Strength and Durability Characteristics of Concrete by Partial Replacement of Fine Aggregate with Crushed Glass

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***Abstract*- The amounts of waste glass have been increasing considerably without being recycled, so cumulative the threat to community health due to the lack of land area. This rising Problematic of waste glass in the India can be relieved if new disposal options additional than landfill can be found. The main aim is to examine to increase the compressive strength over a series of glass percentages. By exhausting glass waste in concrete works, so the awareness is to substitute the crushed glass as much of the natural aggregates and sand as likely to reduce the amount of disposable wastes, as well, but we cannot add too much amount of glass to the concrete. Therefore, samples of the common waste glass materials(such as glass bottles)were collected and crushed to be included popular concrete by way of a partial occupant in the concrete mix replacing fine aggregates. It was proposed to know the strength properties of concrete by conducting tests on the concrete blocks with a nominal mix of 1:1.5:3, by replacing fine aggregate with crushed glass in different proportions (10%, 20%, 30%, 40%) with a water-cement ratio of 0.5.Finally, for concrete mixes having dissimilar proportion of fine crushed glass, it is decided that there was negligible effects on the compressive strength and small reduction on the splitting tensile strength and flexural strength of the mix.**

I. INTRODUCTION

Generally now a days solid waste is the foremost tricky in all countries. Solid wastes are the materials and masses they are released by various human activities. Some of the examples of solid waste materials are manmade waste, domestic waste, medical waste and industrial waste. In a construction industry field, waste material is the common output for the manufacturing, construction, removal of structures, repair works and installing the structures. The final output of the waste materials consists of glass, aggregates, granites, flooring tiles(marbles and tiles),plastic waste, aluminium, wood, paper waste, electric wires and bulbs, PVC pipes and different type of materials. The quantity of waste glass generated is growing day by day in India. The quantity of waste liberation in India is to be in the series of 0.2-0.6 kg/capita/day. This is as per the "Manual on solid waste Management" and this is calculated by the Central Public Health and Environment Engineering Organisation, Ministry of Urban Development, Gov. of India1. Mostly the waste generation is dependent on the living style of the growing population. As the increasing population the labour waste liberation factor is 0.3 kg/capita/day.Solid waste in India mainly consists of household wastes, building debris, agricultural wastes, industrial wastes, medical wastes, workshops wastes, and other waste materials. Out of the solid waste, it is assessed that fine aggregate like sand is 24%, Biodegradable 52%, Rubber, Metals, Textiles, and Leather 12%, Stones and Rubbles 6%, Plastics 1%, Paper and Paper Products 5%.Waste product liberation is increasing similar to increasing of industries and population. Waste products are generally dumped into landfills, it is highly risk to the surroundings and it causes to the health problems due to lack of land area. Removal of this risk to decrease the waste products in India thus, one of the ideas is to replace the waste glass as fine aggregate in concrete. Normally, glasses are manufactured in the form of tubes, rods, flat glass, hollow vessels and different shapes. They are used in different fields like pharmaceuticals, chemistry, laboratory technology, domestic uses, and household appliance technology.

Mainly glasses are classified into four groups based on their oxide composition (by weight). Common glass is one of the classifications of glasses and it consists of glass bottles. It is a combination of sodium silicate, calcium silicate, and iron silicate. Glass bottles are one of the waste products in the growing population. So, in the present investigation common glasses (bottles) are replaced as sand into the concrete and to reduce the disposal wastes.Many studies have highlighting the crushed glass was used in concrete works, such as the glass can be partially replaced as fine and coarse aggregates into the concrete. By doing like this we can get possible benefits as follows less glass is thrown away saving landfill space, the use of fewer natural aggregates (which are the components of concrete) saving. Transportation charges are less and time is saved because waste glass is available in near the junk shops. Generally concrete has compressive strength is high as compared to its tensile strength and cracks will appear in unpredictable areas.Cracks can be reduced with some degree by using steel bars are placed in internal reinforcement and also different building materials are added to reduce cracks. Concrete contains different materials like fine aggregate (sand), coarse aggregate (gravels), water. These are not uniform materials so they form cracks due to this reason other binding materials like glass, plastic and steel are added to reduce the cracks. Generally waste glass bottles are available in many forms they are medicine bottles, drink bottles, sauce bottles and glass jars etc.In this study, the main component of glass is clean, brown colour drink bottles. Other type of glasses such as chemical, laboratory glass, mirrors and ceramic plates are not used in this study.The crushed glass was used in concrete mixes; it is an advantage for the environmental works and compressive strength is slightly increases. The common glasses (bottles) are crushed into the small size particles and they are replaced into the aggregates (fine and coarse) and to prepare the concrete. In this study, the crushed glass is partially replaced as fine aggregate into the concrete and tests like compressive strength, split tensile strength were conducted. The physical properties of materials are also carried out.

II.LITERATURE REVIEW

In the previous decades many peoples has done to inspect the crushed glass used as aggregate in concrete and to know the strength properties of concrete. Literature relating to aggregates in concrete and the effect of curing managements on this concrete are numerous. In this chapter, only literature concerning those aspects related to this particular research i.e. the mechanical and durability properties of hardened concrete integrating waste glass has used as aggregates in concrete are discussed. This survey also includes the impact of curing conditions on the various proportion of waste glass used in concrete.Liang, Hong, Zhu, Huiying, Byars, Ewan A. have studied that waste glass was used as both fine and coarse aggregate replacement in concrete and white Portland cement was used with the replacement of 10% metakaolin and 20% super classified fly ash were used and finally to find the fresh and hardened properties of concrete. The alkali silica reaction has no complete solution to found and waste glass was used in architectural concrete the properties of glass still needs humanizing. The special cement contains very low alkali content so it is potentially mitigate the ASR. The size of glass particles used is 1-3 mm as fine aggregate in concrete and to make colour distribution in some concrete mixes. Pigments were additional to concrete and to form coloured architectural concrete. Super plasticizers were used to decrease the water quantity required and to obtain good workability. L.A. Pereira de Oliveira, P. Santos, J.P. Castro-Gomes have studied that finely ground waste glass added as partial replacement of natural sand in concrete and to find the mechanical and durability properties of concrete.' The alkali silica reaction test was led to check the effect of ground glass as partially replaced as sand into the concrete expansion. The concrete bars of size 40 x 40 x 160mm are prepared and they are immersed into the water for 24 hours and 1N NAOH solution is added to store them at a temperature of 80ºC. After 14 days change in length was measured by using a comparator and change in length is less than 0.002mm. The capillary absorptivity test was conducted on the samples of size 7.5 x 7.5 x 15cm and they are stored in oven until the loss of weight was negligible. Finally, it is noticed that the ground waste glass was partially replaced as sand the concrete absorrptivity coefficient is reduced. The water permeability test was conducted on the

cylindrical test specimen of size 5cm diameter and 4cm height. After oxygen permeability test, water permeability test was conducted with the same specimen. The oxygen permeability is high for 28 days as compared to 63 days by replacing ground waste glass is partially replaced as natural sand into the concrete. As per EN 12350-2 the slump test was conducted and to calculate the workability.

III.SCOPE AND OBJECTIVES

This research is mostly aiming on to treasure the effect of crushed glass on the properties of concrete mixture as a partially replacement of fine aggregate. The usage of crushed glass in concrete is to decrease the some percentage of environmental and health effects. In this study of scope, the main aim is to progress the compressive strength of concrete at partial replacement of crushed glass as fine aggregate. Waste glass (like drink bottles) is the easily available material in local junk shops. So, replacement of crushed glass is used to prepare the concrete or to make the structure the time taken is less and Present days the construction works are increased day-by-day. Natural aggregates used in construction works are relatively increased. So, growing of structures natural aggregates availability is relatively reduced. For this reason to save the natural aggregates crushed glass used as sand in concrete works, but care must be taken do not add too much of glass into the concrete because it has to be weaken.The main aim in this research is to know the concrete properties when partially occupier of glass aggregate in to the concrete. This objective can be achieved through the following objectives:

- To find the workability of concrete at different percentages of crushed glass as a partial replacement of sand.
- Study the influence of hardened properties of concrete such as compressive and split tensile strength of concrete when crushed glass used into the concrete mixes.
- For safe construction, to find the how much percentage of crushed glass is partially replaced as sand in concrete.

IV. TEST RESULTS AND DISCUSSIONS

In this lesson the physical and mechanical properties of crushed glass. Aggregate used in concrete are discussed. The mechanical properties are compression and split tensile and durability of concrete are mentioned in the below tables. Finally to compare the results between the 0% Crushed Glass Aggregate used in concrete and 10, 20, 30, and 40% replacement of Crushed Glass Aggregate used in concrete. The properties of ingredients are shown below

Table 4.1 Physical Properties of Ordinary Portland cement

S.No	Properties	Tested values
1	Normal consistency (%)	34
2	Initial setting time (min)	42
3	Final setting time (min)	320
4	Specific gravity	2.64
5	Fineness of cement (%)	93.67

Table 4.2 Physical Properties of Sand

S.NO	Properties	Sand values
1	Specific gravity	2.6
2	Water absorption (%)	1.0
3	Fineness modulus (%)	3.12
4	Moisture content (%)	1.50

Table 4.3:- Physical Properties of Coarse Aggregate

S.NO	Properties	Tested values
1	Specific gravity	2.6
2	Water absorption (%)	0.5
3	Fineness modulus (%)	8.47
4	Moisture content (%)	1.90

Table 4.4:- Physical properties of Crushed Glass

S.no	Properties	Crushedglass values
1	Specific gravity	2.4
2	colour	Brown
3	Fineness modulus (%)	4.11

The above tables show that the values for the properties of ingredients in concrete. In this investigation the importance to conduct the tests for concrete cubes and cylinders is to befinding the ultimate compressive strength, tensile strength and durability of concrete structures. In this discussion,

the results obtained from the normal strength (0% replacement of crushed glass) concrete can be compared to the results obtained up to 40% replacement of crushed glass as sand in concrete. Qualities such as compressive strength values, tensile strength values, and durability values are observed and recorded. In this project graphs are drawn as compared to the normal concrete vs. replacement of crushed glass in concrete

Slump Cone Test

In this test investigation different percentage of crushed waste glass (0 to 40%) replaced as sand and to prepare the concrete mixes. At each percentage the slump value is calculatedthrough slump test by using slump metallic mould. The difference between the height of the mould and subsided concrete of highest point were identified and reported as slump value.

Table 4.5: Slump Cone Test Results

S.NO	Crushed glass (%)	Slump cone values (cm)
1	0	24
2	10	26
3	20	33
4	30	38
5	40	45

The above table shows the slump cone values for different percentages of crushed glass as sand in concrete.

Figure4.1: variation of slump with crushed glass content

The obtained slumps were considered as true slumps. The slumps were 24 cm, 26 cm, 33 cm, 38 cm, and 45 cm. so; the degree of workability is increased. By increasing of crushed waste glass in concrete, the slump value is gradually increased as compared to normal concrete. So, the workability is increased by increasing of crushed glass in concrete.

Dry Density

For dry density of cubes and cylinders first the dry weight of cubes and cylinders are measured.For this reason the cubes and cylinders are taken away from the curing and they are dried for 24 hours. Then the weight of the cylinders and cubes are taken before the testing of specimens. If cubes and cylinders dry weight are known then to find the dry density for cubes and cylinders. In this project after 28 days curing the dry weight of the cubes and cylinders are observed and their dry density values are mentioned below.By adding different percentage of crushed glass replaced as sand in concrete then to find the dry density at each percentage of sample. For the better results at each percentage two samples are measured at water-cement ratio is 0.5 and to calculate dry density. The density was nearly equal to the for all crushed glass percentage of concrete mixes. This density is compared to the normal concrete mixes and it is tabulated as below.

Table 4.6:- Dry Density and Percentage Change in Weight of the Cubes

Crushed glass (%)	Average dry weight of cubes	Dry density (KN/m3)	Percentage change in weight with respect to normal concrete
0	8310	24.62	0%
10	8282.5	24.54	-0.324%
20	8198	24.29	-1.34%
30	8143	24.12	-2.03%
40	8040.5	23.82	-3.24%

The above table shows the dry density of the cubes. By increasing the crushed glass in concrete the dry density is decreased, similarly the weight of the cube is decreases.

Table 4.7:- Dry Density for Cylinders

Crushed glass (%)	Average dry weight of cylinders (gm)	Dry density for cylinders (KN/m3)	Percentage change in weight with respect to normal concrete
0	8583	30.94	0%
10	8560	30.72	0.71%
20	8345	30.28	-2.13%
30	8215	29.62	-4.26%
40	8150	29.45	-4.815%

The above table shows the dry density for cylinders. As compared to normal concrete by increasing the crushed glass in concrete the dry density is decreases and similarly the weight of the cylinders also decreases.

Compressive Strength

By replacement ofcrushed glass as sand in concrete, to determine the compressive strength for 3 days, 7 days and 28 days curing of the concrete cubes by using compressive strength testing machine.At room temperature these cubes were cured. The water cement ratios were taken as 0.50. Two cubes were casted for each sample because the average values of the two cubes test results are taken for the exact results. By conduct the compressive test to observe the crushing loads for each specimen and they are note down. After knowing the crushing load values by using the formula, the compressive strength values are calculated and they are tabulated below in the table 4.8

Table 4.8:- Compressive Strength Values for Different Proportion of Crushed Glass Used in Concrete

S .no	Crushed glass (%)	Compressive strength (N/mm²)		
		3days	7 days	28days
1	0	17.5	21.7	33.8
2	10	24	25.77	35.6
3	20	24.88	27.99	38.4
4	30	23.9	24.9	34.25
5	40	23.12	23.32	32.54

The above table shows the compressive strength values for different ages at variation of crushed glass percentage in concrete. By increasing the crushed glass in concrete the compressive strength is increased up to 30% replacement at 3 days, 7 days, 28 days, after increasing the crushed glass replacement in concrete it starts decreases. At 56 days, 90 days the compressive strength is increased up to 20% replacement of crushed glass in concrete and further increasing it goes to decreases.

5.4: compressive strength for 28 days

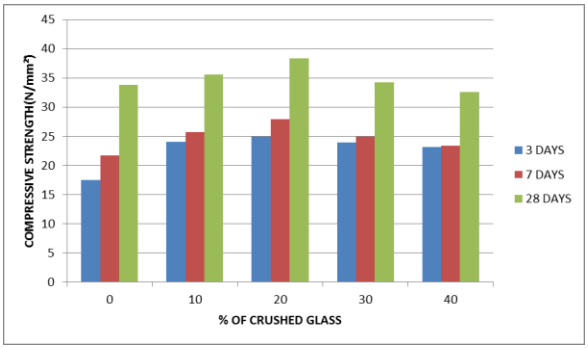

Figure 5.5: Variation of compressive strength at different ages of curing with different percentage of crushed glass

Split Tensile test

The test was carried out conforming to IS 5816-1999 to obtain Split tensile strength of concrete at the age of 28 days. The cylinders were tested using Compression Testing Machine (CTM) of capacity 2000Kn.Then it is tested for different percentage of crushed glass replaced as sand in concrete.

Fig:-Split Tensile Test for Cylinders

Table 4.9: Split Tensile Strength for 28 Days for Different Crushed Glass Percentages Used In Concrete

S.NO	Crushed glass (%)	Split tensile strength for 28 days
1	0	2.68
2	10	2.4
3	20	2.2
4	30	2.12
5	40	2.0

By adding different percentage of crushed glass in concrete the split tensile values are recorded in the above table5.11. With increasing of crushed glass in

concrete the split tensile values are slightly decreasing. By adding 10% replacement of crushed glass as sand in concrete the split tensile value is decreasing by 10.44%. At 20% replacement the split tensile value is decreased by 17.91%. At 30% replacement the split tensile value is decreased by 20.89%. At 40% replacement of crushed glass as sand in concrete the split tensile value is decreased by 25.37%.

Split tensile strength for 28 days is shown in below the figure 5.8

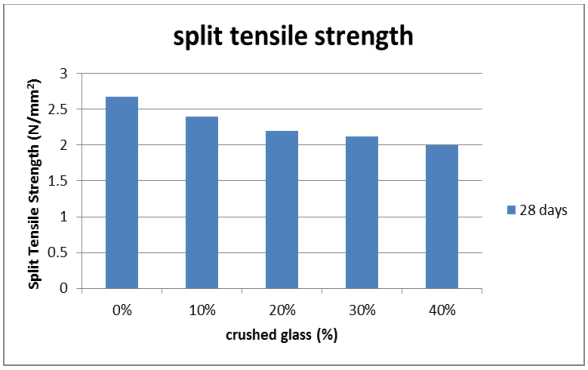

Figure 5.6: Split Tensile Strength of 28 days age of cylinders for different glass percentage used in concrete

FLEXURA L TEST

Fig:-Flexural test for beams

Table 4.10: FlexuralStrength for 28 Days for Different Crushed Glass Percentages Used In Concrete

S.NO	Crushed glass (%)	FlexuralStrengthfor 28 days
1	0	3.78
2	10	3.6
3	20	3.52
4	30	3.59
5	40	3.4

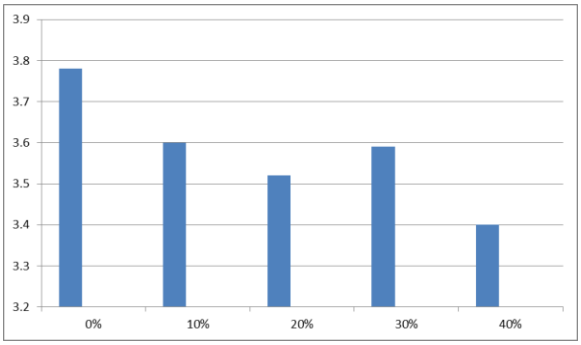

Figure 5.7: Flexural Strength of 28 days age of beams for different glass percentage used in concrete

Crushed glass (%)	Average dry weight before curing (gm.)	Average wet weight after 28 days curing (gm.)	Water absorbed (gm.)	Percentage of water absorption (%)
0	8310	8407	97	1.16
10	8283	8363	80	0.967
20	8198	8267	69	0.841
30	8143	8198	55	0.675
40	8041	8084	43	0.534

In this project the results compressive strength values, split tensile values with replacement of crushed glass in concrete obtained are compared to the results obtained without replacement of crushed glass in concrete. The following conclusions are obtained from this projectTo prepare the concrete by using crushed waste glass used as sand replacement in concrete then the workability of concrete increase with respect to increasing of crushed glass content in concrete. By using water quantity constant to the entire project then the workability is increased because crushed glass absorbs less water quantity to prepare the concrete. So, workability improvement can be achieved. Compressive strength of concrete is depending on the quality of aggregates and recyclable products in concrete. When best quality aggregates are used for the concrete production then the recycling products does not affect the compressive strength. In this project crushed glass used as recyclable product. It is replaced sand in concrete and it is slightly influence the compressive strength at 20% replacement increases and then further replacement the compressive strength value decreases

as compared to normal concrete. The amount of w ater absorption is dependent on the aggregates and quantity of recycling crushed glass particles. The replacement of crushed waste glass content increase then the amount of water absorption is slightly decreased. Water absorption is mainly dependent on the porosity of aggregates. Crushed glass has less porosity then the concrete cube absorbs less water quantity. Based on the results of the load tests on the cubes and cylinders, it is concluded that used coarse aggregate type and quantity has no significant influence on the pattern and width of cracks. First, crack appears in the middle of the span at a load level equal to about one third of the ultimate load regardless of the concrete type. The measured crack widths were approximately the same for all specimen.

V.CONCLUSION

In the interest of the reliability of the study the strength properties of concrete by partially replacing of fine aggregate with crushed glass. Although the detailed conclusions derived from each chapter are given at the end of that chapter, the overall major conclusions regarding their physical and mechanical properties, with fine aggregate replacement materials can be extracted from the test results presented in this thesis and may be summarised as follows. However these conclusions are offered within the limitation of the tests conditions and procedures, as well as the limited duration of the study period.Crushed glass is partially replaced as fine aggregate in concrete with high strength and acceptable structural grade concrete. Curing conditions adopted in this research produced significant changes in the properties of concretes especially those containing different replacement levels.Based on the test data and analysis of results presented in this thesis, the following conclusions can be drawn.

With increasing percentage of crushed waste glass particles, the workability of concrete increased gradually as compared to normal concrete.

By using crushed glass particles into the concrete the water absorption decreases gradually with increase of crushed glass particles.Compressive strength is increases up to 20% replacement of crushed glass as sand into the concrete and after 30% and 40% replacement it starts to decreases.By increasing the crushed glass replacement in concrete the split tensile strength and flexural strength decreases slightly.

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