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Exploring the Utilization of Glass Waste as Fractional Substitution for Coarse Aggregate in Conventional Concrete

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Abstract: **Glass waste is one of the major components of the solid waste torrent in many countries. It can be found in many forms, including container glass, flat glass such as windows, bulb glass and cathode ray tube glass. At current, even though a little share of the post-consumed glass has been recycled, a noteworthy share, which is about 84% of waste glass generated, is sent to land depression fills each year. The mounting consciousness of glass recycling speeds up scrutiny on the utilization of waste glass with diverse forms in an assortment of fields. One of its momentous contributions is to the construction field where the waste glass can be reused for concrete fabrication. Laboratory trials were carried out in SHIATS to further discover the utilization of glass waste which can efficiently be used as coarse aggregate substitution (upto 50%) without substantial alteration in strength. Concerning the environmental and economic issues, this research addresses the use of waste glass as fractional substitution of coarse aggregate in concrete. Here, Coarse aggregate are replaced by waste glass by 10%, 20%, 30%, 40% and 50% by weight for M-20 mix and tested for the parameters such as compressive strength, self weight, etc at the age of 7days and 28 days and the results obtained are compared with those of conventional concrete. The results concluded the permissibility of our research objective.**

Keywords: **Glass Waste, Aggregate, Alkali Silica Reaction, Compressive Strength, Self Weight.**

I. INTRODUCTION

Glass is a transparent material formed by melting a blend of materials such as silica, soda ash and $CaCO_3$ at high temperature followed by cooling during which solidification occurs without crystallization. Glass is a 100% recyclable material with high performances and unique aesthetic properties which make it suitable for wide-spread uses. Also, concrete industry is one of the largest consumers of natural resources due to which sustainability of concrete industry is under threat. The application of glass in architectural concrete still needs improvement. Several study have shown that waste glass that is crushed and screened is a strong, safe and economical alternative to using sand in concrete. During the last decades it has been recognized that sheet glass waste is one of large volume and in increasing year by year in the shops, construction areas and factories.

However, undesirable Alkali-Silica Reaction (ASR) might occur in glass concrete due to its high silica constituent. Some solutions have been formed to alleviate ASR, but these solutions have some limitations which made it still particularly important to investigate the utilization of glass in concrete. There has been a general perception in concrete construction industry that glass aggregate should be precluded to be used in concrete because of their potential for Alkali-Silica Reaction (ASR), even though early researches haven't drawn any definite conclusions yet. Recent publications, while not specifically supporting the use of glass in concrete, have led to a great understanding of ASR parameters and methods by which it can be suppressed and major recent research in USA and UK has made it possible for recycled glass to be viewed as a potentially *'fit for purpose'* concrete construction material. Early researches in 1960s, 70s and 80s on the study of ASR of glass aggregate were conducted without deriving definite conclusions.

In parallel to these scientific advances, changes in environmental legislation are positively encouraging the use of secondary aggregates in concrete and also glass waste is becoming available in larger quantities accompanying with metal containers, end-of-life vehicles, waste electrical & electronic goods and construction demolition waste.

II. METHODOLOGY

In this study all the ingredients are used as per their required standards like mechanical properties, physical properties, chemical properties, shape & size, texture & source, etc. The ingredients of conventional concrete viz. cement, fine aggregate, coarse aggregate and water are used of identical specification in reformed concrete. Only the new material i.e. glass waste aggregate is selected on the basis of specifications published in earlier studies as mentioned ahead. Further the concrete mix was designed for proportions by '*Indian Standard method for Concrete Mix Design'* considering the substitution of glass waste aggregate by 10%, 20%, 30%, 40% and 50% by weight in place of conventional coarse aggregate making considerations with respect to the specific gravities of material. The detailed proportion of different ingredients of concrete is shown in TABLE I below.

Thickness of glass used is 6 mm clear float glass 87% transparent to visible. Glass waste had density of 2500kg/m^3 making it approximately 2.5 times heavier than the equivalent volume of water. Thermal conductivity in most of glasses ranges from 1.5 to 3.5 g-cal/cm^2/^{0}C/cm thickness at 0^0C. Particle size gradation glass waste aggregate is carried out before using as a replacement.

TABLE I
Proportions of various Ingredients of Concrete

Glass Replacement (%)	Water (Liters)	Cement (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)	Glass (kg)
0	3.5	8	17.78	32.90	0
10	3.5	8	17.78	29.60	3.29
20	3.5	8	17.78	26.32	6.57
30	3.5	8	17.78	23.03	9.87
40	3.5	8	17.78	19.74	13.16
50	3.5	8	17.78	16.45	16.45

The selection of concrete proportions involves a balance between economy and requirements for workability, consistency, durability, density and appearance for particular applications. In addition, when mass concrete is being proportioned, consideration is also given to heat of hydration. Also the other materials such chemical admixtures including super-plasticizers, water reducers and air entraining agents can be used to modify the properties of concrete.

For proportioning some significant factors are considered viz. W/C ratio, cement content, gradation of aggregate and consistency. Our effort in proportioning should be to use minimum amount of paste that will lubricate the concrete mass while fresh and after hardening will bind the aggregate particles together and fill the space between them. Any excess of paste involves greater cost, greater drying shrinkage, greater susceptibility to percolation of water and therefore attacked by aggressive water and weathering action. This can be prevented by minimizing the voids by proper gradation and proper workmanship. Further the concrete is prepared in accordance with IS specifications by partial replacement of glass waste aggregate by 10%, 20%, 30%, 40% and 50% by weight in place of conventional coarse aggregate and three specimens are casted for each proportions to derive the average results.

III. RESULTS AND DISCUSSIONS

A. Results

This section describes the results of the test carried out to investigate the various properties of the concrete mixes prepared in contrast with the control mixes. The results for unit weight and compressive strength for 7 days and 28 days are presented in TABLE II below. Analysis and discussions are also made on the findings.

TABLE II

Compressive Strength of Concrete by Partial Replacement

Sr. No.	Partial Replacement of Glass Waste	7 days Avg. Compressive strength of concrete in (N/mm ^{2})	28 days Avg. compressive strength of concrete in (N/mm^2)	Average weight of concrete in (kg)
1.	0%	19.75	28.21	8.64
2.	10%	18.51	26.81	8.41
3.	20%	21.84	28.44	8.47
4.	30%	17.25	22.96	8.34
5.	40%	20.88	20.14	8.24
6.	50%	20.51	26.36	8.58

Following Graphs shows the results of partial replacement of waste glass as coarse aggregate in concrete:

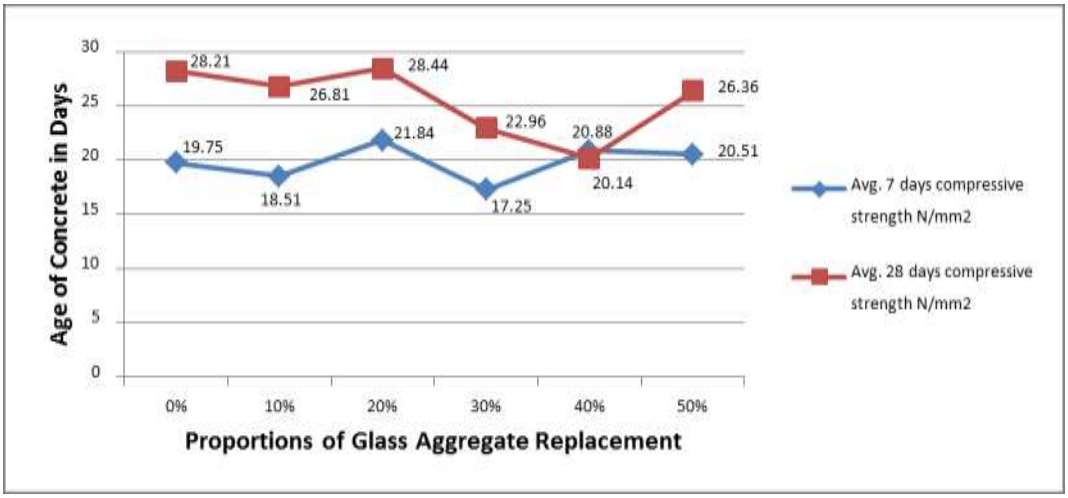

Fig.1: Graph Indicating Comparison between Compressive Strengths of Conventional Concrete with Modified Concrete.

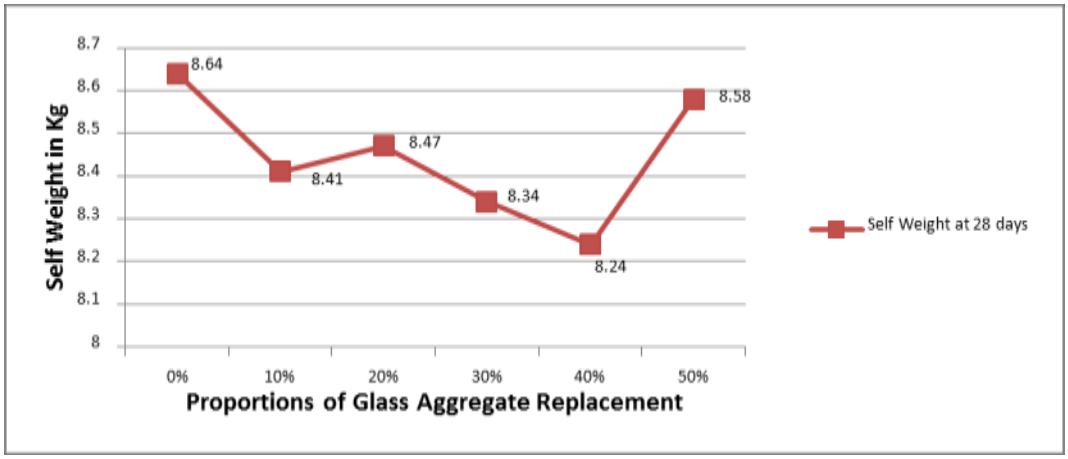

Fig.2: Graph Indicating Comparison between Self Weights of Conventional Concrete with Modified Concrete.

B. Discussions

Following concluding remarks have been made on basis of the work conducted.

- While using waste glass as coarse aggregate replacement, 28 days strength is found to marginally increase up to 20% replacement level.
- Marginal decrease in strength is observed at 30% to 40% replacement level of waste glass with coarse aggregate.
- The optimum replacement level of waste glass as coarse aggregate is 20%.
- It is observed in Fig.2 that self weight of concrete substantially decreases with increase in glass aggregate replacement; this will affect by reducing dimensions of RCC framework due to reduction in loadings and further will help minimizing the cost of concreting.
- Workability of concrete mix increases with increase in waste glass content.
- Use of waste glass in concrete can prove to be economical as it is non useful waste and free of cost.

CONCLUSION

Generation of glass waste around the globe can neither be controlled nor can be decomposed, only can be recycled and reused. The proposal made by this research of replacing coarse aggregate with waste glass aggregate in concrete has proved to be promising with the assistance of results achieved on the positive part. Not significant but in a minor amount compressive strength gets improved after the replacement of 20% of glass aggregate. However it is satisfactory that glass aggregate can replaced conveniently without hampering the properties of conventional concrete. Moreover it has been observed that the self weight also gets reduced, creating influence on positive side.

Research proposes the effective utilization of waste glass, thus eminently expressing the mode of reducing carbon footprints and degradation of environment due to continuous increase in non-decomposable wastes. Thus the concrete prepared by using waste glass aggregate also proves to be eco-friendly along with sustainable and durable option for concreting.

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