AN EXPERIMENTAL STUDY ON FAILURE PROPERTIES OF HYBRID FIBER REINFORCED CONCRETE HAVING THE COMPOSITION OF STEEL AND POLYPROPYLENE FIBERS

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ABSTRACT:

The aim of this research was to establish the Failure properties of Hybrid Fiber Reinforced Concrete (HFRC) containing two widely used types of fibers. The experimental investigation consisted of the tests on cubes, cylinders and prismatic samples made of plain concrete and Hybrid Fiber reinforced concrete(HFRC) with steel or/and polypropylene fibers of different volume fractions of 0.25 %,0.5%,0.75% and 1 %. Extensive data on compressive, splitting and flexural tensile behaviors of casted specimens were recorded and analyzed. The purpose of combining the fibers is to improve the multiple properties of concrete mixture. The behavioral efficiency of this composite material is far superior to that of plain and mono fiber reinforced concrete. The addition of fiber is helpful to improve the failure properties of concrete. The failure behavior of beams was determined in three-point bending condition. Based on test results it was found that the failure properties of concrete such as compressive strength, split tensile strength, and flexural strength are increased.

Keywords: *Fiber Reinforced Concrete (FRC), Hybrid fiber reinforced concrete (HFRC), Steel fiber, polypropylene fiber, Failure behavior.*

INTRODUCTION

1.1 Fiber Reinforced concrete (FRC) :

Fiber reinforced concrete (FRC) displays improved flexural strength, toughness, ductility, and crack resistance. The mechanical properties of FRC can be affected when exposed to heat. Heat can come from many sources such as fire and prolonged high temperature on the exposed surface. It remains one of the most serious risks for tunnels, buildings and other concrete structures. Explosive spalling has been observed by many researchers often resulting in serious deterioration of the concrete. High temperature causes dramatic physical and chemical changes, resulting in the deterioration of the concrete. The absence of voids, which could relieve the continuous pressure build-up as a consequence of vaporization of evaporable water, may cause serious damage or even spalling to the concrete. To reduce the risk of deterioration and spalling, previous literatures claimed that the use of fiber such as polypropylene and steel can have sufficient fire protection on the concrete structures. But minimal or even negative effects of polypropylene fibers on the residual performance of the heated concrete may also occur. The initial moisture state of the concrete and the rate of heating may be the main parameters determining the effect of polypropylene fibers. Therefore, there is necessity to quantify this claim in terms of the fiber dosage, the strength of the concrete and most important is to know the residual mechanical properties of FRC under exceptional actions such as high temperature from fire.

Steel fibers (SF) and propylene Fibers (PPF) are used to achieve the objectives of the study. Propylene Fibers significantly decrease the plastic shrinkage cracking as well as drying shrinkage cracking, while Steel fibers approximately doubled the energy absorption capacity of the unheated concrete. They are effective in minimizing the degradation of compressive strength for the concrete after exposure to elevated temperature. In comparison, the use of PPF's reduced the energy absorption capacity of the concrete, although it had minor beneficial effect on the energy absorption capacity of the concrete before heating. In 2012, Bangi and Horiguchi carried out test on high strength fiber reinforced concrete (HSC) using propylene, polyvinyl alcohol and steel fibers of varying lengths and diameters. Experimental and statistical study was carried out to investigate the effect of fiber type and geometry on the amount of maximum pore pressures measured at different depths exposed to elevated temperature. Pore pressure measurements showed that addition of organic fibers regardless of the type significantly contributes to pore pressure reduction in the heated HSC. Polypropylene fibers were more effective in mitigating maximum pore pressure development compared to polyvinyl alcohol fibers while steel fibers had a slightly low effect. Longer organic fibers of length 12 mm with smaller diameter of 18 μm showed better performance than the shorter ones of length 6 mm with larger diameter of 28 μm and 40 μm. Most of the literature reviews showed that the use of fibers in concrete can significantly improve the concrete resistance.

However, when exposed to elevated temperature, previous studies only tested for one or two parameters instead of the whole mechanical properties of FRC. Mixing only a single fiber can improve only a certain aspect of the mechanical properties and at the same time reduced some of its properties. This can be improved by mixing two or more types of fibers to overcome the weakness of such properties. The current fundamental research is proposed since there is still little information on the effect on the mechanical properties of concrete when mixed with two or more types of fibers and further exposed to elevated temperature.

- Workability of the fresh mix is adversely affected by the addition of fibers and further decreases by increasing the fiber volume fraction.
- No particular trend is observed in compressive strength due to addition of fibers. Different fibers have different responses to the strength of the specimen.
- Flexural and tensile strength, ductility, drying shrinkage and toughness of the material is usually benefited by the addition of fibers.
- Use of fibers in the cement-based material improves its durability. It has been well established by observing improvement in various tests such as freeze-thaw resistance, permeability, carbonation depth and fire resistance. Fiber reinforcement can be utilized in development of high and ultra-high performance concrete.

The test carried out at 7 days, 14 days and 28 days, the comparison is made between the conventional concrete with different proportion and with different proportion nylon fiber. a. The compressive strength of nylon fiber mixed with conventional concrete is increased. b. When we used the nylon fiber in conventional concrete in various proportions 0.2%, 0.25% and 0.3% of volume of concrete the result obtained by the compressive strength is increased. c. In conventional concrete, cement replaced by 10%, 20% and 30% with fly ash. The comparative study of all mixed the result obtained. In conventional concrete 10% fly ash, 90% cement, and 0.2%, 0.25% and 0.3% nylon fiber getting the good strength of concrete.

According to civil engineering point of view Fiber reinforced polymer is an innovative structural technique. Till date research on Fiber Reinforced polymer composites is insufficient1 .The fiber reinforced polymer composites will become more challenging when comparing to old-fashioned construction material and it would be possible to harness its potential in civil engineering structure. In this paper we have focused on structural behavior, material types, durability of marine and floating structure, renovation of traditional piles, etc. The best advantages of these FRP mechanism is that we can reuse the FRP composites and finally we get a eco-friendly polymer. We have studied that the strength of composite is inversely proportional to the critical fiber length for which the internal adhesion strength increases due to slight decrease in the length of fiber. Therefore there is a requirement of case studies and practical applications to fully comprehend its property under various factors of degradation

Experiments with different conventional and fiber reinforced mortars were performed. Firstly basic properties, such as workability, compressive and splitting tensile strength, were determined. After that, single fiber pullout tests from conventional and fiber reinforced mortars were carried out. This was accompanied with observations of the micro cracks, which develop around the fiber during its pullout. On the basis of the results obtained, the following conclusions can be drawn:

- Mortars with lower water/cement-factor (0.30) had a better total performance than those with a higher w / c-factor. This conclusion relates to the single fiber pullout tests as well as to the basic properties.
- The addition of 4% by volume of short fibers OL 6/.16 resulted in a further improvement of the material performance. These fibers played a beneficial role especially in the case of the mortars with a w / c-factor of 0.40, where the average single fiber pullout force increased about 40% compared with the non-reinforced mortar.
- Micro structural observations showed that during the pullout process, intensive micro cracking occurs around the fiber. Short fibers probably act as bridging mechanisms over these cracks, so that the total pullout response can significantly be improved.
- Mortars, in which another 2% by volume of longer fibers OL 13/.20 were added, did not show better total performance than those with 4% of short fibers only. The workability was not satisfactory, which could result in a larger porosity around the single fiber. This may be a possible reason that the pullout response was not improved.
- Pullout of the same fibers (RC-80/40-BP) from mortars with even lower w / c-factors and addition of short fibers and filler materials will probably result in fiber fracture, because bond can-not be improved endlessly. It may therefore be concluded that larger fibers can be successfully implemented in such mixtures.

Based on the past 10 years of research carried out by the author, the following can be listed as the general conclusions: • The main factors that should be considered when using FRC are: o Composition and strength of the initial cementations matrix: as shown in both the masonry and the concrete structure application studies discussed in this paper, the lower strength matrices may benefit more from fiber addition compared to stronger base mixtures. o The amount of fibers: previous literature stated only a medium volume fraction (between 1% and 2%) can affect energy absorption, modulus of rupture, fracture toughness, and impact resistance of the resulting FRC. Our studies have shown significant impact in these characteristics with 0.25%–0.6% volume fractions of fibers, confirming that when the base matrix is of a lower strength, the effect of fibers may be amplified.

The size of the fibers: our findings showed that Nano fibers have negative effects on the FRC, and macro fibers do not fit well with masonry applications. Micro fibers should be preferred for masonry applications. For applications where additional improvements in strength and ductility are desired, hybrid mixtures of micro and macro fibers may be considered. o Geometry and surface texture of the fiber: as stated when describing the problems when using horse hair, excessively oily and smooth fiber surfaces tend to pull out instead of stitching cracks. Further, fibers can be bundled or in the form of single strands. For all of the applications discussed in this paper, except the last study concerning retrofit of reinforced concrete slabs, single strands are suggested.

• FRC use in masonry as joint reinforcement: Compressive strength: previous literature suggested that micro fibers reduce the compressive strength of the mix due to increases in the air content of the mixture relative to plain mortar resulting. We have noted both increased and decreased strength because of the following two potential behaviors in the specimen:

(1) when the compression specimen dilates laterally, tensile stresses form in that direction, and the fibers that are oriented horizontally may then stitch the internal tensile cracks, increasing the compression capacity;

(2) The fibers in general may cause air gaps in the FRC in addition to the naturally forming gaps in plain concrete. Plus, fibers oriented vertically may also break bond in horizontal tension and have no effect on vertical compression.

- Polypropylene fibers reduce the water permeability, plastic, shrinkage and settlement and carbonation depth.
- Workability of concrete decreases with increase in polypropylene fiber volume fraction. However, higher workability can be achieved with the addition of HRWR admixtures even with w/c ratio of 0.3.
- Polypropylene fibers enhance the strength of concrete, without causing the well-known problems, normally associated with steel fibers.
- The problem of low tensile strength of concrete can be overcome by addition of polypropylene fibers to concrete.
- Notable increase in compressive strength is reported with addition of polypropylene fibers. 6. The failure is gradual and ductile in polypropylene fiber reinforced concrete.
- The durability of concrete improves and addition of polypropylene fibers greatly improves the fracture parameters of concrete.
- The compressive strength, split tensile strength, flexural strength and modulus of elasticity increase with the addition of fiber content as compared with conventional concrete..

Plastic shrinkage cracks occurred during the first few hours after casting the overlay concrete while the material was in a semi fluid or plastic state. Cracks appeared very quickly and in a random order. It was observed that the time elapsed between the first appearance of the crack and its growth to the maximum length and width is approximately 15 minutes. Similarly, the time elapsed between the appearances of the first crack and to crack ceasing was approximately 50 minutes to 70 minutes. The width and length of shrinkage cracks were measured after 24 hour. The longer duration was chosen to make sure that all cracks had developed and stabilized. The width of the cracks was measured using a hand - held microscope. A linear scale with 1/20-mm increments was affixed to the microscope lens to facilitate crack width measurements. The width of the crack varies along its length and it is a real challenge to measure the width of a crack at various locations along the length. So, minimum of 4 points were marked along the length and the widths at these points were measured to the nearest 0.05mm. Length of each crack was measured with the help of a piece of string and a measuring tape.

Based on the investigations conducted on restrained plastic shrinkage cracking of plain and fiber reinforced concrete specimens under different ambient conditions, the following important conclusions are drawn. For any concrete mix with any water to cement ratio the total crack area and maximum width of crack increases with the increase in rate of free surface water evaporation. ~ The rate of change of total crack area is rapidly increases with increase in cement to aggregate ratio under higher free surface water evaporation loss, whereas it is moderately increases under lower free surface water evaporation. ~ The quantitative difference in maximum width of crack is moderate for any particular concrete mix with different water to cement ratios subject to any environmental conditions Plastic shrinkage cracking is greatly influenced by the cement to aggregate ratio. Greater the cement to aggregate ratio more is the total crack area and maximum width of crack. , Plastic shrinkage cracking is greatly influenced by the ambient conditions. The greater the free surface water evaporation, the more is the total crack area and maximum width of crack.

The test specimen used in this investigation resembles the field conditions. Therefore, this test method seems to be more appropriate to simulate the actual filed conditions of restrained plastic shrinkage cracking in concrete. » The addition of fibers could effectively control the maximum extent of plastic shrinkage cracking and crack width in any of the concrete mixes

Concrete is characterized by quasi-brittle failure, the nearly complete loss of loading capacity, once failure is initiated. This characteristic, which limits the application of the material, can be overcome by the inclusion of a small amount of short randomly distributed fibers (steel, glass, synthetic and natural) and can be practiced among others that remedy weaknesses of concrete, such as low growth resistance, high shrinkage cracking, low durability, etc. Fiber reinforced concrete (FRC) is a fiver reinforcing cementitious concrete composite, and by adding discrete short fibers randomly in concrete it exhibits many substantially improved engineering properties in compressive strength, tensile strength, flexural strength etc. The fibers are able to prevent surface cracking through bridging action leading to an increased impact resistance of the concrete.

1.1.1 Structural Behavior of FRC:

Fibers combined with reinforcing bars in structural members will be widely used in the future. The following are some of the structural behavior:

Flexure: The use of fibers in reinforced concrete flexure members increases ductility, tensile strength, moment capacity, and stiffness. The fibers improve crack control and preserve post cracking structural integrity of members.

Torsion: The use of fibers eliminates the sudden failure characteristic of plain concrete beams. It increases stiffness, torsional strength, ductility, rotational capacity, and the number of cracks with less crack width.

Shear: Addition of fibers increases shear capacity of reinforced concrete beams up to 100 percent. Addition of randomly distributed fibers increases shear-friction strength, the first crack strength, and ultimate strength.

Column: The increase of fiber content slightly increases the ductility of axially loaded specimen. The use of fibers helps in reducing the explosive type failure for columns.

High Strength Concrete: Fibers increase the ductility of high strength concrete. The use of high strength concrete and steel produces slender members. Fiber addition will help in controlling cracks and deflections.

Cracking and Deflection: Tests have shown that fiber reinforcement effectively controls cracking and deflection, in addition to strength improvement. In conventionally reinforced concrete beams, fiber addition increases stiffness, and reduces deflection.

1.1.2 Mechanical Properties of Fibers (FRC): Addition of fibers to concrete influences its mechanical properties which significantly depend on the type and percentage of fiber Fibers with end anchorage and high aspect ratio were found to have improved effectiveness. It was shown that for the same length and diameter, crimped-end fibers can achieve the same properties as straight fibers using 40 percent less fibers. In determining the mechanical properties of FRC, the same equipment and procedure as used for conventional concrete can also be used. Below are cited some properties of FRC determined by different researchers.

Compressive Strength: The presence of fibers may alter the failure mode of cylinders, but the fiber effect will be minor on the improvement of compressive strength values (0 to 15 percent).

Modulus of Elasticity: Modulus of elasticity of FRC increases slightly with an increase in the fibers content. It was found that for each 1 percent increase in fiber content by volume there is an increase of 3 percent in the modulus of elasticity.

Flexure: The flexural strength was reported to be increased by 2.5 times using 4 percent fibers.

Toughness: For FRC, toughness is about 10 to 40 times that of plain concrete.

Splitting Tensile Strength: The presence of 3 percent fiber by volume was reported to increase the splitting tensile strength of mortar about 2.5 times that of the unreinforced one.

Fatigue Strength: The addition of fibers increases fatigue strength of about 90 percent and 70 percent of the static strength at 2 x 106 cycles for non-reverse and full reversal of loading, respectively.

Impact Resistance: The impact strength for fibrous concrete is generally 5 to 10 times that of plain concrete depending on the volume of fiber used.

Corrosion of Steel Fibers: A l0-year exposure of steel fibrous mortar to outdoor weathering in an industrial Atmosphere showed no adverse effect on the strength properties. Corrosion was found to be confined only to fibers actually exposed on the surface. Steel fibrous mortar continuously immerse in seawater for 10 years exhibited a 15 percent loss compared to 40 percent strength decrease of plain mortar.

Natural Organic and Mineral Fibers: Wood, asbestos, cotton, bamboo, and rockwool. They come in wide range of sizes.

Polypropylene Fibers: Plain, twisted, fibrillated, and with buttoned ends.

Other Synthetic Fibers: Kevlar, nylon, and polyester. Diameter ranges from 0.02 to 0.38mm

1.2 Hybrid Fiber Reinforced Concrete (HFRC):

Latest developments in concrete technology now include reinforcement in the form of fibers, notably polymeric fibers as well as steel or glass fibers. Fiber-reinforcement is predominantly used for crack control and not structural strengthening. Although the concept of reinforcing brittle materials with fibers is quite old; the recent interest in reinforcing cement based materials with randomly distributed fibers is based on research starting in the 1960's. Since then, there have been substantial research and development activities throughout the world. It has been established that the addition of randomly distributed polypropylene fibers reduced the plastic cracking and steel fibers increase their fracture toughness, ductility and impact resistance. Since fibers can be premixed in a conventional manner, the concept of polypropylene fiber concrete has added an extra dimension to concrete construction. There is a hardly anyone type of fiber that can improve all the desired properties of fresh and hardened concrete. To improve all properties of concrete the combination of two or more types of fibers is required and the composite is known as "hybrid fiber reinforced concrete". The basic purpose of using hybrid fibers is to control cracks at different size levels in different zones of concrete, stress levels and to enhance the properties of concrete by combining the benefits that each particular fiber type can impart. In this project experimental study on compressive and flexural behavior of hybrid fiber reinforced concrete will be carried out using the combination of steel and polypropylene fibers.

A Hybrid Fiber Reinforced Concrete (HFRC) is formed from a combination of different types of fibers, which differ in material properties, remain bonded together when added in concrete and retain their identities and properties. The hybridization of fibers provides improved specific or synergistic characteristics not obtainable by any of the original fiber acting alone. Three types of hybrid composites have been used by the researchers using the combinations of polypropylene-carbon, carbon-steel and steel, polypropylene fibers. Two types of steel fibers (continuously crimped and flattened ends with round shaft) and two types of polypropylene fibers (monofilament and fibrillated) have been tried.

The combination of two or more different types of fibers (different fiber types and/or geometries) is becoming more common, with the aim of optimizing overall system behavior. The intent is that the performance of these hybrid systems would exceed that induced by each fiber type alone. That is, there would be a synergy. Banthia classified these synergies into three groups, depending on the mechanisms involved:

1. Hybrids based on the fiber constitutive response, in which one fiber is stronger and stiffer and provides strength, while the other is more ductile and provides toughness at high strains.
2. Hybrids based on fiber dimensions, where one fiber is very small and provides micro crack control at early stages of loading; the other fiber is larger, to provide a bridging mechanism across macro cracks.
3. Hybrids based on fiber function, where one type of fiber provides strength or toughness in the hardened composite, while the second type provides fresh mix properties suitable for processing.

1.2.1 Applications of Hybrid Fibre Reinforced Concrete (HFRC):

In any kind of construction the HFRC can be used because of its unique characteristics and also as it is easy to get various ranges of high strength values.
Some of the applications of HFRC are as follows:

- Bridges
- Tunnel linings.
- Building components like column.
- Sandwich structure like steel concrete structure.
- Industrial flooring and machine foundations

1.3 SCOPE OF STUDY:

The usefulness of fiber reinforced concrete in various Civil Engineering applications is thus indisputable. Hence this study explores the feasibility of hybrid fiber reinforcement; aim is to do parametric study on compressive strength, Split Tensile Strength flexural strength study etc. with given grade of concrete, proportions and percentage of steel and polypropylene fibers.

2.0 LITERATURE REVIEW

Jaya Saxena, Prof. Anil Saxena (2015):
Fiber can be defined as a small piece of reinforcing material possessing certain dimensional characteristics. The most important parameter describing a fiber is its Aspect ratio. "Aspect Ratio" is the length of fiber divided by an equivalent diameter of the fiber. The properties of fiber reinforced concrete are very much affected by the type of fiber. The properties of fiber reinforced concrete are very much affected by the type of fiber. Fibers are secondary reinforced material and acts as crack arrester. Prevention of

propagation of cracks originating from internal flaws can result in improvements in static and dynamic properties of matrix. Fiber reinforced cement and concrete materials (FRC) have been developed progressively since the early work by Romualdi and Batson in the 1960s. By the 1990s, a wide range of fiber composites and FRC products were commercially available and novel manufacturing techniques were developed for use with high fiber content. In parallel with the commercial development of FRC materials and products, an extensive research programme was undertaken to quantify the enhanced properties of FRC materials and more specifically to allow comparisons to be made between various types of fibers. Keywords: Fiber Reinforced Concrete, Nylon Fiber, Conventional concrete.

Nilanjan Tarafder, Raipriti Swain (2016) Fiber reinforced polymer (FRP) composites have become important materials for the new structures and application of FRP is efficient in repairing and strengthening constructions which were architecturally weak. For applications of structures, an overview of different FRP composites are provided by various polymer composites and in civil structures FRP composites are used for reinstatement or firming up the elemental constituent. Now a day's various researches are going on internationally regarding the use of FRP, wraps, laminates and sheets in the renovation and hardening concrete members. FRPis an alternate process to renovation of structures which is also economical. FRP is being using effectively in various cases like less load, high strength and stability. The purpose of this paper is to discuss about different properties, types, applications of FRP. Some case studies & practical applications used in worldwide are also discussed in this paper.

Banthia, N., Yan, C. and Bindiganavile, V (2000): Hybrid fiber-reinforced concrete is a type of fiber-reinforced concrete characterized by its composition. It contains at least two or more types of fibers of different sizes, shapes or origins. Considering that fibers of different types have different effects on the properties of fresh and hardened concrete, the use of hybrid fibers allows optimization of the properties of fiber reinforced concrete at all levels. In this paper are given some basic results of investigation before application of hybrid fiber reinforced concrete with steel and polypropylene fibers. Case studies of application of hybrid fiber reinforced concrete for construction of concrete pavement and repair of bridge deck overlay are also shown. Some particular material properties and technology aspects of hybrid fiber reinforced concrete in practice are analyzed.

Meda, A., Plizzari, G.A., Sorelli, L. and Banthia, N (2003): Steel fiber reinforcement allows enhancing the fracture performance in concrete. The concrete toughness can be increased by adding one or more types of fibers to the concrete matrix. In order to evaluate the fiber effect on the material and the structural response, adequate tests have to be carried out. Fracture properties of concrete reinforced with a combination of fibers with different length is analyzed herein by means of uni-axial and bending tests. Experimental results on specimens reinforced with a low fiber content can be affected by a remarkable scatter: for this reason, an assumption based on the number of fibers expected in the cracked surface was introduced in order to identify a representative curve for each test and each material. A numerical simulation based on non-linear fracture mechanics of the experimental test was carried out in order to better identify the fiber contribution in the fracture propagation.

Lawler, J.S., Zampini, D., and Shah, S.P (1994): The use of fiber reinforcement in traditional concrete mixes has been extensively studied and has been slowly finding its regular use in practice. In contrast, opportunities for the use of fibers in masonry applications and structural rehabilitation projects (masonry and concrete structures) have not been as deeply investigated, where the base matrix may be a weaker cementations mixture. This paper will summarize the findings of the author's research over the past 10 years in these particular applications of fiber reinforced cements (FRC). For masonry, considering both mortar and mortar-unit bond characteristics, a 0.5% volume fraction of micro fibers in type N Portland cement lime mortar appear to be a viable recipe for most masonry joint applications both for clay and concrete units. In general, clay units perform better with high water content fiber reinforced mortar (FRM) while concrete masonry units (CMUs) perform better with drier mixtures, so 130% and 110% flow rates should be targeted, respectively. For earth block masonry applications, fibers' benefits are observed in improving local damage and water pressure resistance. The FRC retrofit technique proposed for the rehabilitation of reinforced concrete two-way slabs has exceeded expectations in terms of capacity increase for a relatively low cost in comparison to the common but expensive fiber reinforced polymer applications. For all of these applications of fiber-reinforced cements, further research with larger data pools would lead to further optimization of fiber type, size, and amount.

EXPERIMENTAL PROGRAM

3.1 Outline: The experimental program consisted of casting and testing of the Cubes of size (150mm*150mm*150mm),Cylinders(150 mm*300mm) and beams (100mm*100mm*500mm) specimens of normal strength concrete. The key parameters in this study were grade of concrete and percentage of steel and Polypropylene fibers added in the concrete mix. In this procedure, cubes, cylinders and beam specimen's were casted with different % (0%,0.25%,0.5%,0.75% and 1%) with combinations of steel and polypropylene fibers and the casted specimens are tested for different properties at 7,14 and 28 days.

3.2 Concrete Grade and Mix Proportion: The grade of concrete taken in this project is M25. The mix design of M25 grade of concrete with 0.45 W/C ratio was carried out according to code IS 10262: 2009 Concrete Mix Proportion Guide lines and also from IS 456-2000. The mix proportion was given in the following table:

Table 3.2: Details of Mix Proportions

S.No	Material	Quantity
1	Cement	432.28 Kg/ m3
2	Fine Aggregate	616.5 Kg/ m3
3	Coarse Aggregate	1216.58 Kg/ m3
4	Water	197 Ltrs

3.3 Materials Used:

Cement: 53 grade Ordinary Portland cement conforming to IS 12269 – 1983 was used for the concrete mix and Specific gravity was found to be 3.5

Fine Aggregate: Locally obtained sand was used in the work which falls in zone – II. The specific gravity was found to be 2.60.

Coarse aggregate: Crushed coarse aggregate of size 20mm are used in this mix, having specific gravity of 2.78.

Water: Portable water supplied by the college is used in this work.

Steel Fibers: The steel fibers used in this project are the crimped type and are obtained from the STEWOLS INDIA (P) LMT located at Nagpur. These fibers having length of 35mm and diameter of 0.5mm.

Polypropylene fibers: These are the fibrillated fibers having the length of 24mm which are brought from the WALTAR ENTERPRISES, Mumbai.

Table 3.2: Properties of Fibers Taken:

Type	Specific gravity(g/cm^3)	Tensile Strength (Mpa)	Elasticity (GN/m^2)	Elongation at failure (%)	Common V (%)
Steel	7.86	400-1200	200	-3.5	<2
Polypropylene	0.91	550-700	3.5-6.8	21	<2

Fig 3.1: Steel and Polypropylene Fibers

3.4 Casting and Curing:

The casting was done for M25 grade of concrete with different volume fractions (0%, 0.25%,0.5%,0.75% and 1%) of fibers with steel and polypropylene fiber combinations. The different proportions of fibers used were given in following table:

Table 3.3: Percentage combinations of fibers used

S.No	Indication	% of Steel Fibers	% of Polypropylene Fibers
1	H-S0-P0	0	0
2	H-S0.5 – P0.5	0.5	0.5
3	H-S0.6 – P0.4	0.6	0.4
4	H-S0.7 – P0.3	0.7	0.3
5	H-S0.8 – P0.2	0.8	0.2

A total of five Mixes was done to caste cubes, cylinders and beams moulds of specified sizes. Each mix was done with the addition of two different types of fibers.

The coarse and fine aggregates were first added to the mixer. After the coarse and fine aggregates were thoroughly mixed, one-third (1/3) of the mixing water was added the cement and the remainder of the mixing water were added to the mixer after a minute. All ingredients were mixed together in the mixer for another minute before the fiber was added. The mixing continued for two more minutes before allowing the mixture to rest for two minutes. After the mixture was allowed to hydrate and absorb some water, the mixer was started again finally the whole mixture was mixed for two more minutes. The total mixing time including the resting time was ten minutes. Twelve cubic feet rotary mixer was used to mix the concrete After casting the specimens are placed in the curing tank for curing period.

3.5: Testing Procedure:

After the curing period all the specimens were taken out and dried out. Then these specimens are tested in Universal testing machine for compressive, split and flexural strength values and the failure load was noted.

4.0 RESULTS

All the casted specimens are tested on the universal testing machine (UTM) under load rate control. At every stage of loading, the failure reading from the reading guage is recorded. This procedure was repeated for all the specimens of Cubes, cylinders and beams. The beam specimens were tested for flexural strength values on a three point loading. Based on the obtained results the following graphs are drawn and the resulted values are tabulated for compressive strength, split tensile strength and flexural; strength values.

4.1 Compressive strength Results: The compressive strength values that are obtained at the age of 7, 14, 28 days are tabulated as follows: **Table 4.1: Compressive strength values**

S.No	Specimen	No. of days	Compressive strength (N/mm$^{2)}$
1	HFRC-S0-P0	7	21.03
		14	24.2
		28	27.9
2	HFRC-S0.5-P0.5	7	22.9
		14	29.4
		28	39.1
3	HFRC-S0.6-P0.4	7	25.6
		14	31.5
		28	39.7
4	HFRC-S0.7-P0.3	7	29.32
		14	37.9
		28	43.9
5	HFRC-S0.8-P0.2	7	32.3
		14	41.5
		28	48.56

Based on the above results the graph is drawn between Compressive strength Vs % addition of Fibers with different combinations.

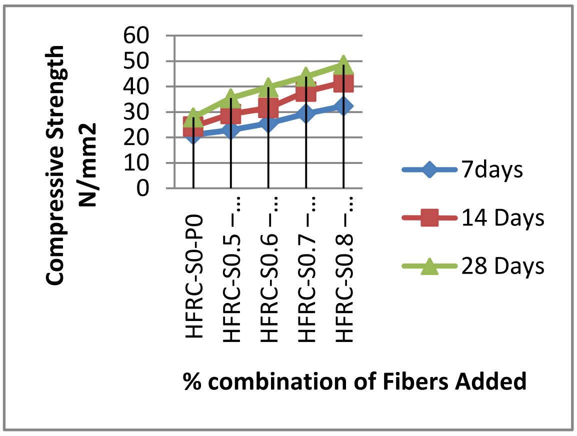


Fig 4.1: Graph between Compressive strength Vs % Addition of combinations of fibers.

4.2 Split Tensile strength Results: The Split tensile strength values that are obtained at the age of 7, 14, 28 days are tabulated as follows:

Table 4.2: Split Tensile strength values

S.No	Specimen	No. of days	Compressive strength (N/mm$^{2)}$
1	HFRC-S0-P0	7	21.03
		14	24.2
		28	27.9
2	HFRC-S0.5-P0.5	7	22.9
		14	29.4
		28	39.1
3	HFRC-S0.6-P0.4	7	25.6
		14	31.5
		28	39.7
4	HFRC-S0.7-P0.3	7	29.32
		14	37.9
		28	43.9
5	HFRC-S0.8-P0.2	7	32.3
		14	41.5
		28	48.56

Based on the above results the graph is drawn between split tensile strength Vs % addition of Fibers with different combinations.

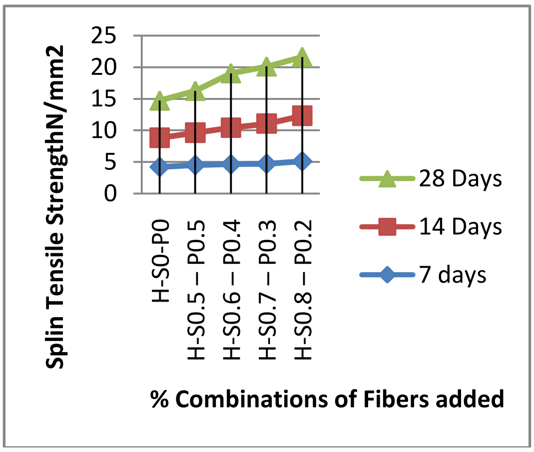


Fig 4.2: Graph between split tensile strength Vs % Addition of combinations of fibers

4.3 Flexural strength Results:

The Flexural strength values that are obtained at the age of 7, 14, 28 days are tabulated as follows:

Table 4.1: Flexural strength values .No	**Specimen**	**No. of days**	**Compressive strength (N/mm^2)**
1	HFRC-S0-P0	7	21.03
		14	24.2
		28	27.9
2	HFRC-S0.5-P0.5	7	22.9
		14	29.4
		28	39.1
3	HFRC-S0.6-P0.4	7	25.6
		14	31.5
		28	39.7
4	HFRC-S0.7-P0.3	7	29.32
		14	37.9
		28	43.9
5	HFRC-S0.8-P0.2	7	32.3
		14	41.5
		28	48.56

Based on the above results the graph is drawn between Flexural strength Vs % addition of Fibers with different combinations.

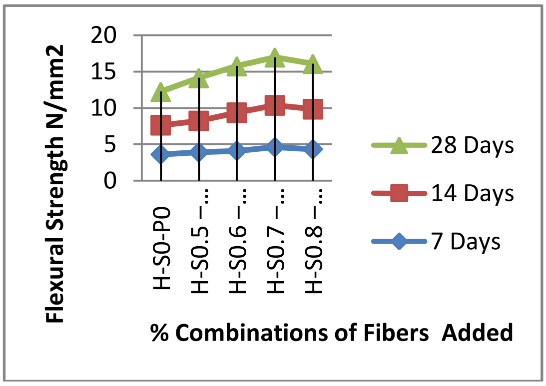
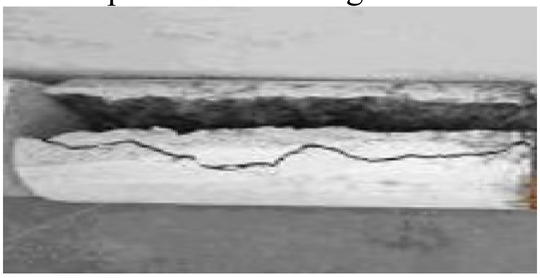


Fig 4.3: Graph between Flexural strength Vs % Addition of combinations of fibers

Cube under Compression

Split Tensile Strength Test



View of Failed Cylinder

Beam Testing for Flexural Strength

View of Failed Beam

5.0 CONCLUSIONS

The experimental study on failure properties of hybrid fiber reinforced concrete (HFRC) with different proportions and combinations of two different fibers can still be a promising work due to the need of overcoming the brittleness problem of concrete.

Based on the experimental investigations and results obtained in this project on HFRC, the following conclusions can be given.

1. The addition of fibers to the concrete reduced the brittleness of the concrete to much extent. The addition of fibers will improve the ductility nature of concrete.

2. As in case of compressive strength, the values are increased with the increase of addition of fibers. The addition of steel fiber and polypropylene fiber results in an increase of 14.30% compressive strength.

3. In case of split tensile strength, the values are increased by increasing the addition of fiber which is same n case of compressive strength.

4. The HFRC-S0.8-P.02 specimen showed the highest compressive and split tensile strength when compared to other specimens.

5. But, in flexural strength case, the strength values are increased upto HFRC-S0.7-P0.3 specimen and then decreased.

6. The HFRC-S0.7-P0.3 specimen given the highest values of flexural strength when compared to other.

7. While mixing it was observed that the slump values is reducing with the increase addition of fibers. Super plasticizers usage in correct proportions may results in good slump values

8. A further studies are needed in order to make hybrid fiber reinforced concrete more sustainable in construction.

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