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EXPERIMENTAL STUDY ON THE EFFECT OF GLASS FIBERS ON METAKAOLIN AND SILICA FUME COMBINED CONCRETE

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ABSTRACT

Concrete is a widely used construction material for various types of structures due to its structural stability and strength. Ordinary Portland Cement (OPC) is one of the main ingredients used for the production of concrete. The search for any such material, which can be used as an alternative for cement continues. Fly ash, Ground Granulated Blast Furnace Slag, Rice Husk Ash, Metakaolin, Silica Fume are some of the pozzolanic materials which can be used in concrete as partial replacement of cement. Here the mechanical properties of metakaolin (15% by weight of cement), silica fume (6% by weight of cement) and glass fiber combined concrete are experimentally investigated through compressive strength test and split tensile strength test, at various ages of concrete in different concentrations of glass fibers. Glass fibers are added by percentage volume of concrete and these are added at 0.5%, 1.0%, 1.5 % and 2% concentrations. Various results were analyzed and improvement in strength of concrete was compared. Maximum compressive strength and Split tensile strength was obtained at 1% glass fiber replacement.

KEYWORDS: Silica Fume, Metakaolin, Glass Fiber Reinforced Concrete.

I. INTRODUCTION :

Cement is an essential ingredient in most forms of building construction. It is the vital binding agent in concretes, and mortars. Since its invention in the 19th century, Portland cement has become the most widely available and used cementitious material.

Portland cements are used world wide because of it quality and assurance in usage. Portland cement is relatively expensive to manufacture and is often in short supply in many developing countries. Thus alternative cements are produced locally, on a small scale and at much lower cost.

Alternative cements are not capable of replacing Portland cement totally, but these can be used in many constructions works. Fly ash, Ground Granulated Blast Furnace Slag, Rice Husk Ash, Metakaolin, Silica Fume are some pozzolanic materials which can be used in concrete as partial replacement of cement.

Fibres can be induced in concrete to improve its strength characteristics. Fibres are usually used in concrete to control cracking due to plastic shrinkage and to drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibers produce greater impact, abrasion, and shatter resistance in concrete.

Glass fibers also have more tensile strength similar to other fibers which can be incorporated in concrete. Lot of studies have been done on glass fiber concrete. But the combination with Silica Fume and Metakaolin with glass fibers have not yet studied, so in our project we have experimentally determined the fresh and hardened properties of metakaolin, silica fume and glass fiber combined concrete. Glass Fibers were added at concentrations ranging from 0.5%, 1.0%, 1.5% and 2.0 % by volume of concrete and specimens were tested for Compressive Strength and Split Tensile Strength.

II. MATERIALS USED :

CEMENT

Cement used is of OPC Grade 53 with a normal consistency of 30% confirming to IS:8112-1988. The physical properties of cement used is listed in Table 1.

FINE AGGREGATE

Fine Aggregate used is M-sand passing through 4.75mm IS sieve. The particle size distribution of fine aggregate is shown in Figure 1.Specific gravity, and other physical properties are tabulated in Table 2.

COARSE AGGREGATE

Coarse Aggregate used is crushed rocks of size 20mm and down. The properties are tabulated in Table 3 and particle size distribution is shown in Figure 2.

GLASS FIBERS

Glass Fibres used are Cem-Fil Anti-Crack, HD-12mm Alkali Resistant glass fibers shown in Figure 3.

SILICA FUME

Silica fume used is densified of specific gravity 2.8.

METAKAOLIN

Metakaolin used is of specific gravity 2.9.

SUPERPLASTICIZER

Superplasticizer used is of brand Ceraplast. These are the materials used in this study.

Table 1. Properties of cement

Sl.No	Properties	Observed Values
1	Specific Gravity	2.97
2	Standard Consistency	30%
3	Compressive Strength	56N/mm^2

Table 2. Properties of fine aggregate

Sl. No.	Property	Observed Value
1	Particle Size Distribution	Zone II
2	Bulk Density	1.8 g/cc
3	Specific Gravity	2.76

4	Fineness Modulus	2.916
5	Void Ratio	0.41
6	Porosity	25%

Table 3. Properties of coarse aggregate

Sl. No	Properties	Observed Values
1	Bulk Density	1.598 g/cc
2	Specific Gravity	2.83
3	Fineness Modulus	5.23
4	Void Ratio	0.7
5	Porosity	41%

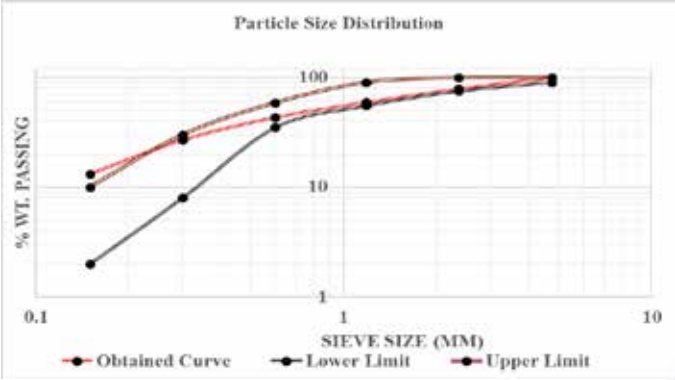

Figure 1 : Particle size Distribution of Fine Aggregate

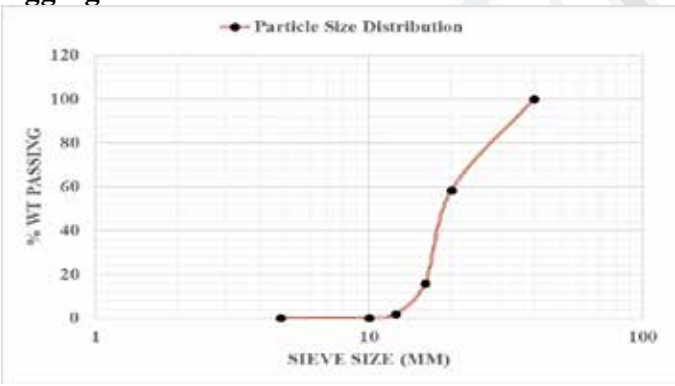

Fig 2 : Particle Size Distribution of Coarse Aggregate

Fig 3 : Glass Fibers

III. MIX PROPORTION :

M_{30} mix was designed as per IS 10262:2000. Mix proportion adopted for the study is tabulated below in table 4.

Table 4 : – Ingredients used per cubic meter of concrete

Sl.No	Materials	Quantity
1	Water (L)	167
2	Cement (Kg/m^3)	418
3	Fine Aggregate(Kg/ m^3)	655
4	Coarse Aggregate (Kg/m^3)	1253
5	Super plasticizer	0.75% by wt of cement

IV. METHODOLOGY :

The methodology adopted for the current study includes the following steps.

- Detailed literature studies.
- Preliminary investigations involving the laboratory tests on constituent materials line cement, coarse aggregate and fine aggregate.
- Mix design of M30 grade concrete as per IS 10262-2009
- The specimens are designated as OC for Ordinary concrete, SMC for silica metakaolin concrete and SMC-0.5%, SMC-1.0%, SMC-1.5% and SMC-2.0% denotes Silica metakaolin concrete with 0.5%, 1.0%,1.5% and 2.0% of glass fibres
- Preparation of trial mixes for ordinary M30 grade concrete to obtain the required compressive strength.
- Casting of cube specimens of dimensions 150x150x150 mm to determine the compressive strength.
- Casting of cylindrical specimens of dimensions 15cm Diameter and 30cm height to determine the split tensile strength .
- Testing of concrete specimens.

- Metakaolin and Silica Fume combined concrete is tested for Compressive strength test and Split Tensile Strength Test with 3 specimens each.
- Glass Fibers are added at 0.5%, 1%, 1.5%, 2% (by volume) and 3 specimens each from the respective mixes are tested for Compressive strength and Split Tensile Strength.
- After curing properly, the above specimens are tested on 7th day and 28th of after casting of specimens.
- Analysis of the test results.

V. EXPERIMENTAL INVESTIGATION :

To study the effect of glass fibres on the mechanical properties of metakaolin, silica fume and glass fiber combined concrete, standard cubes of size 150x150x150 (mm) and cylinders of diameter 15cm and height 30cm were cast.. 3 Specimens each were casted for testing compressive strength and spit tensile strength for OC, SMC, SMC-0.5%, SMC-1.0%, SMC-1.5% and SMC-2.0% on the 7th and 28th day respectively. 15 % by weight of cement and 6 % by weight of cement were replaced by metakaolin and silica fumes respectively in SMC series. Mechanical properties tested are compressive strength on standard cube specimens and split tensile strength on cylindrical specimens. Slump Cone test and Compaction factor test were also done to study the effect on fresh properties of concrete.

Fig 4 : Cubes and Cylinders

Fig 5 : Experimental Set up for Compression Test

VI. RESULTS AND DISCUSSION :

EFFECT ON FRESH PROPERTIES OF CONCRETE

The fresh properties of concrete were analyzed through slump test and compaction factor test. The comparisons of results are shown in Table 5.

Table 5 : Fresh Properties of concrete

Type of concrete	Slump Value	Compaction Factor
OC	15	0.89
SMC	15	0.91
SMC-0.5%	14	0.91
SMC-1.0%	12	0.92
SMC-1.5%	10	0.93
SMC-2.0%	9	0.94

Thus from the above table it is clear that the slump values decreases from 15 to 9 as glass fibers are added at specified concentrations. The compaction factor has increased from 0.89 to 0.94 as glass fibers are added to concrete. As glass fibers are added the workability of concrete decreases and compaction factor increases. Same slump value of 15 is observed for Ordinary concrete and Silica Metakaolin Concrete beyond the addition of glass fibers workability decreases.

EFFECT ON COMPRESSIVE STRENGTH

The effect on compressive strength on various specimens are tabulated in Table 6 and their variation is plotted as graph shown in Figure 7.

Table 6: Comparison of 7th and 28th Day Compressive Strength

Type of Concrete	7th Day compressive Strength(N/mm²)	28th Day Compressive Strength(N/mm²)
OC	27.5	45.83
SMC	30.11	50.18
SMC-0.5%	31	51.67
SMC-1.0%	33	55.00
SMC-1.5%	29.05	48.41
SMC-2.0%	29.00	46.50

From the test results it is observed that there is an increase in 7th and 27.5N/mm² to 33 N/mm². This shows an increase of 20% of 7th day compressive strength on addition of glass fibers. Thus the maximum compressive strength is obtained at 1 % addition of glass fibers to concrete. Similarly there is an increase in the 28th day strength from 45.83 N/mm² to 55 N/mm² by adding 1% of glass fibers to concrete.

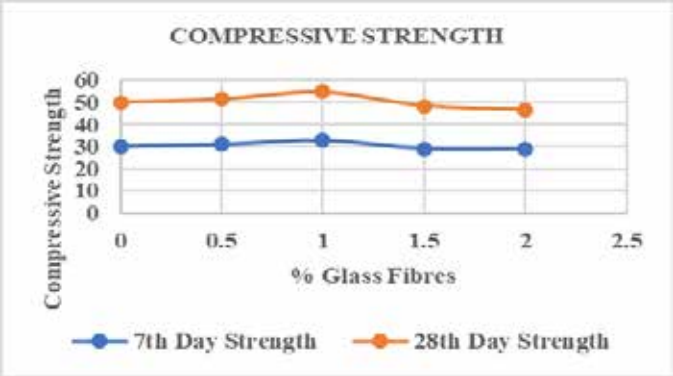

Fig 7 : Compressive Strength Variation

From the graph plotted it is clear that the optimum value of glass fibres that can be added to concrete for attaining a maximum compressive strength is 1%. As glass fibres added at 1% concentration the compressive strength of concrete showed an increase of 20% and beyond 1 % addition showed a decrease in strength.

EFFECT ON SPLIT TENSILE STRENGTH

The effect on Split tensile strength on various specimens are tabulated in Table 7 and their variation is plotted as graph shown in Figure 8.

Table 7 : Comparison of 7th and 28th Day Compressive Strength

Type of Concrete	7th Day compressive Strength(N/mm²)	28th Day Compressive Strength(N/mm²)
OC	1.85	3.083
SMC	2.02	3.36
SMC-0.5%	2.30	3.83
SMC-1.0%	2.50	4.16
SMC-1.5%	1.80	3.00
SMC-2.0%	1.70	2.95

Here it is clear from the observations that there is an increase in split tensile strength from 1.85 N/mm² to 2.5 N/mm².Thus the optimum value of glass fibers is around 1%. As we go on adding glass fibers from 0.5% to 1.0%. there is an increase in split tensile strength on the 7th day to 28th day .

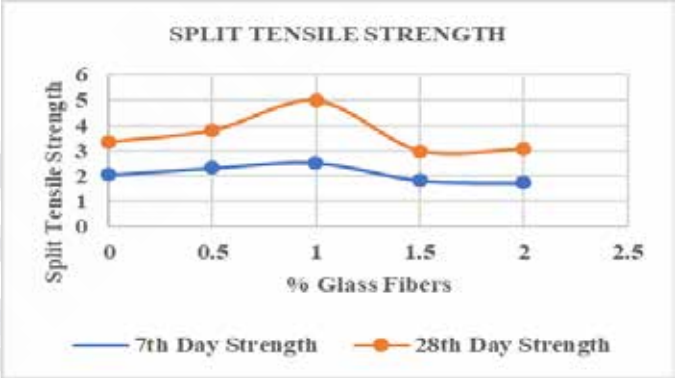

Fig 8: Split Tensile Strength variation

It is clear from the graph that as glass fibres are added at 1% concentration the split tensile strength of concrete showed an increase of 15% and beyond addition showed a decrease in strength.

VII. CONCLUSIONS :

- The workability of concrete decreases as glass fibre's are added to concrete.
- There is a decrease in slump values as glass fibres concentration increases.
- As glass fibres added at 1% concentration the compressive strength of concrete showed an increase of 20% and beyond 1 % addition showed a decrease in strength
- As glass fibres are added at 1% concentration the split tensile strength of concrete showed an increase of 15% and beyond addition

showed a decrease in strength

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