

A Comparative Study on the Properties of High Strength Hybrid Fibre Concrete

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Abstract- Concrete is a composite material made of cement, coarse and fine aggregate and water. Recently High Strength Concrete (HSC) is being widely used in many applications. Concrete having compressive strength more than 40MPa is termed as HSC. It can be achieved by increasing the cement content and reducing water content by the addition of super plasticizers. HSC are brittle in nature and they are ready for plastic shrinkage in earlier stage. In order to reduce the brittleness and shrinkage effect fibres are used in HSC. Concrete cube (150mm × 150mm × 150mm) and cylindrical (100mm diameter and 200mm length) specimens were cast and experimental study was carried out for different concrete mixes having compressive strength of 40MPa. In this study two different combination of 2%, 4% of polypropylene fibre, 2%, 4% steel fibre and combination of both fibres of 2%, 4% have been used. The compressive strength and split tensile strength properties of concrete were specimens tested at normal condition. The result shows that the maximum compressive strength and split tensile strength of HSC specimen is increased by addition of polypropylene fibre and steel fibre.

Index Terms- polypropylene fibre, Steel fibre, cement, Fly ash and M-sand.

I. INTRODUCTION

Concrete is a composite material made of cement, coarse and fine aggregate and water. Even though concrete is a widely accepted building material it is not without any drawbacks. The low tensile strength and brittle nature of concrete necessitates it to be reinforced with steel rods. Placing the steel reinforcement in the tension zone of concrete will enhance the tensile strength of concrete. Later on, in 1960, it was found that addition of fibres in concrete can dramatically increase the various strength properties of concrete along with the ductility of concrete. For this purpose, various fibres can be used in the concrete. The various fibres that are commonly

used in concrete are steel, GI, polypropylene, glass, carbon, asbestos, jute plastic etc. The addition of fibres to concrete delays the failure mechanism and induces ductility to concrete. Such product where in the fibres are introduced in concrete is called “Fibre Reinforced Concrete” (FRC).

“Fibre reinforced concrete (FRC) can be defined as a composite material consisting of mixture of cement mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibres”. Fibre reinforced concrete is thus a relatively new material in which steel or other fibres are introduced as micro reinforcements. By the introduction of steel or other fibres, not only the occurrence of the first crack is delayed but flexural strength, modulus of rupture, fatigue, impact strength, shock resistance, shear and torsional strength, ductility, and failure toughness are also greatly improved.

Researchers have shown that as the percentage of fibres increase in fibre reinforced concrete, the strength properties also increase. But, the higher percentage addition of fibres, say above 4% possess many difficulties. For example, the balling effect of fibres will be conspicuous when the percentage of fibres is high. For the fibre reinforced concrete to be effective, the fibres should be dispersed uniformly in concrete. Now a day, the construction industry has shown more interest in the use of High Strength Concrete (HSC). This is due to the improvements in structural performance, such as high strength and durability, while comparing the HSC with NSC, the size of the members can be reduced in HSC and it will increase the working place. HSC is widely used in various applications such as high rise buildings, bridges, off-shore structures and infrastructure projects. One of the major uses of HSC in buildings is for structural framing consisting of beams and columns, which are the primary load-bearing components.

II. MATERIAL COLLECTION

CEMENT: -

Cement is a binder, a material that sets and hardens and can bind other materials together. Cement is a product including lime as the primary curing ingredient, but it is far from the first material used for cementation. Cement starts to set when mixed with water which causes a series of hydration chemical reactions. The constituents slowly hydrate and the mineral hydrates solidify; the interlocking of the hydrates gives cements its strength.

SAND:-

Those fractions from 4.75 mm to 150 micron are termed as fine aggregate. The river sand and crushed sand is being used in combination as fine aggregate conforming to the requirements of IS: 383-1987. The aggregates are the important constituents in concrete. One of the most significant factors for producing workable concrete is a good gradation of aggregates. Good grading implies that a sample fraction of aggregates in required part such that the sample contains minimum voids. Minimum void means less quantity of cement and less water, which are further mean increased economy, higher strength, lower shrinkage and greater durability.

COARSE AGGREGATE: -

The fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Coarse Aggregates from crushed Basalt rock, conforming to IS: 383 is being used. Also, the properties show minimal presence of Sulphates (SO₃) which causes formation of secondary in concrete leading to its expansion and rupture; thus the coarse aggregates are deemed to be innocuous and are suitable for production of concrete.

WATER:-

This is the least expensive but most important ingredient of concrete. The quantity and quality of water required to be looked in to very carefully. It should be free from organic matter and the pH value should be between 6 to 7.

POLYPROPYLENE: -

Polypropylene fibres are available both in single-filament and fibrillated form in lengths ranging from 6 to 50 mm. Short fibres in the form of pulp are also

available. Polypropylene pulp seems to have lower strength than polyethylene pulp made with oriented molecules.

Polypropylene fibres are new generation chemical fibres. They are manufactured in large scale and have fourth largest volume in production after polyesters, polyamides and acrylics. About 4 million tones of polypropylene fibres are produced in the world in a year.

Polypropylene fibres were first suggested for use in 1965 as an admixture in concrete for construction of blast resistant buildings meant for the US Corps of Engineers.

Subsequently, the polypropylene fibre has been improved further and is now used as short discontinuous fibrillated material for production of fibre reinforced concrete or as a continuous mat for production of thin sheet components. Further, the application of these fibres in construction increased largely because addition of fibres in concrete improves the tensile strength, flexural strength, toughness, impact strength and also failure mode of concrete.

The oldest forms of fibre-reinforced composites were made with naturally occurring fibres such as straw and horse hair. Now fibres are also extracted from various plants, such as jute and bamboo, to be used in cement composites. Natural fibres used in Portland cement composite include akwara, bamboo, coconut, flax, jute, sisal, bagasse, wood and others. However, their low elastic modulus, high water absorption, susceptibility to fungal and insect attack, alkali attack from the cement concrete are the disadvantages of using natural fibres.

STEEL FIBRES: -

Steel fibres are made of either carbon steel or stainless steel. The tensile strength ranges from 345 to 1380 MPa. The minimum strength specified in ASTM (AMERICAN SOCIETY FOR TESTING & MATERIALS) is 345 MPa. The modulus of elasticity for metallic fibres is about 200 GPa. The fibre cross section may be circular, square, crescent shaped or irregular. The length of the fibre is normally less than 75 mm even though the longer fibres have been used. The length-diameter ratio typically ranges from 30 to 100 or more. Among metallic fibres, the steel fibres are most widely used. As these fibres fulfil all the requirements and add to the properties of concrete.

Application of these types of fibres is gaining importance. It has been observed that the steel fibres give good results.

Steel fibre (SF) is the most popular type of fibre used as concrete reinforcement. Initially, SFs are used to prevent/control plastic and drying shrinkage in concrete. Further research and development revealed that addition of SFs in concrete significantly increases its flexural toughness, the energy absorption capacity, ductile behaviour prior to the ultimate failure, reduced cracking, and improved durability.

FLY ASH: -

There are various types of waste materials that can be considered for usage in concrete. The disposal of fly ash will be a big challenge to environment, especially when the quantum increases from the present level. When coal is burned mainly fly ash and bottom ash is produced. The fly ash is collected by Electrostatic precipitator process. Fly ash, also known as "pulverised fuel ash", is a coal combustion product that is composed of the particulates (fine particles of fuel) that are driven out of coal-fired boilers together with the flue gases. Fly ash in concrete is used for the purpose of economy and at the same time fly ash contributes in better durability, reduced permeability, reduction in W/C ratio, reduction in expansion due to alkali aggregate reaction, and improved long term strength and most importantly reduction in cement content.

III. RESULTS AND DISCUSSIONS

TEST ON FRESH CONCRETE: -

A slump test is a method used to determine the consistency of concrete. The consistency, or stiffness, indicates how much water has been used in the mix. The slump test is carried out on a frustum of a cone, 300 mm of height. The base is 200 mm in diameter and it has a smaller opening at the top of 100mm with different dosage of fly ash and pond ash along with controlled concrete. Each layer is tamped 25 times with a standard 16 mm diameter steel rod, rounded at the end. Immediately after filling is completed and the concrete is levelled, the cone is slowly and carefully lifted vertically, an unsupported concrete will now slump. The decrease in the height of the centre of the slumped concrete is called slump.



Figure 1. SLUMP CONE TEST
Workability of the concrete in slump cone test is 115mm.

**TEST ON HARDENED CONCRETE:-
COMPRESSIVE STRENGTH TEST**

This test is considered as one of the most important properties of concrete and it is often used as an index of the overall quality of concrete. For this, the cubes were tested for its compressive strength at the age of 7th, 14th & 28th days. From the test results, it was observed that the strength of concrete which contains timber waste slightly higher than the conventional concrete up to 20 % replacement of timber Waste for river sand . Below listed tables and graphs shows the relationship between the no. of days and its mean compressive strength



Figure 2. COMPRESSIVE STRENGTH TEST BY CTM

SPLIT TENSILE TEST

The cylindrical specimens were tested for its split tensile strength at the age of 7, 14 & 28th days. The test result shown in table revealed that split tensile strength of timber waste replaced concrete and standard concrete. Chart shows the relation between no. of days and its mean split tensile strength of cylinders.

Table 1. 7th day test by CTM

REPLACEMENT DETAILS	CUBE (N/mm ²)	CYLINDER (N/mm ²)

Steel Fibre -2%	34.62	3.50
Steel Fibre -4%	32.22	3.28
Polypropylene Fibre -2%	33.47	3.12
Polypropylene Fibre -4%	31.47	2.58
Steel Fibre + Polypropylene Fibre -2%	35.47	3.95
Steel Fibre + Polypropylene Fibre -4%	30.27	3.60

Table 2. 14th day test by CTM

REPLACEMENT DETAILS	CUBE (N/mm ²)	CYLINDER (N/mm ²)
Steel Fibre -2%	44.04	4.55
Steel Fibre -4%	41.51	4.14
Polypropylene Fibre -2%	43.07	3.88
Polypropylene Fibre -4%	40.76	3.12
Steel Fibre + Polypropylene Fibre -2%	45.24	4.93
Steel Fibre + Polypropylene Fibre -4%	39.78	4.52

Table 3. 28th day test by CTM

REPLACEMENT DETAILS	CUBE (N/mm ²)	CYLINDER (N/mm ²)
Steel Fibre -2%	50.58	5.03
Steel Fibre -4%	47.33	4.84
Polypropylene Fibre -2%	49.73	4.17
Polypropylene Fibre -4%	46.13	3.44
Steel Fibre + Polypropylene Fibre -2%	52.09	5.63
Steel Fibre + Polypropylene Fibre -4%	43.38	4.77

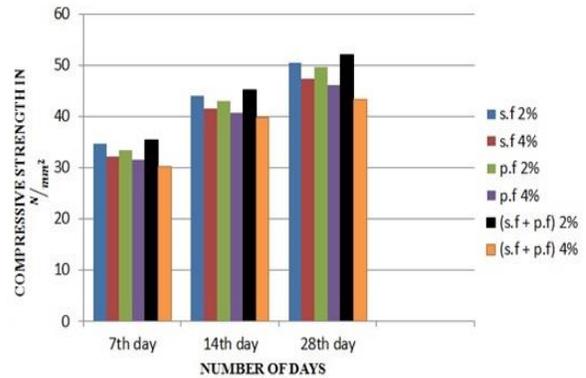


Figure 3. COMPRESSIVE STRENGTH TEST RESULT

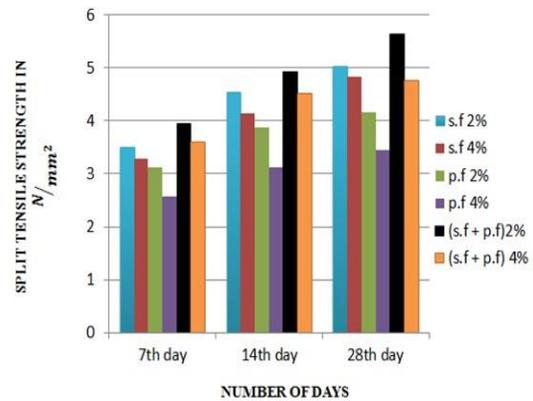


Figure 4. SPLIT TENSILE STRENGTH TEST RESULT

IV. CONCLUSION

Based on the experimental investigations done, the following conclusions are made.

- The mode of failure of High Strength Concrete is not sudden because of adding fibre material
- Addition of polypropylene fibre delay the formation of micro cracks and increases the strength of High Strength Concrete tested by Compression Testing Machine.
- There is an appreciable increase in the compressive strength and split tensile strength in High Strength Concrete when volume fraction of polypropylene fibre and steel fibre increased in 2%.

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