximum damage to concrete. A characteristic whitish appearance is the indication of sulphate attack.

Test procedure is as follows:

The steel cube moulds of dimension 150 mm X 150 mm X 150 mm were coated with oil on their inner surfaces and were placed on plate. The amount of cement, sand, coarse aggregates for required number of cubes were weighed. The materials were first dry mixed then mixed with total amount of water thoroughly to get homogeneous mix. The slump test was conducted to ascertain the workability of the mix, which requires a slump of 50 -100 mm. Concrete was poured into the moulds in three layers and the top surface was finished using trowel. After 24 hours, concrete cubes were de-moulded and the specimens were kept for curing in water for 28 and 56 days. Then the specimen was immersed in a 5% $MgSO_4$ solution for 28 and 56 days. Compressive strength and split tensile strength tests are conducted.

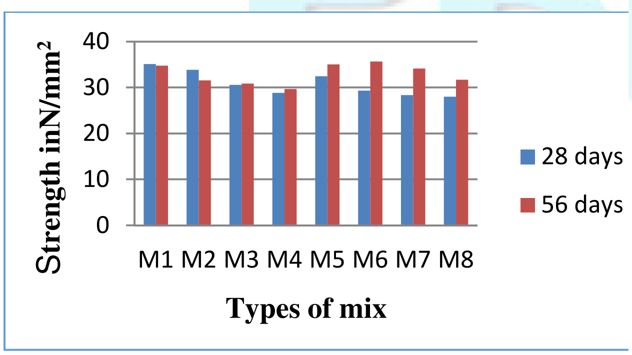
4.1.1 Compressive strength test

4.1.1.1 Strength after 28 and 56 days immersion in $MgSO_4$ solution

TABLE 4.1
COMPRESSIVE STRENGTH TEST FOR 28 AND 56 DAYS

Types of mix	Compressive Strength 28 days (N/mm^2)	Compressive Strength 56 days (N/mm^2)
M1	35.08	34.78
M2	33.87	31.54
M3	30.54	30.86
M4	28.86	29.64
M5	32.42	35
M6	29.31	35.66
M7	28.34	34.11
M8	27.97	31.65

Figure 4.1 Specimen under attack of Sulphate



Graph 4.2: Comparison of compressive strength when immersed in $MgSO_4$

Graph 4.2 shows the compression strength test results for the cubes and cylinders subjected to sulphate attack. The specimens are immersed in 5% $MgSO_4$ solution. The strength reduces with increase in percentage of recycled coarse aggregate. Also strength reduces with the introduction of glass powder, but percentage of strength reduction is less when compared to specimens without glass powder. This may be due to the filling effect of glass particles, and conversion of CH to C–S–H available in the old mortar/cement paste attached to the surface of recycled aggregate.

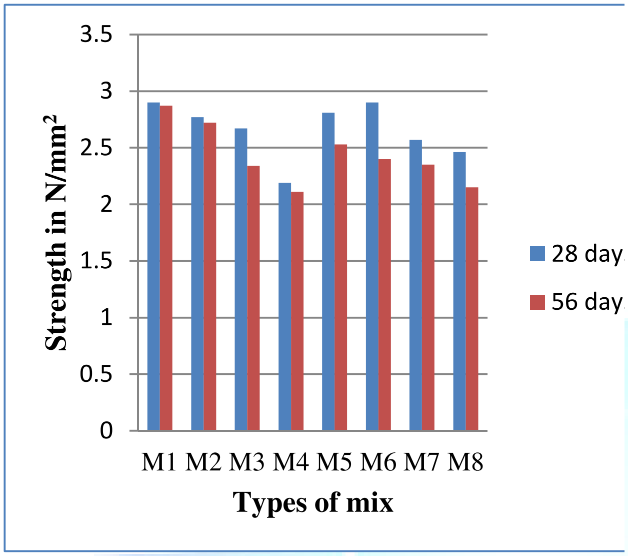
4.1.2 Split tensile strength test

4.1.2.1 Strength after 28 and 56 days immersion in $MgSO_4$ solution

TABLE 4.2
SPLIT TENSILE STRENGTH TEST FOR 28 AND 56 DAYS

Types of mix	Split tensile Strength 28 days (N/mm^2)	Split tensile Strength 56 days (N/mm^2)
M1	2.9	2.87
M2	2.77	2.72
M3	2.67	2.34
M4	2.19	2.11
M5	2.81	2.53
M6	2.90	2.40
M7	2.57	2.35
M8	2.46	2.15

Figure 4.3: Specimen under attack by Sulphate



Graph 4.4: Comparison of split tensile strength when immersed in $MgSO_4$

Graph 4.4 shows the split tensile strength test results for the cubes and cylinders subjected to sulphate attack. The specimens are immersed in 5% $MgS0_4$ solution. The strength reduces with increase in percentage of recycled coarse aggregates. Also strength reduces with the introduction of glass powder but percentage of strength reduction is less when compared to specimens without glass powder. This may be due to the filling effect of glass particles, and conversion of CH to C–S–H available in the old mortar/cement paste attached to the surface of recycled aggregates.

5. CONCLUSION

1. The use of milled waste glass as partial replacement for cement is estimated to effectively overcome the limitations of recycled aggregates.

2. When glass is used in fine particle size as partial replacement for cement in concrete, it is estimated to undergo pozzolanic reaction that results in improved microstructure of recycled aggregate concrete.

3. The density of concrete reduces with the increase in the percentage of replacement of cement by glass powder because of the lower specific gravity of glass powder.

4. The workability increases as the glass powder content increases since glass powder absorbs lesser water.

5. It is recommended that utilization of waste glass powder in concrete as cement replacement is possible.

6. It is recommended that the utilization of recycled aggregates in concrete as virgin coarse aggregates replacement is possible.

7. Significant increase in the later age strength is achieved through the formation of denser and less permeable microstructure.

8. Improvement in 56 days strength provides an indirect measure of the pozzolanic activity of milled waste glass.

9. Waste glass powder in appropriate proportions could be used to resist Sulphate attack.

6. REFERENCES

[1]. Dhanaraj Mohan Patil, Dr. Keshav K. Sangle, Experimental investigation of waste glass powder as partial replacement of cement in concrete, International Journal of Advanced Technology in Civil Engineering, Volume-2, Issue-1, 2013.

[2]. D. N Parekh and Dr. C. D. Modhera, Characterization of recycled aggregate concrete, International Journal of Advanced Engineering Technology, Volume 2, Issue 4, October-December, 2011.

[3]. Dr. G.Vijayakumar, Ms H. Vishaliny, Dr. D. Govindarajulu, Studies on Glass Powder as Partial Replacement of Cement in Concrete Production, Volume 3, February 2013.

[4]. IS: 10262 – 2009, and IS 456, Recommended Guidelines for Concrete Mix, Bureau of Indian Standards, New Delhi.

[5]. Jabbar Abbas Jabir, Influence of internal sulphate attack on some of properties for concrete containing recycled aggregate.

[6]. M.N.Bajad 1, C.D.Modhera 2 and A.K.Desai, Effect of glass on strength of

concrete subjected to sulphate attack, International Journal of Civil Engineering Research and Development, Volume 1, Number 2 May-October2011.

[7]. M.S.Shetty,,Concrete Technology and Theory of Practice, S.Chand & Co.ltd, 6 Edition,2005.

[8]. Parviz Soroushain, towards broad use of recycled aggregates.

[9]. R. Idir, M. Cyr, A. Tagnit-Hamou, Use of waste glass as powder and aggregate in cement-based materials- SBEIDCO, 1st International Conference on Sustainable Built Environment Infrastructures in Developing Countries ENSET Oran (Algeria),12 Oct 2009.

[10]. R.Vandhiyan, K. Ramkumar and R. Ramya, Experimental Study On Replacement Of Cement By Glass Powder, International Journal of Engineering Research & Technology (IJERT),Vol. 2 Issue 5, May 2013.

[11]. Roz-Ud-Din Nassar, Parviz Soroushian, Construction and Building Materials,(2012).

[12]. Sudhir p.patil, Ganesh single, Prashant d.sathe, Recycled coarse aggregates, International Journal of Advanced Technology in Civil Engineering, ISSN: 2231 –5721, Volume-2, Issue-1, 2013.

[13]. Sunny O. Nwaubani and Konstantinos I. Poutos, the Influence of Waste Glass Powder Fineness on the Properties of Cement Mortars, Volume 2, Issue 2, February 2013.