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Experimental Study on Properties of Glass Fibre Reinforced Concrete with Metakaolin

Amir Akhtar[1], Raj Bandhu Dixit[2], Aleem Aijaz[3]

P.G. Student, Department of Civil Engineering, Integral University, Lucknow, UP, India[1]

Assistant Professor, Department of Civil Engineering, Integral University, Lucknow, UP, India[2]

Lecturer, Department of Civil Engineering, University Polytechnic, Integral University, Lucknow, UP, India[3]

ABSTRACT: Concrete is weak in tension. The introduction of fibres with 10% fixed metakaolin by the weight of cement in concrete have significantly improves its compressive as well as tensile strength. The use of different types of fibres & their orientation in the matrix have shown positive responses among the researchers. In the present study alkali resistant glass fibres were used in the concrete mixes. A total of 7 mixes were prepared by varying the percentages of glass fibres and metakaolin in M25 grade of concrete mixes. Based on the laboratory results the compressive and split tensile strength was reported to increase up to 26% and 9.97%. However the workability of concrete mixes is not much affected by the addition of fibres. The split tensile strength of concrete is improved which shows the use of glass fibres in concrete mixes may reduce its shortcoming of low split tensile strength without affecting its workability and compressive strength.

KEYWORDS: Compressive Strength, Split Tensile Strength, Glass Fibres, Metakaolin, Grade of concrete.

I. INTRODUCTION

Concrete is the most important construction material of use after water. The simplest reason for its widely use in the construction of almost all civil engineering works is that the properties of concrete can be controlled within a wide range by using appropriate ingredients and by some special mechanical, physical and chemical processing techniques. Concrete is the most widely used construction material due to its several properties like high compressive strength, stiffness and durability under different environments. Normally concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. This shortcoming is improved by providing reinforcement at appropriate locations at the time of casting the members to take up the tensile stresses and sometimes the compressive stresses if required. The advantage of using steel in concrete improved duarability and cracking of concrete.These properties can be improved by the use of Glass fibres and Metakaolin in the concrete. It has been found that concrete reinforced with a limited amount of fibre and metakaolin possess better performance in compression as well as in ,tention, in which the degree of improvement relies on the types of fibres used. Experiments have been carried out by several investigators using glass fibres[.Moreover glass fibres also helps in restricting the growth of micro-cracks at the mortar-aggregate interface thus transforming it into a better matrix . Metakaolin is pozzolanic materials which is manufactured from selected kaolins, after refinement and calcination under specific condition. It is a highly efficient pozzolana and react rapidly with the excess calcium hydroxide resulting from OPC hydration by a pozzolanic reaction, to produce calcium silicate hydrate and calcium alumino silicate hydrates. Glass fibre–reinforced concrete (GFRC) with metakaolin is a type of concrete which is composed of a cementitiousmatrix consisting cement, sand, coarse aggregate, water, polymer and Metakaolin, in which short length glass fibres are dispersed .In general, fibres are the principal load-carrying members, while the surrounding matrix keeps them in the desired locations and orientation, acting as a load transfer medium between the fibres and protecting them from environmental damage. In fact, the fibres provide reinforcement for the matrix and other useful functions in fiber-reinforced composite materials. Glass fibres can be incorporated into a matrix either in continuous or discontinuous (chopped) lengths .Glass fibres have large tensile strength and elastic

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modulus but have brittle stress-strain characteristics and low creep at room temperature. Glass fibres are usually are usually round and straight with diameters from 0.005 mm to 0.015 mm .Different types of glass fibres are available in the market having different length, diameter and aspect ratio. In the present study alkali resistant glass fibres were used throughout the experiments. The study comprises of a comparative study of some of the properties of M25 concrete by varying the percentages of fibres and replacing the 10% cement by weight withmetakaolin.

II. EXPERIMENTAL PROGRAMME & RESULTS

The experimental Programme consist of various processes of material testing, mix proportioning, mixing, casting and curing of test specimens which is elaborated in the following sections. Testing of materials were performed in Material Testing Lab at Integral University Lucknow.

MATERIALS USED

The materials used in the preparation of concrete mix includes cement, fine aggregates, coarse aggregates glass fibres and metakaolin. Each material was tested & its physical properties are described below.

A) *Cement Used*

Ordinary Portland cement of 43 grade were used conforming To recommendations stated in IS4031(1999) the normal consistency and initial setting time of cement was 30% and 30 minutes respectively.

B) *Fine Aggregate*

Coarse sand locally available to us was used as fine aggregate. The test procedures as mentioned in IS-383(1970) were followed to determine the physical properties of fine aggregate as shown in Table 1 below

Table 1: Physical Properties of Fine aggregate

Physical Properties	Observed values	Recommended Values
Grading Zone	2	-
Fineness modulus	3.173	2.9-3.2
Specific Gravity	2.62	2.6-2.67

C) **Coarse Aggregate**

Two single sized crushed stone aggregates ranging from 12.5 mm to 2.36 mm and 20 mm to 4.75 mm (10mm and 20mm sizes) were used in respective proportions in concrete mixes. The aggregates were tested in accordance to IS-383: (1970). The results obtained are tabulated in Table 2

D) **Glass Fibre**

Cem-Fil Anti-Crack, HD-10mm, Alkali Resistant glass fibres were used throughout the experimental work. From the micro to the macro fibre range, these fibers control the cracking processes that can take place during the life-span of concrete. The specifications of these fibres are presented in Table 3.

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Table 2: Physical Properties of coarse aggregate

Physical Properties	Recommended values by the Supplier
Specific gravity	2.68
Elastic Modulus (GPa)	72
Tensile Strength (MPa)	1700
Length (mm)	10

Table 3: Physical Properties of Glass Fibre [10]

Physical Properties	Observed values		Recommended Values
	10mm Aggregate	20mm Aggregate	
Fineness Modulus	6.916	7.11	6.5-8.0
Aggregate crushing value (%)	18.15	25.13	Not more than 45%
Aggregate impact value (%)	28.63	22.10	Not more than 45%

GLASS FIBRE

E) Water

As per recommendation of IS: 456 (2000), the water to be used for mixing and curing of concrete should be free from deleterious materials. Therefore potable water was used in the present study in all operations demanding control over water quality

F) Metakaolin

Metakaolin is refined kaolin clay that is fired (calcined) under carefully controlled conditions to create an amorphous alumina silicate that is reactive in concrete. Like other pozzolans (fly ash and silica fume are two common pozzolans) ,metakaolin reacts with the calcium hydroxide (lime) by products produced during cement hydration.
metakaolin as a cement replacement in concrete mixes, instead of other pozzolans such as silica fume, to:
· Boost compressive strength
· Make finishing easier
· Reduce efflorescence
· Mitigate alkali-silica reaction and maintain colour, especially in white concrete

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Metakaolin

Methodology

The mix proportioning procedure for the concrete was done according to IS 10262: 2009. The proportioning is carried out to achieve specified characteristics at specified age, workability of fresh concrete and durability requirements. concrete grade of M 25 were proportioned according to the procedure as mentioned in the code

Mix Proportioning

The basic mix proportion for M 25 grade of concrete is cement, fine aggregate, coarse aggregate and water: 1.0:1.39:2.52 . Mix 1 contain 0% glass fiber and 0% metakaolin. Mix 2 contain 0% glass fibre and 10% metakaolin replacing cement bywieght, then 3,4,5,6 and 7 contains 0.03%, 0.06% ,0.1% 0.13% and 0.16% of glass fibre by weight with 10% metakaolin replaced by cement by weight. A total of 7 mixes were studied. Water/cement ratio of 0.44 forM 25 were maintained for all the concrete mixes. Details of these mixes are presented in Tables 4.

Mixing of Concrete, Casting and Curing of test Specimens

Machine mixing was done during the entire process of casting of specimens. Firstly the dry mix constituents of the mix namely cement, fine aggregate and coarse aggregate Metakaoline and required amount of glass fibre was mixed for two minutes in the mixer and then the water were added and mixing continued for another 2 minutes. The total mixing time was kept at 4 minutes until a homogeneous mixture was obtained. Compaction was achieved by means of vibration and stored in water till the 28 days for testing . All specimens were de moulded after 24 hours.

Compressive Strength Test

Compressive strength test was performed according to IS 516: 1959.Cubes of specimen of size 150 mm x 150 mm x 150 mm were prepared for each mix. After 24 hours the specimens were de molded and cured in water for 28 days until testing. For specimens with uneven surfaces, capping was used to minimize the effect of stress concentration. The compressive strength reported is the average of three results obtained from three identical cubes.

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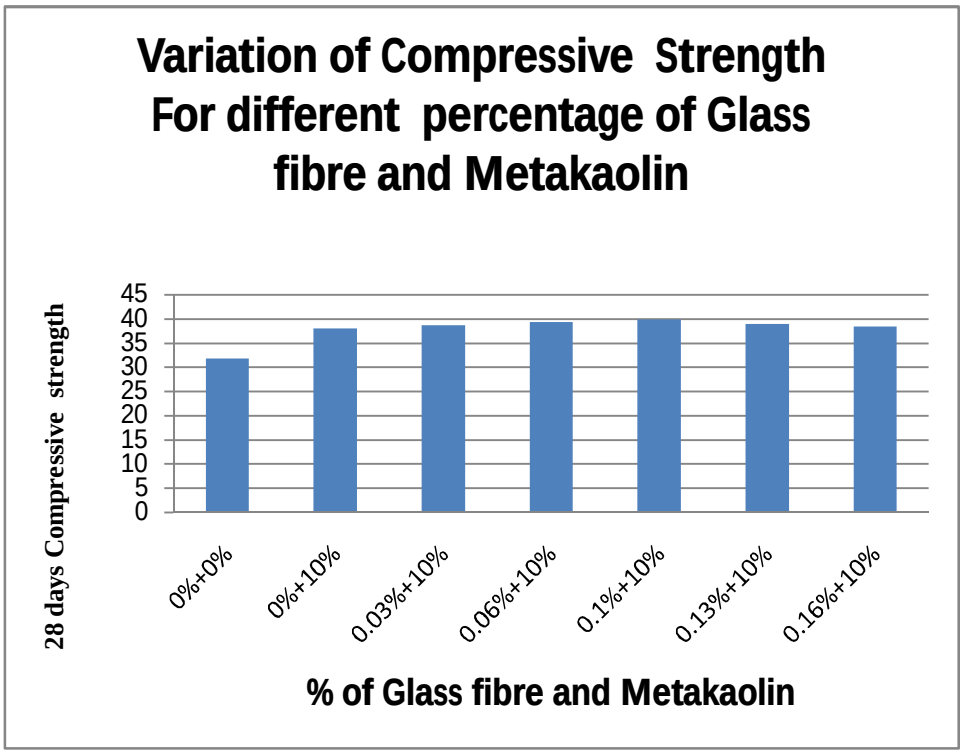
Table 4: Compressive Strength

	Types of Mix	% of Metakaolin	% of Glass Fibre	Compressive strength in MPa
MIX Grade M25	M1	0%	0%	31.70
	M2	10%	0%	38.00
	M3	10%	0.03%	38.64
	M4	10%	0.06%	39.27
	M5	10%	0.1%	39.90
	M6	10%	0.013%	38.95
	M7	10%	0.016%	38.32



Split Tensile Strength Test

The split tensile strength tests is a well known indirect tests used for calculating the tensile strength of concrete. The test consists of applying a compressive line load along the opposite generators of a concrete cylinder placed with its axis horizontal between the compressive platens. The test were performed according to the procedure adopted in IS 5816: 1999. Cylinder of size 150 mm x 300 mm were prepared for each mixes. Then tensile strength calculated after

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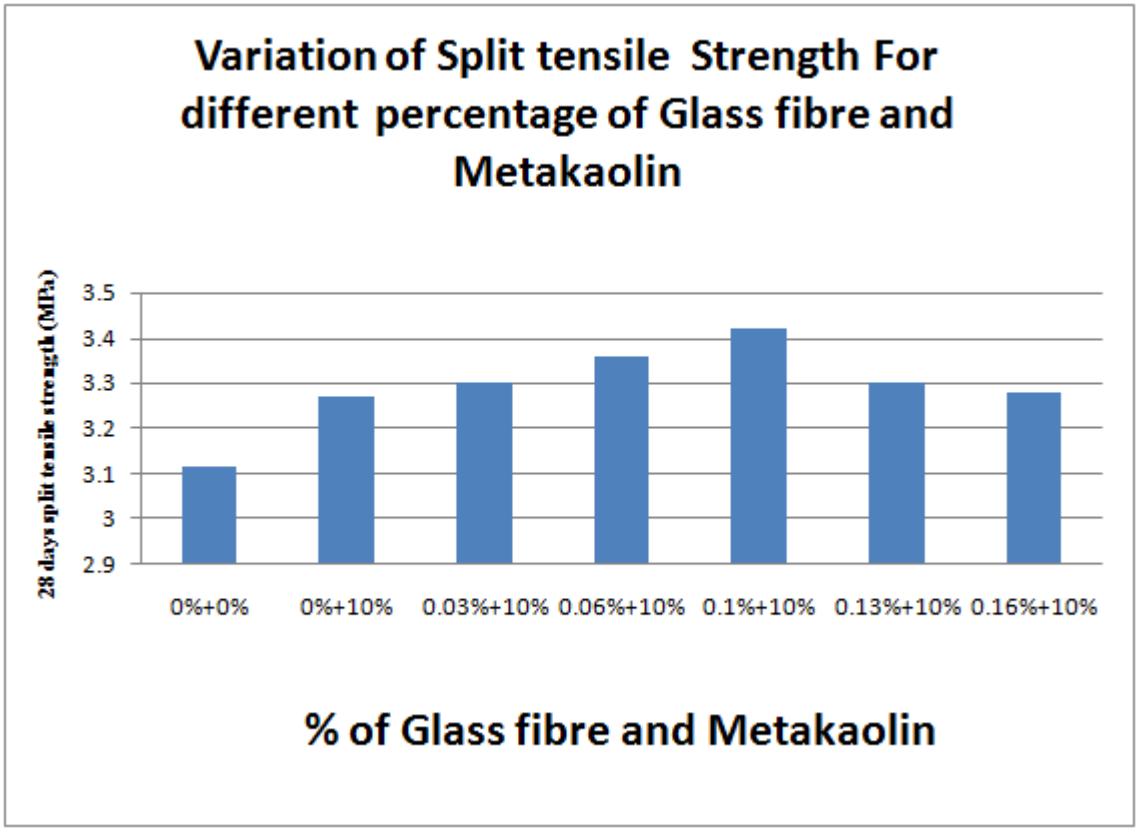
finding out the mean of three results obtained from identical three cylinders.

Table 5: Split Tensile strength of Glass fibre Reinforced Concrete with Metakaolin

	Types of Mix	% of Metakaolin	% of Glass Fibre	Split Strength in Mpa
MIX Grade M25	M1	0%	0%	3.115
	M2	10%	0%	3.27
	M3	10%	0.03%	3.30
	M4	10%	0.06%	3.36
	M5	10%	0.1%	3.42
	M6	10%	0.013%	3.30
	M7	10%	0.016%	3.28



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III. CONCLUSION

Based on the experimental study on concrete mixes, the following conclusions could be made:

1) It has been found that compressive strength & split tensile have their maximum values for 10%. Metakoalin dosage. The compressive strength is increased by 20%,& split tensile strength by 5.0% when compared to their nominal strength.
2)When 10%Metakoalin is added along with 0.1% Glassfiberdosage, maximum strengths are obtained . The compressive strength is increased by 26.00%, split tensile strength by 9.97% when compared to their nominal strength.

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