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An Experimental Study on Engineering Properties of Concrete by Partial Replacement of Cement with Waste glass powder and Silica Fume.

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ABSTRACT

Concrete is the most versatile material used for construction all over the world. It is well known that concrete is the combination of cement, aggregates and water. The production of cement results in the formation of carbon dioxide gas causes the environmental pollution. About 7 percent of carbon dioxide gas is evolved from cement industries to atmosphere all over the world. Use of waste glass powder and silica fume in concrete as partial replacement of cement could be significant step towards development of sustainable, eco- friendly and economical infrastructure systems. In the present study waste glass powder and silica fume are used in concrete as a partial cement replacement with a view of reducing environmental pollution by minimizing the production of carbon-dioxide and to improve the strength of concrete. In this research work the mixture of waste glass powder and silica fume are used in concrete as a partial cement replacement, and its effect upon concrete strength are studied. In this research study, the ordinary Portland cement (Grade 53) is partially replaced by waste glass powder at various proportions 10%, 15%, 20% and 25% respectively and silica fume at a constant proportion of 5% by weight of cement. A control sample of concrete is prepared and is compared with the various samples containing different percentages of mixture of waste glass powder and silica fume as a partial replacement of cement in concrete. The tests conducted are compressive strength, flexural strength and split tensile strength of concrete for both conventional concrete and concrete with admixtures and are compared at 7 days and 28 days of curing. The optimum amount of admixtures required to attain higher strength economically is evaluated based on tests conducted on engineering properties of concrete.

Keywords-Waste glass powder, Silica fume, Compressive strength, Flexural strength and Tensile strength

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I. INTRODUCTION:

Concrete is the second largest material consumed on earth after water due to which the production of cement has been increased enormously throughout the world which in turn increases the emission of carbon dioxide and effects the environment causing global warming. As we know now-a-days, most of the developing countries are facing shortage of post consumer's disposal waste site and it has become very serious problem. For this reason, regenerating and using waste product as resources prevents environmental pollutions. Due to increase in the awareness of environmental protection the solid waste or the by-products generated are used as partial replacement of cement in concrete. Waste glass powder is one of the solid wastes which are generated in huge quantity. Instead of Waste glass ending up as a landfill it can be used as replacement for cement.As of 2015, the total waste glass production estimate was 65 Mt (million tons) throughout the world, in which the European Union and USA produced approximately 13 Mt and 11.86 Mt, respectively. Being non-biodegradable in nature, waste glass disposal as landfillcausesenvironmental pollution and also could be expensive.

Glass is unformed material with high silica content, thus making it potentially pozzolanic when particle size is less than 75µm. Recent studies have shown that finely ground glass does not contribute to alkali – silica reaction. At present, various efforts and research have been made to use waste glass as a substitute in conventional concrete and to reduce greenhouse effect

II. METHODODLOGY:

Experiments were guided on concrete prepared by partial replacement of cement by waste glass powder of particle size 75µm and silica fume. The waste glass powder was replaced by 10%, 15%, 20% and 25% and silica fume by 5% of the binder and the mix design was prepared. The physical and chemical characteristic of concrete and the chemical components of the glass powder used in the concrete are examined.

III. MATERIALS USED:

Cement:

Ordinary Portland cement of grade53 conforming to Indian Standards IS 12269-1987 was used throughout the experimental program. In general similar types of cements have quite different rheological and strength characteristics, mainly when used in combination with admixtures and cementing material. Specific gravity of cement is 3.15.

Table 1: Chemical composition of cement:

S. No	Chemical composition	OPC
1	SiO_2	20.8
2	Na_2O	0.31
3	CaO	65.40
4	MgO	1.3
5	Al_2O_3	4.60
6	K_2O	0.44
7	SO_3	2.2
8	Fe_2O_3	2.8

Fine Aggregate:

Fineaggregate (sand) used for this entire investigation for concrete was river sand conforming to zone-II of IS: 383-1970.Locally available river sand passed through 4.75mm IS sieve is considered as fine aggregate. Specific gravity of river sand is 2.62.

Coarse Aggregate:

Coarse Aggregate in concrete occupies up to35 to 70% of the volume of the concrete. Smaller sized aggregates produce higher concrete strength. The workability of fresh concrete is affected by particle shape and texture. Coarse aggregate crushed granite of 20 mm down size has been used as coarseaggregate. Specific gravity of coarse aggregate is 2.75.

Silica Fume:

Silica fume is a very fine artificial pozzolanic admixture which is composed of ultrafine amorphous glassy sphere of silicon dioxide produced during the manufacture of silicon by electric arc furnace at temperatures over 2000$^{\backslash 0}$. The amorphous form of SiO2 makes it highly reactive. Silica fume reacts with the free lime or also known as calcium hydroxide to form C-S-H gel. Thus imparting additional strength to the concrete. Specific gravity of silica fume is 2.2.

Table 2: Chemical composition of Silica fume:

Chemical Composition	Percentage
SiO_2	94.03
Al_2O_3	0.09
Fe_2O_3	0.10
CaO	0.30
MgO	0.43
K_2O	0.83
Na_2O	0.27

Waste Glass Powder:

Waste glass available locally in market have been collected and made into glass powder. Glass waste is very hard material. Before addition of glass powder in the concrete it is powdered to the desired size. In this experiment, waste glass powder ground in

Ball/pulverizer for a period of 30 to 60 minutes resulted in particle sizes less than size 150 µm and sieved in 75 µm was used. This material partially replaces the cement in mix proportion. Specific gravity of waste glass powder is2.6.

Table 3: Chemical composition of waste glass powder

S. No.	Chemical composition (%)	Glass Powder
1	SiO_2	72.08
2	Na_2O	13.71
3	CaO	10.45
4	MgO	0.72
5	Al_2O_3	2.19
6	K_2O	0.16
7	Fe_2O_3	0.22
8	TiO_2	0.1
9	Cr_2O_3	0.01

Super Plasticizer:

Their addition to concrete reduces the water-cement ratio, not affecting the workability of the mixture, and enables the production of self-consolidating concrete and high performance concrete. Super plasticizer used is ZYCAPLEX.

III. MIX DESIGN:

Mix design for M35 grade of concrete was prepared by using the guidelines of IS 10262:2009. The mix proportion of mix design of material is 1:2.34:3.29 with water cement ratio as 0.42.The study is conducted to determine the compressive strength, split tensile strength and flexural strength of concrete when cement is partially replaced by waste glass powder and silica fume.The moulds used in this experiment are cube with a size of 150mm×150mm×150mm, cylinder with a size of

150mm dia. and 300mm height, prism /beam with size of 700mm×150mm×150mm.The cement, coarse aggregate, fine aggregate, waste glass powder and silica fume are mixed thoroughly until uniform mixture is attained and then is mixed with super plasticizer and water. Compression and split tensile strength are conducted on compressive strength machine and flexural strength is conducted on flexural testing machine. Three samples per batch were tested and average strength values are reported.

IV. RESULTS AND DISCUSSION:

Compressive Strength of Concrete**:**

The test was carried out conforming to IS 516-1965 to obtain compressive strength of concrete at the age of 7 days and 28 days. The specimens (cubes) were tested using compression testing machine (CTM) 2000 KN.

Mix-1: Conventional concrete
Mix-2: 5% silica fume +10% waste glass powder
Mix-3: 5% silica fume +15% waste glass powder
Mix-4: 5% silica fume +20% waste glass powder
Mix-5: 5% silica fume +25% waste glass powder

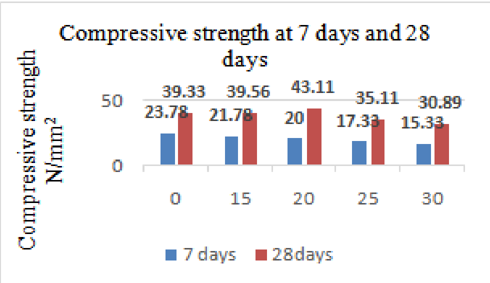


Figure 1: Compressive strength at 7 days and 28 days

Table 4: Compressive strength at 7days and 28days

S. No	Mix	7days	28days
1	Mix-1	23.78	39.33
2	Mix-2	21.78	39.56
3	Mix-3	20	43.11
4	Mix-4	17.33	35.11
5	Mix-5	15.33	30.89

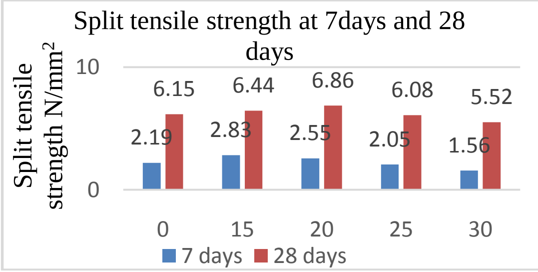
Split Tensile Strength:

The test was carried down conforming to IS 516-1959 to obtain split tensile strength of concrete at the age of 7 days and 28 days. The cylinders were tested by using compression testing machine (CTM) of capacity 2000KN.

Table5: Split tensile strength at 7days and 28 days.

S. No	Mix	7days	28days
1	Mix-1	2.19	6.15
2	Mix-2	2.83	6.44
3	Mix-3	2.55	6.86
4	Mix-4	2.05	6.08
5	Mix-5	1.56	5.52

Figure 2: Split tensile strength at 7days and 28days



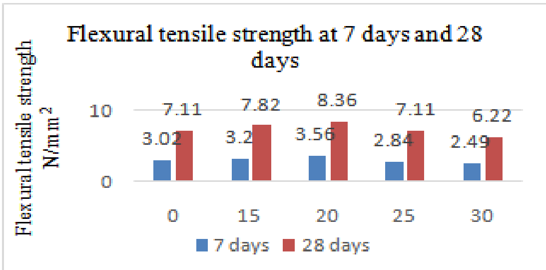
Flexural Tensile Strength:

The test was carried down conforming to IS 516-1959 to obtain Flexural strength of concrete at the age of 7 days and 28 days. The prisms were tested using flexural testing machine

Table 6: Flexural tensile strength at 7days and 28days

S. No	Mix	7days	28days
1	Mix-1	3.02	7.11
2	Mix-2	3.2	7.82
3	Mix-3	3.56	8.36
4	Mix-4	2.84	7.11
5	Mix-5	2.49	6.22

Figure 3: Flexural tensile strength at 7days and 28days



VI. CONCLUSIONS:

The following conclusions are drawn from the results:

- Replacement of silica fume by 5% and glass powder by 10%, 15%, 20%, and 25% in cement decreases the compressive strength when compared with conventional concrete at 7 days testing.

- Replacement of silica fume by 5% and glass powder by 10%, 15%, 20%, and 25% in cement increases split tensile strength for 10% and 15% replacement of glass powder and decreases for 20% and 25% replacement of glass powder when compared with conventional concrete at 7 days testing.
- Replacement of silica fume by 5% and glass powder by 10%, 15%, 20%, and 25% in cement increases flexural tensile strength for 10% and 15% replacement of glass powder and decreases for 20% and 25% replacement of glass powder when compared with conventional concrete at 7 days testing.
- Replacement of silica fume by 5% and glass powder by 10%, 15%, 20%, and 25% in cement increases compressive strength for 10% and 15% replacement of glass powder and decreases for 20% and 25% replacement of glass powder when compared with conventional concrete at 28 days testing.
- Replacement of silica fume by 5% and glass powder by 10%, 15%, 20%, and 25% in cement increases split tensile strength for 10% and 15% replacement of glass powder and decreases for 20% and 25% replacement of glass powder when compared with conventional concrete at 28 days testing.
- Replacement of silica fume by 5% and glass powder by 10%, 15%, 20%, and 25% in cement increases flexural tensile strength for 10% and 15% replacement of glass powder, for 20% replacement remains constant and decreases for 25% replacement of glass powder when compared with conventional concrete at 28 days testing.
- The concrete containing 5% of silica fume and 15% of waste glass powder gave the better results when compared with other proportions and conventional concrete.

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