A practical study on Effective Utilisation of Waste Glass in Concrete

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Abstract- In recent Concrete is one of the most widely used construction materials in the world. However, the production of portland cement, an essential constituent of concrete, leads to the release of significant amount of CO2, a greenhouse gas; one ton of portland cement clinker production is said to creates approximately one ton of CO2 and other greenhouse gases (GHGs). Glass is a widely used product throughout the world; it is versatile, durable and reliable. The uses of glass ranges drastically, therefore waste glass is discarded, stockpiled or land filled. About million tons of waste glass is generated and around large percent of this glass is disposed of in landfills. This pattern has influenced environmental organizations to pressure the professional community to lower the amount of glass being discarded as well as find use to the non-recycled glass in new applications. In relation, the recycling of waste glass as a component in concrete gives waste glass a sustainable alternative to land filling and therefore makes it economically viable. One of its significant contributions is to the construction field where the waste glass was reused for concrete production. The implication of glass in architectural concrete still needs improvement. Laboratory experiments were conducted to further explore the use of waste glass as coarse and fine aggregates for both ASR (Alkali-Silica-Reaction) alleviation as well as the decorative purpose in concrete. The study indicated that waste glass can effectively be used as fine aggregate replacement (up to 40%) without substantial change in strength.

Index Terms- Compressive strength, crushed glass particles, flexural strength, Glass powder, partial replacement.

I. INTRODUCTION

Waste glass is a major component of the solid waste stream in many countries [1]. It can be found in many forms, including container glass, flat glass such as windows, bulb glass and cathode ray tube glass. Glass is a 100% recyclable material with high performances and unique aesthetic properties, which make it suitable for wide-spread uses. When mixed-color waste glass, is crushed to about the particle size of cement and used in concrete as replacement for about20% of cement, improves the moisture barrier qualities, durability, and mechanical performance of concrete [2]. Glass is an inert material which could be recycled and used many times without changing its chemical property [3]. Besides using waste glass as cullet in glass manufacturing waste glass is crushed into specifiedsizes for use as aggregate in various applications such as water filtration, sand cover for sport turf and sand replacement in concrete. Glass is amorphous material with high silica content, thus making it potentially pozzolanic when particle size is less than 75μm.Studies have shown that finely ground glass does not contribute to alkali – silica reaction. [4].Glass is very valuable to be 'thrown away' as aggregate: glass should be recycled as glass.' Closed loop recycling is thought to be a more viable option in terms of sustainability and cost. Meanwhile demand for waste glass aggregate largely depends on location, transport costs and scarcity of natural aggregates [5]

II. EFFECT OF USING GLASS POWDER IN CONCRETE

Experiment were conducted on concrete prepared by partial replacement of cement by waste glass powder of particle size 90 micron and crushed glass particles retained on 2.36mm and 1.18 mm IS Sieve. The waste glass powder (GLP) and crushed glass particles (CGP)were replaced by 5%, 10%, 15% and 20% of the cement and natural sand respectively in the same mixture of concrete.

1) Cement, water and Aggregates:Concrete is prepared by mixing various constituents like cement, aggregates, watered which are economically available. Ordinary Portland cement of 43grade conforming to IS 8112 was used throughout the work. The coarse aggregate used in this investigation was 20mm size crushed stone. Two size of fine aggregate was used; one retained on 2.36 mm and second retained on 1.18 mm IS sieve.
2) Glass powder:The Land filling of waste glasses is undesirable because they are not biodegradable, which makes them environmentally less friendly. So we use the waste glass in concrete to become the construction economical as well as eco-friendly.

Table No- 1

Physical properties of glass powder

Sr.No.	Physical properties	Values
01	Specific gravity	2.7
02	Fineness Passing 150μm	100 %
03	Fineness Passing 90μm	98 %

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Table No- 2

Chemical properties of glass powder

Sr.No.	Chemical properties	Values
01	pH	10.30
02	Colour	white

III. TESTING VULNERABILITY AGAINST CONCRETE PROPERTY

SPLIT TENSILE STRENGTH

Vijayakumar G. et al [2013] studied that the glass powder concrete increases the tensile strength effectively when compared with conventional concrete. **Vandhiyan R. et al [2013]** showed that there was a marginal improvement in the tensile strength. **Chikhalikar S.M. and Tande S.N. [2012]** in their study on Steel Fibre Reinforced Concrete (SFRC) presented that the tensile strength attains a peak value at 20% replacement of cement by waste glass powder. **Dali J.S. and Tande S.N. [2012]** performed tests on concrete containing mineral admixtures at high temperatures and concluded that 20% replacement level is optimal when concrete is not subjected to alternative wetting and drying and also when concrete subjected to alternative wetting and drying.

Table 1 - Fresh concrete property test results

Mix Code	Slump (mm)	Air Content (%)	Density (kg/m^3)
LH-A-A	48.00	1.00	2.30
LH-A-B	56.00	3.60	2.22
LH-A-C	110.00	2.10	2.26
LH-A-D	120.00	1.50	2.29

Mix No. Description:

LH-A-A Glass Aggregate and MK without Pigment

LH-A-B Glass Aggregate and MK with Pigment

LH-A-C Glass Aggregate and SPFA without Pigment

LH-A-D Glass Aggregate and SPFA with Pigment

WATER ABSORPTION TEST

The water absorption is calculated as the increase in mass resulting from immersion expressed as a percentage of the mass of the dry specimen [10] and the test results are shown in Fig. 6.

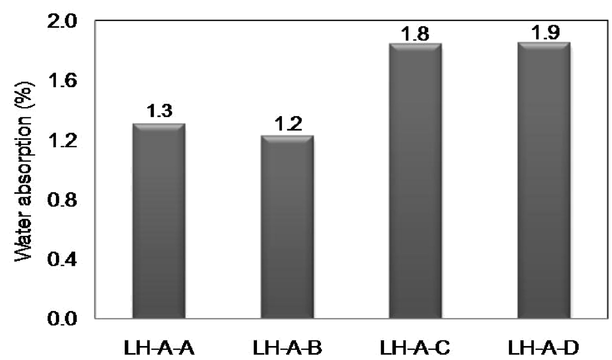

Figure 6. - Water absorption

It can be seen from Fig. 6 that the first two concrete mixes have similar water absorption performance as well as the second two mixes and the former absorbs more water than the later. This discrepancy could be explained by the fact that, the first two mixes have larger surface areas due to the use of MK and smaller glass particle size than the second two mixes.

SORPTIVITY TEST

Nassar Roz-Ud-Din and Soroushian Parviz [2012] in their study resulted that the partial replacement of cement with milled waste glass results in significant reduction of water sorption of the concretes produced with recycled aggregates**.** **Oliveira L. A. Pereira de et al [2008]** replaced natural sand by glass powder and observed that the sand replacement by the waste glass sand reduced the concrete sorptivity coefficient. The reduction attaint a maximum of 39% for 28 days with 100% of natural sand replacement and 29% of reduction at 63 days for the same waste glass rate. This reduction can be influenced by the favourable effect of waste glass sand gradings that improve the particles packing almost certainly reducing the quantity of capillary pores.

FLEXURAL STRENGTH

Vandhiyan R. et al [2013] experimented on replacement of cement by waste glass powder and concluded that a considerable improvement in the flexural strength was seen at 10% replacement of cement**. Vijayakumar. G et al [2013]** showed that flexural strength increment is achieved upto 40% replacement of cement by waste glass powder. **Jangid Jitendra B. and Saoji A.C. [2012]** in their work proposed that flexural strength increases upto 35% replacement of cement by waste glass powder as compared to control mix and

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the peak % increment is at 20%, beyond which it decreases. **Chikhalikar S.M. and.Tande S.N. [2012]** tested flexural strength parameter in his study and resulted that 20% dosage of waste glass powder is optimal for replacing cement**. Dali J.S. and Tande S.N. [2012]** studied the properties of concrete containing mineral admixtures, when it is subjected to alternative wetting and drying and high temperatures and showed that 20% replacement gives higher strength in both the cases when concrete not subjected to alternative wetting and drying, and when concrete subjected to alternative wetting and drying. **Bajad M.N. et al [2011]** experimentally showed that 20% replacement by waste glass powder is optimal both in the case of concrete subjected to sulphate attack and when not subjected to sulphate attack.

WORKABILITY TEST:

Workability is the property of freshly mixed concrete that determines the ease with which it can be properly mixed,placed, onsolidated and finished without segregation. The workability of fresh concrete was measured by means of the conventional slump test as per IS; 1199(1989). Before the fresh concrete was cast into moulds, the slump value of the fresh concrete was measured using slump cone. In this project work, the slump value of fresh concrete was in the range of 95mm to 100mm.

RESULT AND DISCUSSION

The compressive strength test on both conventional and glass added concrete was performed on standard compression testing machine of 3000kN capacity, as per IS: 516-1959.Totally 35 numbers of cubical specimens of size 150mm X150mmX150mm, and tested for the compressive strength, 35 number of cylinder of diameter 150 mm and length 300 mm was casted and tested for the Split tensile strength and 35 number of beam of size 100mm x100mm x500 mm was casted and tested for flexural strength at the age of 7 days and 28 days. Each of the strength test data corresponds to the mean value of the compressive strength of three cubes. At 28 days the GLP & CGP shows a compressive strength of 32.88N/mm2, 3.94N/mm2 flexural strength, and 1.96 N/mm2 split tensile strength at 15% cement and sand replacement. No sudden increase in strength was seen after 7 days of curing. After 28 days of curing concrete hasgained more strength than theconventional concrete (zero percent replacement).

CONCLUSIONS

The paper presents the effective utilisation of coloured glass aggregates in a range of architectural concretes and their properties tests. The performance test results conducted in this research confirm that the properties of those special mixed concretes are satisfactory. The properties tested include workability, air content, density, compressive strength, tensile strength, and water absorption. Moreover, it is found that water absorption is strongly related to the strength of the concrete. Ultimately, glass is found to be an ideal material as a decorative aggregate in architectural concrete with its satisfactory performances and aesthetic property improvement.

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