Study on Steel and Glass Fibre Reinforced Concrete

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***Abstract*—The inherent weakness of plain concrete is due to the presence of micro cracks in the mortar aggregate interface. By the inclusion of fibres these cracks can be removed to a considerable extend. Fibres are circular, triangular or flat in cross section reinforcing material having certain characteristic properties. To increase the toughness and ability to resist crack growth, fibres used in traditional composite materials are introduced into the concrete mixture. These composite properties depend on the mechanical and bonding properties of the fibre. By this project we aimed at analyzing and comparing the properties of steel fibre reinforced concrete and glass fibre reinforced concrete with conventional concrete. Specimens of M30 grade concrete with different percentages of fibres are casted and tested.**

Keywords—Fibre reinforced concrete; Steel fibre; Glass fibre; Superplasticizer

I. INTRODUCTION

Concrete is the world's most used construction material. It is efficiently and widely used in construction due to its ability to get casted in any shape. Old construction materials are replaced by concrete as it has more strength compared to those materials. Concrete is well suitable for a wide range of applications as by making some changes in its ingredients and by adding some special ingredients, its strength and durability can be increased. However it has some deficiencies too as listed below.

1) Low tensile strength
2) Low post cracking capacity
3) Brittleness and low ductility
4) Limited fatigue life
5) Incapable of accommodating large deformations
6) Low impact strength

In modern construction age, every structure has its own purposes and to meet this purposes, a mandatory modification in traditional concrete has become essential. Micro cracks in mortar aggregate results in weakness of plain concrete. This can be removed by adding fibres to the mixture. Fibres are reinforcing materials having certain characteristic properties which is available in circular triangular and flat cross section. Addition of fibre into the concrete mixture increases the toughness and posses an ability to resist crack growth. They helps in transferring loads at the internal micro cracks. Such a concrete is called fibre-reinforced concrete (FRC). The principle reason for adding fibres into the concrete mix is to increase the toughness and tensile strength and to improve the cracking deformation of the concrete.

Steel Fibre Reinforced Concrete (SFRC) is defined as the concrete made with hydraulic cement containing fine and coarse aggregate and discontinuous discrete steel fibre. In SFRC, thousands of small fibres are dispersed and distributed randomly in the concrete during mixing, and thus improve concrete properties. SFRC is being used to improve static and dynamic tensile strength, energy absorbing capacity and better fatigue strength. Steel fibres are the strongest commonly available fibre, and come in different lengths and shapes. Steel fibres can only be used on surfaces that can tolerate or avoid corrosion and rust stains. In some cases, a steel-fibre surface is faced with other materials.

Glass fibre is an inexpensive and corrosion-proof fibre, but not as strong as steel. The design of glass fibre reinforced concrete proceeds from knowledge of its basic properties under tensile, compressive, bending and shears forces, coupled with estimates of behavior under secondary loading effects such as creep, thermal response and moisture movement.

II. EXPERIMENTAL WORK

A. Materials and Properties

Materials used for experimental study and their properties are given below.

Steel fibre

Steel fibres are available in different length and shapes and they are the commonly available strongest fibre. The steel fibre used can avoid or tolerate corrosion and rust stains. Steel fibre reduces permiability and water mitigation in concrete. When steel fibre surface is faced with other materials, it ensures protection against ill effects of moisture.

Fig 1. Hooked end steel fibre

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TABLE 1. PROPERTIES OF STEEL FIBRE

Properties	Values
Type	Hooked end
Length	50mm
Diameter	1mm
Aspect ratio	50

Glass fibre

Glass fibres are numerous fine strands of extremely fine glasses. They are lightweight, extremely strong and robust. On comparing with steel fibre, they are less stiff and have less strength. Also they are less brittle and the raw materials are less expensive. They are formed by moulding process and when comparing with metals its bulk strength and weight properties are very favorable.

Fig 2. Glass fibre

Chopped strands of glass were used. Inorder to avoid less durability, alkali resistant glass fibres are used.

TABLE 2. PROPERTIES OF GLASS FIBRE

Properties	Values
Length	50mm
Diameter	0.5mm
Aspect ratio	100

Cement

Cement used for preparation of test specimen is OPC. They are used for producing high sterngth concrete. Out of the total production, ordinary Portland cement accounts for about 80-90 percent. . Many tests were conducted on cement, some of them are consistency tests, setting tests, etc.as per Indian standard specifications.

TABLE 3: PROPERTIES OF CEMENT

Properties	Values
Grade	53
Specific gravity	3.126
Fineness of cement	2%
Standard consistency	38%
Initial setting time	More than 52.38 mins

Fine aggregate

The sand particles should pack to give minimum void ratio, higher voids content leads to the requirement of more water while mixing. In our present study the sand conforms to zone II as per the Indian standards.

TABLE 4. PROPERTIES OF FINE AGGREGATE

Properties	Values
Specific gravity	2.73
Bulk density	1.56kg/l
Void ratio	0.7492

Coarse aggregate

It should be hard, strong, dense, durable and clean. It must be free from vein, adherent coatings and injurious amount of disintegrated pieces, alkalis, vegetable matters and other deleterious substances. It should be roughly cubical in shape. Flaky pieces are avoided as it increase the voids. Size of coarse aggregate used is 20mm.

TABLE 5. PROPERTIES OF COARSE AGGREGATE

Properties	Value
Specific gravity	2.68
Bulk density	1.46kg/l
Void ratio	0.8146

Water

Water should be free from acids, oils, alkalies, vegetable matters or other organic impurities. Soft water also should be avoided as it produce weaker concrete. Water has two functions in a concrete mix. Firstly, it reacts chemically with the cement to form the cement paste in which the inert aggregates are held in suspension until the cement pastes are hardened. Secondly, it serves as a lubricant in the mixture of fine aggregates and cement. Water available in the college campus conforming to the requirements of water for concreting and curing as per IS: 456-2000 is used.

Superplasticizer

Super plasticizers belong to a relatively new category and improved version of plasticizers. The use of super plasticizers allows the reduction of water to an extent of 20% without reducing workability. To obtain additional workability, a super plasticizer (CERAPLAST 400) was used. It is a high performance, low dosage super plasticizer based on Melamine Formaldehyde Sulphonate (MFS). Ceraplast 400 disperses cement particles more rapidly in the concrete mix. When incorporated into the concrete, it improves the workability of the concrete without entraining air due to its excellent dispersion characteristics.

TABLE 5: PROPERTIES OF SUPERPLASTICIZER

Properties	Values
Supply form	liquid
Colour	transparent
Specific gravity	1.3

B. Casting of specimens

Casting is done as per IS specification and compacted using a tamping rod having one end rounded. Cleaned moulds were used and inner surface is oiled. The concrete was filled into the moulds as three layers each being tamped 25 times. Proper compaction is provided and the top surfaces were leveled and smoothened.

C. Compressive strength test

The strength of concrete is usually defined and determined by the crushing strength of 150mm x 150mm x 150mm, at an age of 7 and 14 days. Compressive strength test is most commonly conducted test on hardened concrete as the desirable characteristic properties of concrete are directly related to its compressive strength. Moulds are made of wood with dimension 150mm x 150mm x 150mm is used for casting of test specimens. The moulds were filled with concrete containing steel fibres of 0%, 0.5%, 0.75% and 1% and concrete containing alkali resistant glass fibres of 0% and 0.5%, 0.75% and 1% by weight of total materials. All the sides and base plates of the moulds were oiled before casting to avoid bonding between the mould and specimen. The specimen was then kept undisturbed for 24 hours at temperature of l8°C to 22°C and a relative humidity which is not less than 90% (IS 516-1959) is maintained. Then the specimens are detached from the moulds and placed in the curing tank.

After 7 and 14 days of curing, the specimens are tested using compression testing machine. It is stated in IS516-1959 that the load should be applied without any shock and it should be increased continuously at an approximate rate of 140 Kg/sq cm/min until the specimen breaks down and no greater load can be resisted. The maximum load value is noted. The testing of cube under compression is shown in Fig.3.

Fig.3. Compressive strength testing

D. Split tensile strength test

Split tensile strength is done to obtain the tensile strength of the concrete specimen. Cylindrical specimens of dimension 150 mm diameter and 300 mm length were casted for split tensile strength test. The specimens are detached from the moulds after 24 hours and they were kept in the curing tank for 7 and 14 days curing. Cylindrical specimen was placed horizontally between the loading surface of the machine and a load is applied without any shock and increased continuously at a normal rate within the range 1.2 N/mm^2 to 2.4 N/mm^2/min until the failure of specimen along the vertical diameter occurs. For each percentage of fibres, three cylinders are tested and the average value is noted. The testing of cylinder is shown in Fig.4.

Fig.4. Split tensile strength testing

E. Flexural strength test

For flexural strength test beam specimens of dimension 100x100x500 mm are casted. The specimens are detached from the moulds after 24 hours of casting and are placed in curing tank for 7 and 14 days of curing. The flexural strength specimens are tested under three point loading as per I.S. 516-1959, over a load effective span of 400 mm on flexural strength testing machine. Load and corresponding deflections are noted up to the failure of specimen. For each percentages of fibre content, three beams are tested and their average value is noted.

Fig.5. Specimen after flexural strength test

II. RESULTS AND DISCUSSIONS

A. Compressive strength test results on SFRC after 7 and 14 days curing is graphically represented in Fig.6.

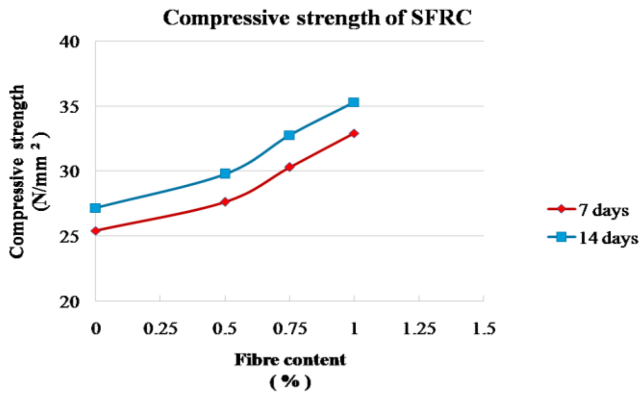

Fig.6. Compression test results of SFRC

B. Compressive strength test results on GFRC after 7 and 14 days curing is graphically represented in Fig.7.

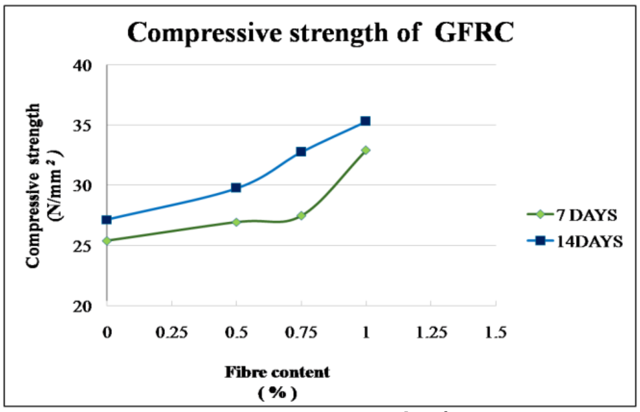

Fig.7. Compression test results of GFRC

C. Split tensile strength test results on SFRC after 7 and 14 days curing is given in the figure given below.

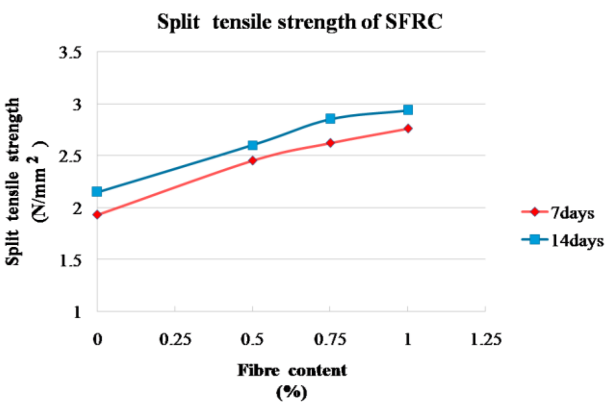

Fig.8. Split tensile strength test results of SFRC

D. Split tensile strength test results on GFRC after 7 and 14 days curing is given in fig.9.

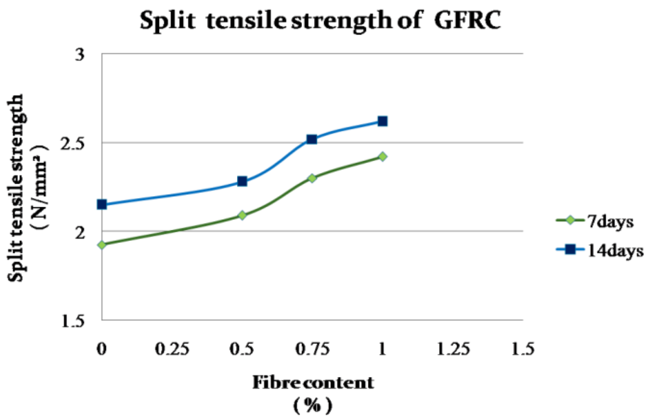

Fig.9: split tensile strength test results of GFRC

E. Flexural strength test results on SFRC after 7 and 14 days curing is given in the figure given below.

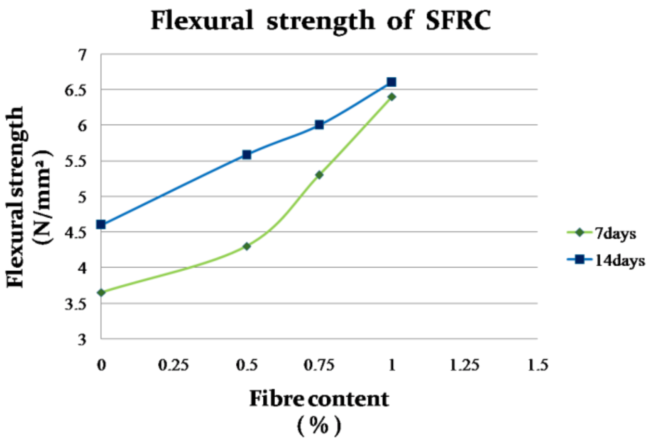

Fig.10. Flexural strength test results of SFRC

F. Flexural strength test results on GFRC after 7 and 14 days curing is given in the figure given below.

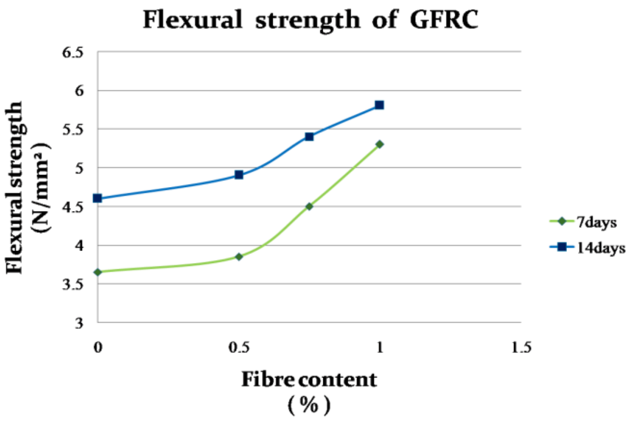

Fig.11. Flexural strength test results of SFRC

IV. CONCLUSION

From the results obtained it can be concluded that the compressive, split tensile and flexural strengths increases gradually with addition of small quantities of glass and steel fibres. The compressive, split and flexural strengths are high for steel fibre reinforced concrete than glass fibre reinforced concrete.

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