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EXPERIMENTAL INVESTIGATION ON THE BEHAVIOUR OF HIGH PERFORMANCE HYBRID FIBRE REINFORCED CONCRETE

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Abstract—**Fiber-reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. Fibers are usually used in concrete to control cracking due to plastic shrinkage and drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. The main aim of the present experimental investigation was to combine different fibres namely crimped stainless steel fibre, and Jute fibre to produce HFRC and thus to evaluate its mechanical performance. In Addition Quartz powder is added to obtain high performance. So here an attempt has been made to utilize Jute and Steel fibre together to obtain hybrid fibre reinforcement, along with Quartz powder to have high performance. Based on I.S. Code method of mix design, proportion of different ingredients was obtained to get M60 grade concrete. Master Gelenium SKY 8233 superplasticizer is used. Samples were prepared by varying the volume fraction of Jute fibre from 0 to 1.5% while keeping 1.5% of steel fibre as constant. Amount of quartz powder added is 1.5% which is also kept as a constant for all the mixes. Total 3 different types of FRC matrices were considered for performance evaluation. Three specimens of Cubes, Cylinders, and Prisms for each volume fraction of fibers are casted. Mechanical properties of each concrete composite were studied.**

Keywords— **High performance concrete, Steel fibre,Jute fibre, Quartz powder**

I. INTRODUCTION

Concrete is a rigid material with high compressive strength and low tensile strength with little resistance to cracking. Internal microcracks are inherently present in the concrete and its poor tensile strength is due to the propagation of such microcracks, eventually leading to brittle fracture of the concrete. Reinforcing bars are used to improve the tensile strength. In addition to that fibres can make the concrete more homogeneous and can improve the tensile response, particularly the ductility. Fibre reinforced concrete is a composite material consists of Portland cement, aggregate and fibres. Normal unreinforced concrete is brittle with a low tensile strength and strain capacity. The function of the irregular fibres distributed randomly is to fill the cracks in the composite. Fibres are generally used in concrete to reduce the plastic shrinkage cracking and drying shrinkage cracking. They also lower the permeability of concrete and therefore reduce the flow of water. Some types of fibres create greater impact, abrasion and shatter resistance in the concrete. Usually fibres do not raise the flexural strength of concrete. The quantity of fibres required for a concrete mix is normally determined as a percentage of the total volume of the composite materials. The fibres are bonded to the material and allow the fibre reinforced concrete to withstand considerable stresses during the post- cracking stage. The actual effort of the fibres is to increase the concrete toughness. High performance concrete is a concrete mixture, which possess high durability and high strength when compared to conventional concrete. This concrete contains one or more of cementious materials such as fly ash, Quartz, Silica fume or ground granulated blast furnace slag and usually a super plasticizer. Here an attempt is made to study the mechanical behaviour of high performance concrete reinforced with jute and steel fiber along with Quartz powder (15%) as a replacement for cement.

II. MATERIALS AND MIX DESIGN

A. Materials used

In developing the concrete mix for high strength concrete, it is important to select proper ingredients, evaluate their properties and understand the interaction among different material for optimum usage. The different materials used in this investigation are Cement, Quartz Powder, Water, Fine aggregate, Coarse aggregate, Jute fibre, Stainless Steel Fibre and Chemical admixture. Ordinary Portland Cement of 53 grades available in local market is used in the investigation. A quartz powder with a diameter smaller than 1.0 µm was used as micro filler. Its particle fills the lack between the cement

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particles and makes the grading curve of the mixture composed of cement and quartz powder continuous. Stainless steel is a steel alloy possessing minimum amount of Chromium (10.5% min). It is manufactured from number of different processes. It has positive effect on the concrete matrix, improving attributes such as toughness, flexural strength, crack control, impact resistance, fatigue and shear resistance. Jute textile is a low cost eco-friendly product and is abundantly available, easy to transport and has superior drapability and moisture retention capacity. It is widely being used as a natural choice for plant mulching and rural road pavement construction. Fibres are shown in figure 1. Superplaticizer used in this investigation is MasterGlenium SKY 8233.

Fig. 1. Stainless steel and Jute fibre

B. Mix proportioning

The aim of studying the various properties of materials of concrete, fresh concrete and hardened concrete is to design a concrete mix for particular strength. Design of concrete mix needs complete knowledge of the various properties of the constituent material, the implications in place of change on the conditions at site, the impact of the properties of plastic concrete on the hardened concrete and the complicated interrelationship between the variables. Table 4.1 shows the mix design used for experimental investigation.

Table 1 Mix proportion for M60

CEMENT	QUARTZ	WATER BINDER RATIO	F.A	C.A	SP
600 Kg/m^3	90 Kg/m^3	174 Kg/m^3	711 Kg/m^3	810 Kg/m^3	7.2 Kg/m^3
1	0.15	0.29	1.18	1.35	0.012

III. Experimental works and Results

This chapter presents the details of experimental investigations carried out on the test specimens to study the strength-related properties of high performance concrete. To produce high performance concrete a substantial reduction in water cement ratio is required. The reduction of water cement ratio less than 0.3 will greatly improve the qualities of transition zone to give inherent qualities expected to be satisfied by high strength concrete. Here, an attempt was made to study the strength development at different addition levels at different ages with stainless steel fibre and Jute fibre and the results were compared. The strength-related properties such as compressive strength, splitting tensile strength, were studied. Minimum three specimens were tested for each mix for each test. The entire tests were conducted as per specifications required.

A. Compressive strength test

The cube specimen is of the size 15 x 15 x 15 cm. For each trial mix combination, three cubes were tested at the age of 7 and 28 days of curing using 400 tone capacity HELICO compression testing machine a BIS: 516-1959. The tests were carried out at a uniform stress after the specimen has been centered in the testing machine. Loading was continued till the dial gauge needle just reserves its direction of motion. Table 2 shows the compressive strength values of various mixes.

Table 2 Compressive Strength of Specimens

FIBRE CONTENT (%)		COMPRESSIVE STRENGTH N/mm^2	
Jute	Steel	7 DAYS	28 DAYS
0	0	28.35	64.60
0.5	1.5	31.06	69.03
1	1.5	33.23	73.84
1.5	1.5	31.54	70.09

B. Split tensile strength test

Splitting tensile tests were carried out on 150mm x 300mm sized cylinder specimens at an age of 7 days using 400 Tonne capacity Heico compression testing machine as per IS: 5816 – 1970. The load was applied till the specimen split and readings were noted. Table 3 shows the values of the Split Tensile strength of mixes with varying fibre content (0%, 0.5%, 1%, 1.5% of Jute fibre and 1.5% of steel fibre)

Table 3 Split tensile Strength of Specimens

FIBRE CONTENT (%)		SPLIT TENSILE STRENGTH N/mm^2	
Jute	Steel	7 DAYS	28 DAYS
0	0	2.92	4.43
0.5	1.5	3.06	4.92
1	1.5	3.27	5.32
1.5	1.5	3.09	5.02

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C. Flexural strength test

Table 4 shows the values of the Flexural strength of mixes with varying fibre content (0%, 0.5%, 1%, 1.5% of Jute fibre and 1.5% of steel fibre)

Table 4 Flexural Strength of Specimens

FIBRE CONTENT (%)		FLEXURAL STRENGTH N/mm^2	
Jute	Steel	7 DAYS	28 DAYS
0	0	3.73	5.63
0.5	1.5	3.90	6.35
1	1.5	4.03	7.02
1.5	1.5	4.65	7.26

Figure 2,3,4 shows the variation of strength values for different mixes.

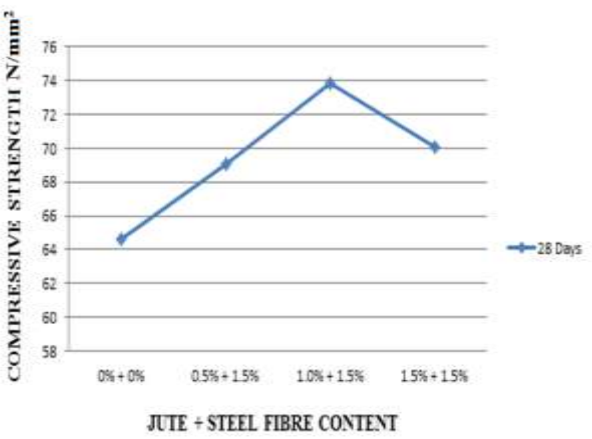

Fig 2 Compressive Strength after 28 days

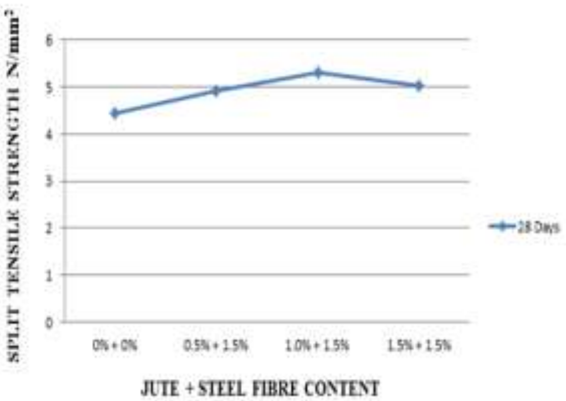

Fig 3 Split tensile Strength after 28 days

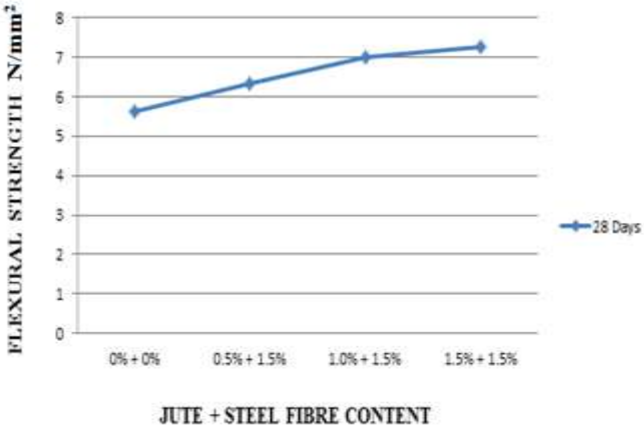

Fig 4 Flexural Strength after 28 days

IV. CONCLUSION

Based on the experimental results using jute fibre and stainless steel fibre the following conclusions are drawn.

1. In the mix with 0.5% of jute fibre and 1.5% of steel fibre, there is a considerable increase in compressive strength, split tensile strength and the flexural strength by 6.86%, 11.06 and 12.79% respectively.
2. In the mix with 1.0% of jute fibre and 1.5% of steel fibre, there is an optimum increase in compressive strength, split tensile strength and the flexural strength by 14.3%, 20.09% and 24.69% respectively.
3. In the mix with 1.5% of jute fibre and 1.5% of steel fibre, there is a considerable increase in compressive strength, split tensile strength and the flexural strength by 8.49%, 13.32% and 28.95% respectively.
4. The mix with 1.0% of jute fibre and 1.5% of steel fibre by volume of cement is found to have maximum compressive strength and spilt tensile strength whereas the mix with 1.5% of jute fibre and 1.5% of steel fibre by volume of cement is found to have maximum flexural strength.
5. Thus overall observation of this study shows that it advantageous to use High Performance Hybrid Fibre Reinforced Concrete mix with (1% of jute fibre + 1.5% of steel fibre + 15% of Quartz Powder) which gives satisfactory results in all conducted tests for concrete Grade M60.

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