Experimental Study On Replacement Of Cement By Glass Powder

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Abstract

In a growing country like India a huge amount of industrial waste are polluting the environmental. With a view to the above, this study aims at utilization of such industrial by product for value added application. In addition the waste can improve the properties of construction materials. The recycled glass has been used in the form of powder. The glass powder was tested with concrete and mortar. Cement was replaced by the glass powder in the proportion of 5%, 10% and 15%. The compressive strength, split tensile strength, consistency and flexural strength were conducted for the above replacements. The result showed glass powder improves the mechanical properties. The advantages of this project are that the replacement of glass powder is economically cheap as well as a superior concrete can be made.

1.0 INTRODUCTION

The quantity of waste glass has slowly increased over the years due to the growing need and usage of glass products, this gives way for large quantity of glass waste. Most of these waste glasses can be recycled. At the same time today's annual global cement production has reached 2.8 billion tons, and is expected to increase to some 4 billion tons per year. The cement industry is facing challenges such as cost increases in energy supply, requirements to reduce CO2 emissions and the supply of raw materials in sufficient qualities [1]. The usage of waste glass to replace cement could reduce the cost of concrete and also the consumption of cement; there by directly reduce the CO2 emission which is related to the production of cement. Also this reduces the cost of making concrete since a waste material in used. Attempts have been made to use glass as a replacement for coarse aggregate and also as a hydration enhancing filler. However, replacement of cement with flass to make concrete will be a great value addition.[2]. The pozzolanic property of glass powder [3] has shown the possibility to improve the concrete property by using waste glass in concrete. Glass is made by combining several inorganic minerals, based on their composition glasses can be classified in to many categories but soda-lime glass is the widely used type of glass. The typical glass contains 70 % silica approximately. The presents of alkali in glass may cause alkali-silica reaction and change in volume but it has been found that finely ground glass does not contribute to alkali-silica reaction [4]. As a pozzolan, glass powder provides a more uniform distribution and a greater volume of hydration products. Addition of glass powder to a concrete mix alters the cement paste structure. The resulting paste contains more of the strong calcium-silicate hydrates (C-S-H) and less of the weak and easily soluble calcium hydroxides (Ca(OH)2) than ordinary cement pastes. The calcium silicate hydrate formed is the glue, or binder, which holds the system together, and is the main source of concrete strength. The weaker calcium hydroxide does not contribute as a binder, and can occupy space. Further, the calcium hydroxide can combine with carbon dioxide to form a soluble salt which will leach through the concrete, and can cause efflorescence. The small particles size of powder glass are very good at infiltrating and plugging capillary pores in concrete making pores smaller and fewer and concrete more dense. The microfiller effect greatly reduces permeability and improving the paste-to-aggregate bond of concrete with glass powder compared to conventional concrete.[5].

2.0 MATERIALS

2.1 Aggregate

River sand form the river cavery near tirchy confirming to zone III as per IS: 383-1970 was used as fine aggregate (F.A). Specific gravity of fine aggregate was 2.65. Broken stones form the local quarry at Reddiarchattiram, near dindigul confirming to table 2 of IS 383-1970 was used as coarse aggregate (C.A). Specific gravity of coarse aggregate was 2.69.

2.2 Cement

Cement used was Ordinary Portland Cement (OPC)

supplied by Dalmia Cements. Specific gravity of cement was 3.13. Analysis of the cement is given in the Table 1.

2.3 Water

TABLE I

CHEMICAL ANALYSIS OF CEMENT IN %	
Silicon di oxide SiO_2	21.56
Aluminium oxide Al_2O_3	5.39
Ferric oxide Fe_2O_3	3.39
Magnisium oxide Mgo	1.19
Calcium oxide CaO	65.5
Sulphur tri oxide SO_3	2.76
Loss of Ignition	1

Water used in the concrete was ordinary portable water.

2.4 Waste Glass

Waste Glass used in the experiments was that of green colored glass. The glasses were soaked in water to remove foreign bodies. The glasses were grounded to powder to make glass powder(GP) of size that 100% passes through 90 micron sieve and 50 % retained in 75 micron sieve. The Specific gravity of glass powder is 2.39. Analysis of the Glass powder is given in the Table 2.

2.5 Concrete Mix proportion

Four different mix proportions were chosen for this study. A plane concrete with water cement ratio of 0.45 was used a control mix. In other three mixes 5%, 10%, 15% of cement is replaced by glass powder in weight. The mix proportions are given in Table 3

2.6 Cement Mortar Mix proportion

Four different mix proportions were used for this study with the mix ratio of 1:4. A plane cement mortar mix with water cement ratio calculated form the relation, Water = (p/4+3.0) % of combined weight of cement and glass powder, where p is the water required for standard consistency

2.7 Test Details

The tests applied in this study to investigate the effect of utilizing waste recycled glass as cement replacement on the properties of concrete are shown in Table 4.

TABLE 2

CHEMICAL ANALYSIS OF GLASS POWDER IN %	
Silicon di oxide SiO_2	72.39
Aluminium oxide Al_2O_3	1.47
Ferric oxide Fe_2O_3	0.29
Magnisium oxide Mgo	0.54
Calcium oxide CaO	11.25
Sulphur tri oxide SO_3	0.07
Tio_2	0.09
Cr_2O_3	0.13
Na_2O	13.52
K_2O	0.27

TABLE 3
MIX PROPOTION FOR 1 M^3 OF CONCRETE

Symbol	Cement (kg)	F.A. (kg)	C.A (kg)	Glass Powder (kg)	Water (l)
0% GP	426	545	1186	0	191.9
5% GP	404.7	545	1186	21.3	191.9
10% GP	383.4	545	1186	42.6	191.9
15% GP	362.1	545	1186	63.9	191.9

3.0 TEST RESULTS AND DISCUSSION

3.1 Plastic state Tests

There is a small increase in the water demand when the replacement percentage was increased to 10 % and above. This must be due to the increased surface area of finer glass particles; there was increase in the water demand. The initial setting time was reduced by very little up to 10 % replacement of glass powder but at 15

% replacement there was a 10 % reduction in the setting time. The workability was reduced due to the replacement and it reduced with increase in replacement, this is due to the increase in the surface area of the glass powder and also the angular shape of the glass particles [6]

3.2 Compressive Strength of cement mortar

TABLE 4

PLASTIC AND MECHANICAL PROPERTIES TESTS

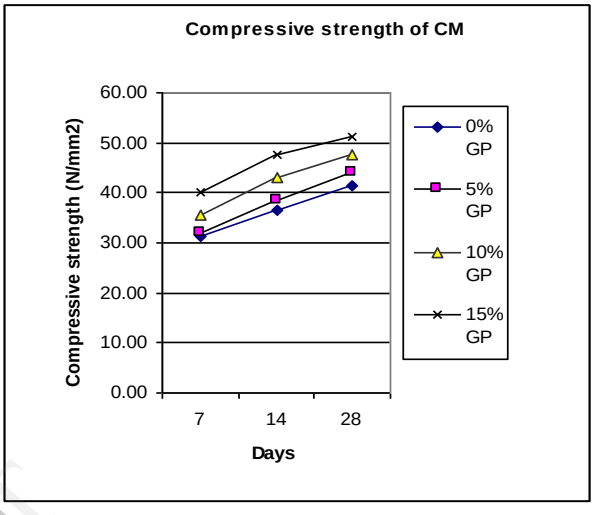
Plastic Properties	Standard consistency test
	Initial setting time
	Workability test
	Compaction factor test
Mechanical Properties	Compressive strength of cement mortar
	Compressive strength of concrete cube
	Flexural strength test
	Split tensile strength

The compressive strength at the 7 day showed a Considerable increase in the early strength gain particularly at Specimen 15% GP gave a 29% increase in the strength at 7th day more than control specimen. At 28th day this difference in strength reduces to 23 %. The strength improves at all replacements of glass powder. The strength improvement can be seen form the graph in the figure 1.

3.3 Compressive Strength of concrete

The figure 2 shows the strength gain at various percentages of glass powder replacement at 7, 14 & 28th day. It can be seen clearly that there a reduction in the strength at the 15 % replacement. Waste glass when ground to a very fine powder, SiO2 react chemically with alkalis in cement and form cementitious product that help contribute to the strength development. Also it may be due to the glass powder effectively filling the voids and giving rise to a dense concrete [7]. When comparing the strength gain with the cement mortar strength gain it can be seen that there is increment of strength even at 15% glass powder replacement. This must be due to the dilution effect takes over and the strength starts to drop [7]. The presents of excess glass powder without necessary calcium to react, forms weak pockets in the concrete that reduces the concrete strength, this happens due to alkali silicate reaction. [8]

Figure 1



3.4 Split Tensile Strength of concrete

The figure 3 shows the split tensile strength gain at various percentages of glass powder replacement at 28th day. It can be seen clearly that there a reduction in the strength at the 15 % replacement. The split tensile strength is improvement is marginal compared to the compressive strength increase.

Figure 3

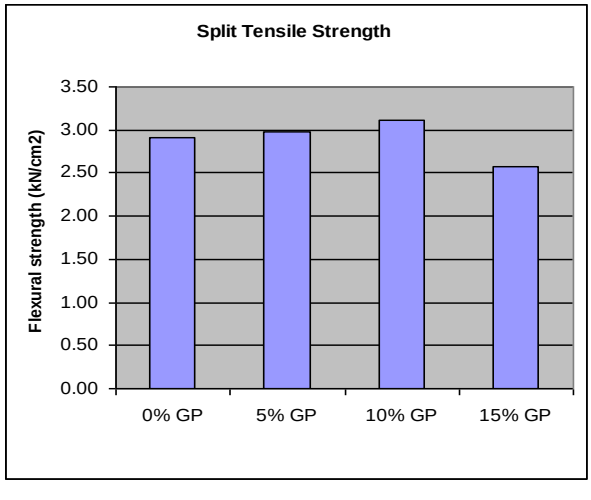
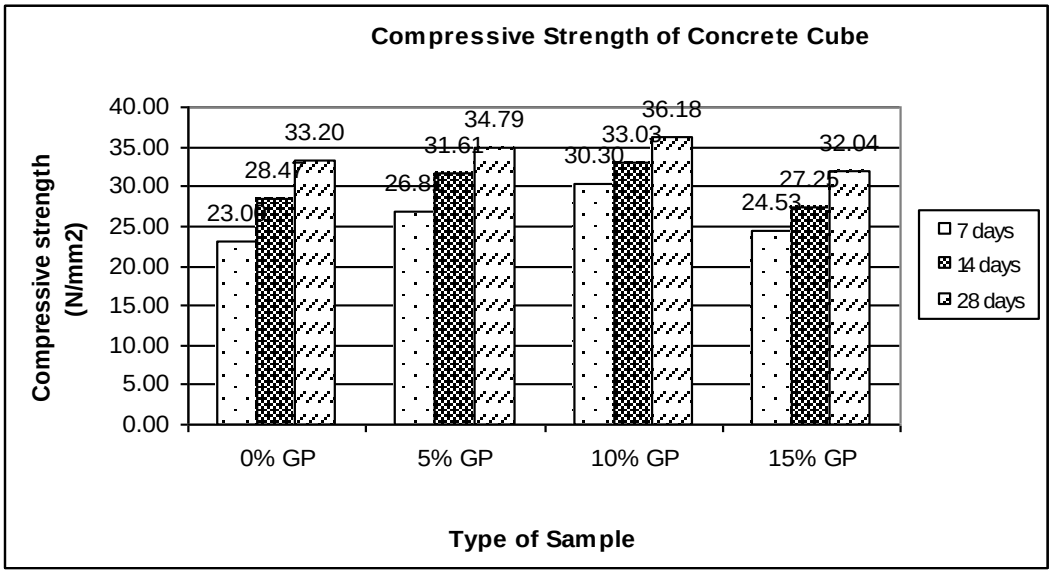


Figure 2

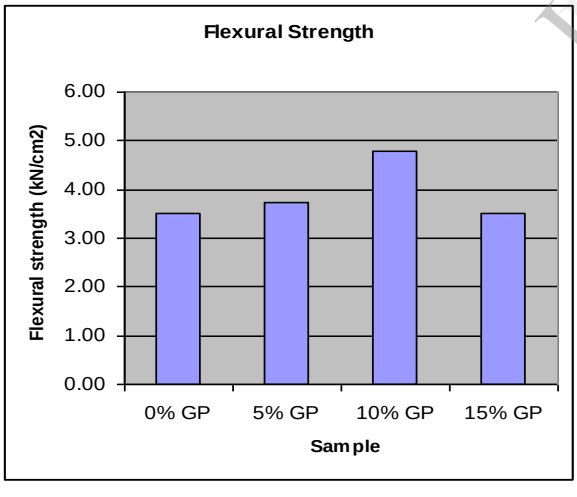


3.5 Flexural Strength of concrete

The figure 4 shows the flexural strength improvement at various percentages of glass powder replacement at 28th day. It can be seen clearly that there a reduction in the strength at the 15 % replacement here also. The flexural strength improves considerably at 10 % replacement which is about 37 % compared to the control specimen.

3.6 Alkali–silica reactivity

Figure 4



The potential of expansion due to alkali–silica reaction of glass powder modified mortars investigation using the accelerated mortar bar test reported that the use of fine glass powder with a high Na2O content (about 14%, similar to the glass powder used in this study) does not result in expansion.[9]

4.0 Conclusion

Based on experimental observations, the following conclusions are drawn.

1. The compressive strength of concrete cube up to a replacement proportion of 10% of cement.
2. In case of cement mortar the strength improves up to 15% replacement of cement.
3. There was marginal improvement in the Split tensile strength
4. A considerable improvement in the flexural strength was seen at 10% replacement of cement.
5. It can be concluded form the above result that 10% replacement of cement by glass powder is the best proportion.
6. Alkali-silica reactivity effect is controlled when glass powder with high Na_2O is used.
7. Further investigation can be done by using plasticizers to improve the workability and strength. Also durability investigation can be done to see the long term effect of glass powder replacement.

10. References

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11. Acknowledgment

The authors would like to thank**.** R.A.Reena, Sancha hangma Subbeni for their support for the success of the study.