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Influence of Fine Glass Aggregate On Cement Mortar

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Abstract: ***In order to make concrete industry sustainable, the use of waste materials in place of natural resources is one of the best alternatives. In this paper, an investigation was conducted to study on the viability of using waste glass as an alternative material applied as partial replacement of fine aggregates in manufacturing fresh mortar. Fine aggregates were replaced by waste glass aggregate as 10%, 20% and 30% by weight for mortar mix1:3. The mortar specimens were tested for compressive strength at 1, 3, 7, 28 days of age and the results obtained were compared with those of control block of mortar. The test results shows that the replacement of fine aggregate by fine glass at level of 20% by weight has a significant effect on the compressive strength of the mortar blocks as compared with the control sample because of pozzolanic nature of fine glass.***

Keywords: Mortar, Pozzolanic, Waste glass, compressive Strength.

1. Introduction

In developing countries such as India, where diversified projects for industrialization in conjunction with rapid urbanization are vigorously embarked upon to improve the standard of living, the major problem is environmental pollution by the increasing generation of domestic and industrial waste. Disposal of wastes has become a major problem in metropolitan areas in India, especially the disposal of waste glass generated from domestic and industry in the country. Quantities of waste glass have been on the rise in recent years due to an increase in industrialization and the rapid improvement in the standard of living. Unfortunately, the majority of waste glass is not being recycled but rather abandoned and is therefore, the cause of certain serious problems such as waste of natural resources and environmental problem. For these reasons, this study has been conducted through basic experimental research in order to analyze the possibilities of crushed waste glass as fine aggregates in mortar. If the large amount of waste materials generated is used instead of natural materials in the construction industry, there would be three benefits: conserving natural resources, disposing of waste
materials (which are often unsightly) and freeing up valuable land for other uses [J Blewett et al., 2000]. Glass is a common product that can be found in different forms: bottles, jars, windows and windshields, bulbs, cathode ray tubes, etc. Due to the limited landfill space available and stringent environmental regulations, many waste glasses are attempting to develop efficient, economic and environmental sound alternatives for utilizing this waste glass. Therefore, the civil engineers have been challenged to convert this waste glass to useful building and construction materials.

2. Materials

The materials used for this experimental work are cement, sand, water, fine waste glass aggregate.

2.1 Sand

Two types of sand were used.
(1) Standard sand - Standard sand conforming from IS 650:1991 used as fine aggregate for control mortar block.
(2) Natural Sand - The Wainganga sand was used as fine aggregate for control mortar block.

2.2. Water

Potable water was used for experimentation.

2.3. Cement

Ordinary Portland cement of 53grade was used in this experimentation conforming to IS-12269-1987.

Table1: Typical composition of ordinary portland cement.

Chemical	Weight
Tri-calcium silicate -C3S	55%
Di-calcium silicate -C2S	18%
Tri-calcium aluminate -C3A	10%
Tetra-calcium alumino ferrite -C4AF	8%
Calcium sulphate dihydrate -CSH2	6%

2.4. Waste glass

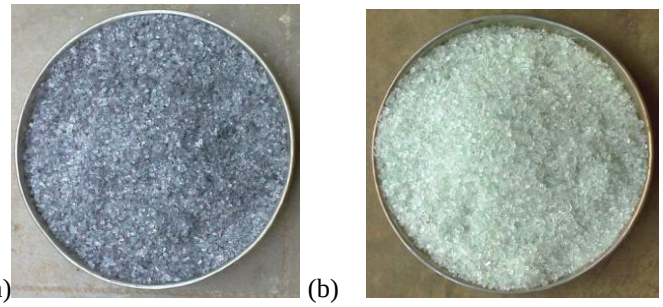
The broken windows glass was used as waste which was supplied from windows glass market. The Fine Glass (FG) Aggregates and Coarse Glass (CG) aggregates were produced

by using pulveriser and separated by IS sieves in two different particle sizes as follows:

- Fine glass aggregate of size: - 600µm – 1.18mm
- Corse glass aggregate of size: - 1.18mm – 4.75mm

In this study, two different colour waste glasses were used in two different sizes as follows:

- White fine glass aggregate (WFG): - 600µm – 1.18mm
- Colour fine glass aggregate (CFG): - 600µm – 1.18mm
- White coarse glass aggregate (WCG): - 1.18mm – 4.75mm
- Colour coarse glass aggregate (CCG): - 1.18mm – 4.75mm



(a) (b)

Figure 1: Photo of material used (a) Colour coarse glass aggregate (b) White coarse glass aggregate

3. Experimental Work

In this research, mortar mix 1:3 according to the IS 2250:1981 of masonry mortar was used. Total fourteen series of mixtures of 1:3 proportions were prepared in the laboratory trials. The fourteen mixtures in series includes a control mixture using natural sand and standard sand with zero percent glass aggregate (GA). The cement and water proportion in the mixes was constant to determine the effect of various fine glass (FG) and coarse glass (CG) combinations. The replacement of fine aggregate (FA) with FG and CG were at levels from 10%, 20% and 30% by weight. In the mixing process of mortar, waste glass, fine aggregates and cement content (all dry) were mixed for 1 min in mortar mixer. Then, water was poured into mortar mixer for another 3 min. The temperature of the water and that of the test room at the time when the mixing operation is being performed was 27 ± 2° C.

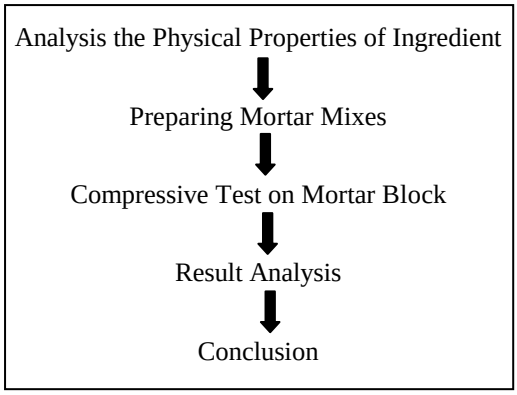
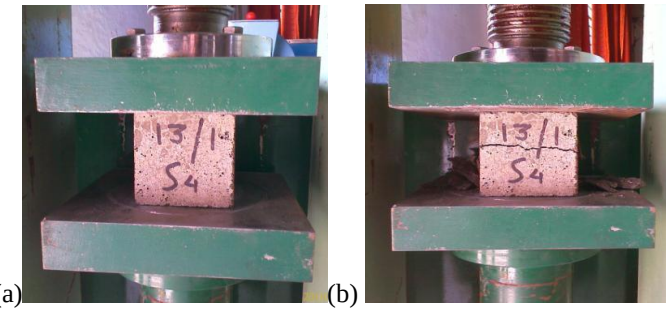


Figure 2: Flow Chart of Experimental Work

Afterward the fresh mixes were fed into the steel moulds with internal dimensions of 70.6x70.6x70.6 mm. The steel moulds were filled with material to about half height and the layer compacted by tamping it with the tamping rod in a uniform manner over the mortar surface in such a way to produce full compaction of the mortar with neither segregation nor excessive laitance. The moulds were then be completely filled and the upper layer of the mortar compacted in a similar manner, after which the mould were kept on the vibrating table. Then, the surface of the mortar struck off plane and leveled the top of the mould using a trowel. The specimen was marked for later identifications. Mortar cube then removed from the mould after 24 hrs and stored in clean water until the time of test. The temperature of the storage water was 27 ± 2°C. The specimen was tested at an interval 1, 3, 7 and 28 days.



(a) (b)

Figure 3: Picture of sample testing (a) Specimen before testing (b) Specimen after testing

4. Results and Discussion

In this research, waste glass was used as fine aggregate with different colour and different replacement level in production of the cement mortar. In this mix, two different colours of waste glass were substituted in weight ratio of 10%, 20% and 30% of each size fraction. The Portland cement, sand and water mixing proportion was 1:3. Figure 4,5,6,7 shows the test result of the compressive strength depending on the changes in the mixing rate of the waste glass and the age of testing. The strength development of the cement mortar containing waste glass was compared with that of mortar containing 100% local sand and standard sand at the same age. It has been found that white course glass and colour course glass incorporation reduces the compressive strength of mixture as compared to the other mixtures. However, there are some exceptional results obtained from 20% coloured fine glass replacement. The maximum compressive strength values were measured at 20% replacement level for all curing days.

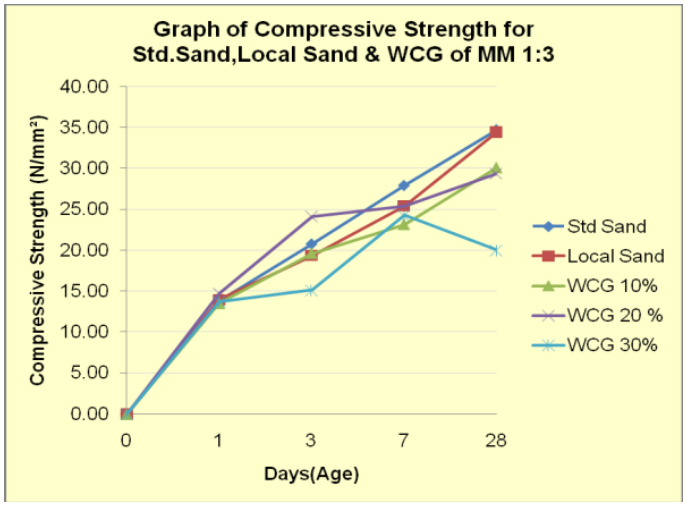


Figure 4: White coarse glass compressive strength result

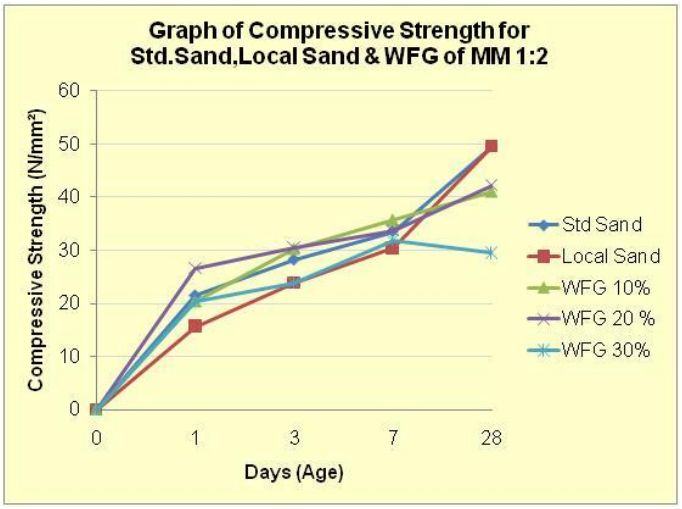


Figure 5: White fine glass compressive strength result

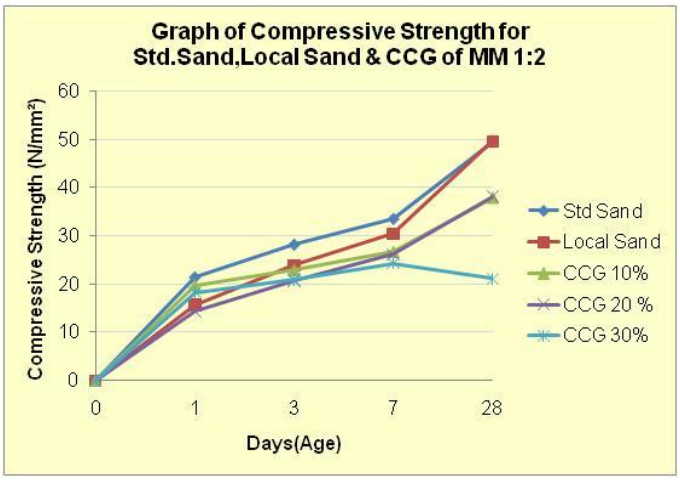


Figure 6: Colour coarse glass compressive strength result

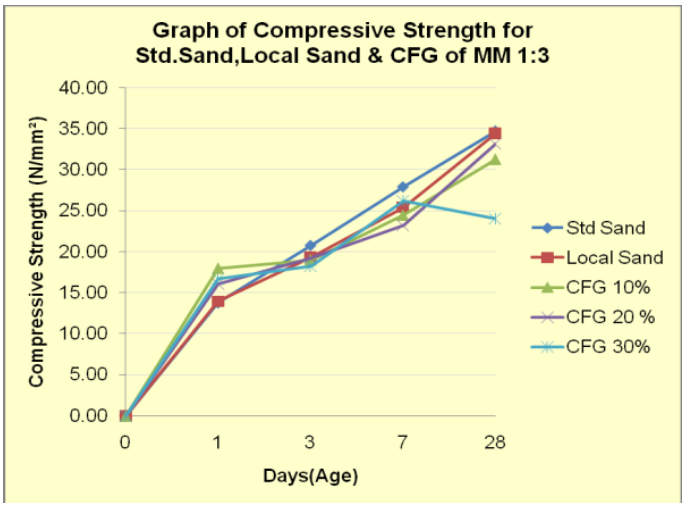


Figure 7: Colour fine glass compressive strength result

The mortar containing 100% standard sand exhibited generally a high compressive strength than the other mixtures. As shown in figure 4,5,6,7 the mortar containing 100% standard sand achieved a compressive strength of 13.80 Mpa, 20.80 Map, 27.94 MPa and 34.74MPa at the age of 1, 3, 7 and 28 days respectively whereas, the mortars containing local sand achieved the compressive strengths 14.00 MPa, 19.41 MPa, 25.47 MPa and 34.48 MPa at the 34.74MPa at 28 days whereas the mortar containing local sand, 20% white fine glass and 20% colour fine glass achieved the 28days compressive strength 34.48 MPa, 32.48 MPa, 31.27 MPa respectively which are very close to the strength of 100% standard sand mortar. The mortar containing 10% white course glass, 10% white fine glass, 10% colour course glass and 10% colour fine glass achieved the compressive strength of 30.14 MPa, 32.41 MPa, 29.14 MPa and 31.27 MPa respectively at 28 days. At 10% replacement of white fine glass, the compressive strength value of the white fine glass containing mortar were slightly less than that of the 100% standard mortar block and local sand mortar block.

5. Conclusion

1. On addition of waste glass as fine aggregate, the rate of gain of strength is low at early age but it meets nearly required design strength at 28 day.
2. At the level of 20% coloured fine glass replacement of sand meets maximum strength as compared to that of control mortar block and other percentage of replacement of sand.
3. Addition of 30% glass aggregate decreases the strength of mortar.
4. As the size of waste glass particle decreases in cement mortar, the strength of cement mortar increases.
5. From results, it is concluded that particle size less than 1.18 mm get higher strength than that of particle size ranges from 4.75 mm to 1.18 mm.
6. The optimum replacement level of waste glass as fine aggregate is 20%.

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