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EXPERIMENTAL STUDY ON USE OF WASTE GLASS POWDER AS PARTIAL REPLACEMENT TO CEMENT IN CONCRETE

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ABSTRACT

Glass is unstable in the alkaline environment of concrete and could cause deleterious alkali-silica reaction problems. This property has been used to advantage by grinding it into a fine glass powder (GLP) for incorporation into concrete as a pozzolanic material**.** In this study the cement is partially replaced using glass powder which is rich in silica. Therefore, we have planned to prepare some numbers of cubes, cylinders and beams using conventional concrete and going to test them for its strength and other properties then we are going to prepare concrete specimens using glass powder at various proportions like 5, 10 and 15%. The casted specimens are tested for its strength. From the test results, we are going to compare the behavior of glass powder concrete with conventional concrete. In this work we are going to use waste glasses, so the cost will be comparatively low when compared with normal concrete.

KEYWORDS: Glass powder, silica.

I. INTRODUCTION

Concrete is the most widely used building material in construction industry. It is a homogeneous mixture of cement, fine aggregate, coarse aggregate and water. The strength of concrete is mainly depends upon the cement content. Cement is a finely pulverized material which by itself is not a binder but develops the binding property as a result of hydration. The binding nature of cement is due to the presence of silica.

Chief Constituents of Portland cement:

Lime (CaO)	- 62%
Silica (SiO_2)	- 22%
Alumina (Al_2O_3)	- 05%
Calcium Sulphate ($CaSO_4$)	- 04%
Iron Oxide (Fe_2O_3)	- 03%
Magnesia (MgO)	- 02%
Sulphur	- 01%
Alkalies	- 01%

Glass: Glass is an amorphous (non-crystalline) that in essence, a super-cooled liquid and not a solid. Glass can be made with excellent homogeneity in a variety of forms and sizes from small fibers to meter-sizes pieces. Primarily glass is made up of sand, soda ash, limestone and other additives (Iron, Chromium, Alumina, Lead and Cobalt). Glass has been used as aggregates in road construction, building and masonry materials.

Constituents of Glass:

Silica (SiO_2)	- 72.5%
Alumina (Al_2O_3)	- 1.06%
Lime (CaO)	- 0.8%
Iron Oxide (Fe_2O_3)	- 0.36%
Magnesia (MgO)	- 4.18%

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Sodium Oxide (Na_2O)	-	13.1%
Potassium Oxide (K_2O)	-	0.26%
Sulphur Trioxide (SO_3)	-	0.18%

Advantages of Using Glass Powder in Concrete:

The reuse of very finely ground waste glass in concrete has economical and technical advantages. If the glass could be ground to a very fine size, it could satisfy the active pozzolanic behavior. Glass waste is recognized to be increasing year by year in a large volume from shops, construction areas and factories. These waste storage disposals are becoming a serious environmental problem.

Thus usage of waste glass in construction sector is advantageous as the construction cost decreases.

Properties & Applications of Glass:

- Glass is a uniform amorphous solid material, usually produced when the viscous molten material cools very rapidly to below its glass transition temperature, without sufficient time for a regular crystal lattice to form.
- The most familiar form of glass is the silica-based material used for windows, containers and decorative objects.
- Glass is a biologically inactive material that can be formed with very smooth and impervious surfaces.

II. OBJECTIVE

- To evaluate the utility of Glass powder as a partial replacement of cement in concrete.
- To study and compare the performance of conventional concrete and Glass powder concrete.
- To understand the effectiveness of glass powder in strength enhancement.

III. METHODOLOGY

- Investigation on Glass powder.
- Preparation of Glass powder.
- Casting of control specimen.
- Casting of Glass powder concrete specimen.
- Testing of specimen.
- Comparison of test results.

Experimental Work

The waste glass is collected from various places such as construction sites, industries, etc. Then it is crushed and ground to a size fine enough to achieve its pozzolanic behavior. Cement is now partially replaced by its weight by glass powder at varying rates such as 10%, 20% and 30%.Various laboratory tests to determine the fineness, specific gravity, consistency, setting time of normal Portland cement and cement mixed with glass powder at different rates is carried out. With these results, the control mix, utilizing glass powder and quarry dust replaced as cement and fine aggregate respectively is to be designed for cube, cylinder and prism.Now, 16 cubes, 16 cylinders and 16 beams -- such as two specimens for each combination – are to be casted for the whole and cured at room temperature. At the end of curing period, each specimen is tested for compressive, tensile and flexural strength and the average is recorded.

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Fig.1.Finely powdered glass

IV. TESTING ON SPECIMENS

When comparing with conventional concrete the glass powder concrete shows an increased strength of 51 % in 5% replacement but it will reduce its strength while increasing the percentage.

Dimension of Specimen: 150 x 150 x 150 mm
Days of Curing: 28 Days

Fig.2.Testing of cubes

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Table.1. compression test on cubes

S.No	Type of Specimen	Compressive							
		Load in x 10^3N				Strength in N/mm^2			
		Trial 1	Trial 2	Trial 3	Mean	Trial 1	Trial 2	Trial 3	Mean
1	Conventional	595	625	600	606.6	26.44	27.78	26.67	27
2	5 % Glass Powder	850	965	950	921.6	37.78	42.89	42.22	40.96
3	10 % Glass Powder	780	870	850	833.3	34.67	38.67	37.78	37
4	15 % Glass Powder	690	720	790	733.3	30.67	32	35.11	32.59

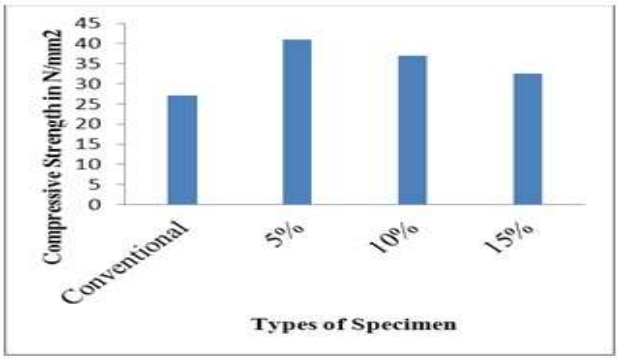

Fig.3.graph showing compression test results

Tension Test on Cylinders (Indirect Tension):
While performing indirect tension test the glass powder concrete shows 32.3 % increment in 5% replacement but it will reduce its strength while increasing the percentage.

Dimension of Specimen:150mm Diameter, 300mm Height
Days of Curing: 28 Days

Table.2. split tensile test on cubes

S.No	Type of Specimen	Split Tensile							
		Load in x 10^3N				Strength in N/mm^2			
		Trial 1	Trial 2	Trial 3	Mean	Trial 1	Trial 2	Trial 3	Mean
1	Conventional	187.5	175	162.5	**175**	2.65	2.475	2.275	**2.47**
2	5 % Glass Powder	225	240	230	**231.6**	3.18	3.39	3.25	**3.27**
3	10 % Glass Powder	190	200	175	**188.3**	2.69	2.828	2.475	**2.65**
4	15 % Glass Powder	180	190	175	**181.7**	2.54	2.69	2.475	**2.56**

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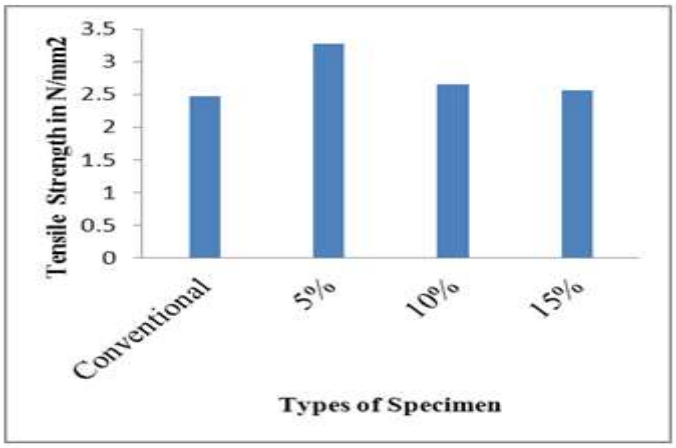

Fig.3.graph showing tensile test results

Flexural Strength of Beams:

While performing bending test on the glass powder concrete shows 22.96 % increment in 5% replacement and it increases its strength while increasing the percentage.

Dimension of Specimen: 1200x 150x 230 mm
Days of Curing: 28 Days

Fig.5. flexural test on beams

Table.3. flexural strength test results on beams

	Type of Specimen	Flexural Strength in kN/mm^2			
		Trial 1	Trial 2	Trial 3	Mean
1	Conventional	27.3	29.3	28.4	28.3
2	5 % Glass Powder	37.3	33.7	33.4	34.8
3	10 % Glass Powder	35.5	37.6	38.3	37.2
4	15 % Glass Powder	41.2	40.5	39.1	40

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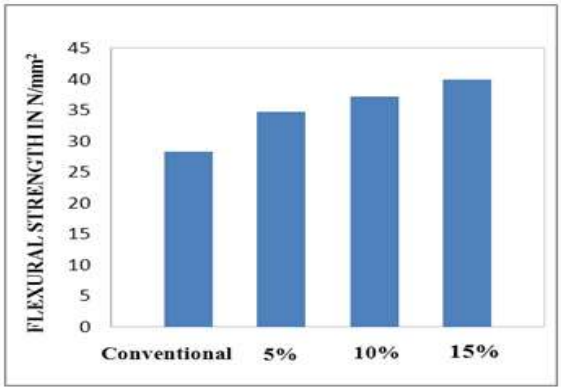

Fig.5. graph showing flexural strength test results on beams

V. CONCLUSION

From the test results the following conclusions were drawn, Conventional concrete shows a 28 days compressive strength as 27 N/mm^2,split tensile strength of 2.47 N/mm^2,Replacement of glass powder in cement by 5%, 10% and 20% increases the compressive strength by **51.7** %, **37**% and **20.7**% respectively. Replacement of glass powder in cement by 5%, 10% and 20% increases the tensile strength by **32.3**%, **7.28**% and **3.64**% respectively. Replacement of glass powder in cement by 5%, 10% and 20% increases the Flexural strength by **22.97**%, **31.45**% and **41.34**% respectively. Glass powder concrete increases the compressive strength, tensile strength and flexural strength effectively. The optimum usage percentage of glass powder is 10%.

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