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Comparative Study Of Hybrid Fibre Reinforced Concrete And Find Optimum Dosage Of Fibre

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Abstract— Concrete is the most widley used construction meterial across the world Due to the persistent and continuous demands made on concrete to meet the various difficult requirements, extensive and wide spread research work is being carried out in the area of concrete technology. Researchers have developed variants of concrete composites like Admixture Concrete, Fiber Reinforced Concrete (FRC), Polymer Impregnated Concrete (PIC), High Performance Concrete (HPC), Self Compacting Concrete (SCC), Geopolymer Concrete etc. But certain inherent properties like low ductility, formation of shrinkage cracks etc. cannot be rectfied Formation of cracl is a major problem, these cracks propagate in all direction causes corrosion of reinforcement in structures The introduction of different types of fibres to the conrete mix helps to improve the different mechanical properties of concrete and also helps to reduce the cracks formation to a great extent.The present study is steel and polester hybrid fibre concrete and a comparison of which with conventional concrete mix and also find out the optimum dosage of steel fibre in the hybrid reinforced concrete Presently, concrete includes the use of steel fibre and polister hybried fibre, etc. . The entire project work has been divided into two phases, namely Phase-I and Phase-II. The theoretical and experimental studies have been carried out. The strength properties are studied for the conventional concrete. In the present experimental investigation, Concrete grade of M30 has been deisgned. A combination of mineral admixtures likesteel fibre, Recron 3S Polyster fibreOPC is used..

Keywords— steel fibre, polyester fibre. OPC

I. INTRODUCTION

Hybrid Fibre Reinforced Concrete is a composite material consisting of hydraulic cement ,sand,coarse aggregate water and more than one type of fibres. Fibres helps to improve post peak ductility perfomance pre-crack tensile strength fatigue strenth and eleminate temperure and shinksge cracks . The amount of fibres added to the concrete mix is measured as a percetage of the total volume o composite termed volume fraacton, typically range from 0.1 to 3%. One of the major problems the consruction industry faces is the failure of concrete by the corrosion of reinforcement bars due to the development of micro cracks that are invisible to naked eye These cracks are formed due to stress es developed during shrinkage Hybried concrete has wide applications as secondary reinforcement in recent yearss because of their property to resistthese micro cracks.There are a number of different type of steel fibres with different commercia names. The main advantage of steel fibres are it increses the ductility toughness strength fatigue resistance etc.

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Polyester is a category of polymers which contain the ester functional group in their main chain. Although there are many types of polyester, the term “polyester” as a specific material most commonly refers to polyethylene terephthalate (PET). Polyesters include naturally-occurring chemicals, such as in the cuting of plant cuticles, as well as synthetics through step-growth polymerization such as polycarbonate and polybutyrate. Natural polyesters and a few synthetic ones are biodegradable, but most synthetic polyesters are not.

The other major inherent factor that affects the properties of the fibre reinforced is the bond strength of the fibre with cement composite. The bundles of polyester fibres added to concrete are separated into millions of individual strands due to the abrasive action of the aggregates. The fibres provide support to concrete in all possible directions by getting evenly distributed throughout the matrix.

1. 1 APPLICATIONS OF HYBRID FIBRE

Several manufactures currently produces steel and polyesters fibres for the use in concrete as a form of secondary reinforcement and in cement mortar. Different applications of these hybrid fibres are,

- Mortar (Internal plaster, external plaster, tunnel linings)
  In exposed un-reinforced concrete surfaces (Runways, taxiways, road pavements, canal linings, railways platforms, parking decks etc.)
- In reinforced cement concrete (Reduces amalgamation of cracks at joints, increases durability of the structure due to its corrosion resistance)
- Blast resistant structures
- Structures subjected to dynamic loading
- In water retaining structures (Dams, swimming pools, aqua ducts, spillways, intake structures, etc.)
- In precast concrete products (Paver tiles and blocks, pipes)
- In repairs and restoration (Saves repair and restoration costs as it extends corrosion-free life to structural steel reinforcement thereby increasing useful life span of the structure)

1.2 ADVANTAGES OF CONCRETE WITH HYBRID FIBRE

Steel and Polyester HFRC exhibits the following improvement in properties over any other same mix design control concrete.

1. Drying Shrinkage (Reduces from 80%-100%)
2. Water permeability / Penetration (Reduces from 40% to 50%)

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3. Compressive Strength (Increases from 10% to 20%)
4. Tensile Strengths (Increases from min of 6% -10%)
5. Abrasions Resistance (Increases from 20% to 40%)
6. Impact Resistance (Increases from 80% to 120%)
7. Improves Resistance of Structures to Earthquake.
8. It has a larger surface area, thus ensuring a wider area for concrete and mortar aggregates to bind more securely
9. It can be used for wide and varied applications of concrete and mortar due to wide range of cut lengths available.

Polyster is a technology and instrumentation as well as its related scientific areas such as physics and chemistry are making the research on nanotechnology aggressive and evolutional. Not surprisingly, it is observed that expenditure on nanotechnology research is significant. Nanotechnology products can be used for design and construction processes in many areas. It is provided to demonstrate that nanotechnology generated products have many unique characteristics, and can significantly fix current construction problems, and may change the requirement and organization of construction process. This paper examines and documents the applications of nanotechnology using nano admixtures and super plasticizers that can improve the overall strength of concrete so as to competitive the modern construction industry. Nano Technology applied to concrete includes the use of nano materials like nano silica, nano fibers etc. By adding the nano materials, concrete composites with superior properties can be produced. Addition of nano silica (nS) in concretes and mortars results in more efficient hydration of cement. Due to the pozzolonic activity, additional calcium silicate hydrates are formed to generate more strength and to reduce free calcium hydroxide. This also helps in reducing the cement requirement, nS improves the microstructure and reduces the water permeability of concrete thus making it more durable. Use of nano silica in HPC and SCC improves the cohesiveness between the particles of concrete and reduces segregation and bleeding. Concretes with strengths as high as 100 MPa with high workability, anti bleeding properties and short demoulding time can be produced. Nano silica can be used as an additive to eco concrete mixtures.

II. MATERIALS AND METHODS

A. Cement

IS:12269-1987**,** Specifications for 53 Grade Ordinary Portland Cement, Bureau of Indian Standards, New Delhi.

B. Fine Aggregate

The fine aggregate (sand) used was clean dry sand. The sand was sieved in 4.75mm Sieve to remove all pebbles.

C. Coarse Aggregate

Hard stones of size less than 20mm were used as coarse aggregate.

D. Seel Fibre, Hybrid Polyester Fibre

III. DETAILS OF CONTROL SPECIMENS

The details of control specimens for the preliminary study are presented in Table 3.6

Table 3.6 Details of Control Specimens

[1]Grade of Concrete	[2]Group	[3]Mix Proportion	[4]Fibre Content [5](% of Cement)	[6]Number of Specimens			
		[7]C : F : CA : w		[8]Cubes	[9]Cylinder	[10]Beam	[11]Disc
[12]M30	[13]MSO	[14] *1:2.05:3.71*	[15]0.00	[16]6	[17]6	[18]3	[19]3
	[20]MS1		[21]0.10	[22]6	[23]6	[24]3	[25]3
	[26]MS2		[27]0.15	[28]6	[29]6	[30]3	[31]3
	[32]MS3		[33]0.20	[34]6	[35]6	[36]3	[37]3
	[38]MS4		[39]0.25	[40]6	[41]6	[42]3	[43]3
[44]Total				[45]30	[46]30	[47]15	[48]15

IV. MIX DESIGN

4.1. STIPULATIONS FOR PROPORTIONING

a) Grade designation : M30

b) Type of Cement : OPC 53 grade conforming to IS 12269

c) Maximum nominal size of aggregate : 20 mm

d) Minimum cement content : 320 kg/m^3

e) Exposure condition : Severe (for reinforced concrete)

f) Type of aggregate : Crushed natural stone

g) Maximum cement content : 450 kg/m^3

h) Chemical admixture type : Super plasticizer

4.2. TEST DATA FOR MATERIALS

a) Specific gravity of :
1) Cement : 3.13
2) Coarse aggregate : 2.72
3) Fine aggregate : 2.68
b) Sieve analysis
1) Coarse aggregate : No zone
2) Fine aggregate :Conforming to grading zone II

4.3. TOTAL VOLUME OF CONCRETE

Total volume of concrete = Volume of (Cube+Cylinder+Beam+Disc) = (30×10^3) + $(30\times\pi/4\times15^2\times30)$ + $(15\times10\times10\times50)$ + $(15\times\pi/4\times15^2\times5)$
= 277296.725 cm^3

Assuming 20% loss,
Volume of concrete required = 1.2 × 277296.725
= 332756.07 cm^3
= 0.332 m^3

4.4. CALCULATION OF TARGET MEAN STRENGTH

According to IS 456, the target-mean compressive strength,

$$f_t = f_{ck} + ks$$

where,

f_{ck} = characteristic compressive strength at 28 days

k= statistical value depending on the expected proportion of low results.

According to IS 456, k = 1.65

s = standard deviation. From table 8 of IS 456, s= 5 N/mm^2 for M30 concrete.

Therefore target mean strength,

f_{ck} = 30 + 1.65 × 4 = 38.25 MPa

4.5. SELECTION OF WATER CEMENT RATIO

Different cements, supplementary cementitious materials and aggregates of different maximum size, grading, surface texture, shape and other characteristics may produce concretes of different compressive strength for the same water-cement ratio. Therefore, the relationship between strength and free water-cement ratio should preferably be established for the materials actually to be used. In the absence of such data, the preliminary free water-cement ratio (by mass) corresponding to the target strength at 28 days may be selected from the established relationship, if available.

From Table 5 of IS 456, maximum water cement ratio = 0.45

Based on experience, adopt water-cement ratio as 0.40
Therefore water-cement ratio = **0.4**

4.6. SELECTION OF WATER CONTENT

The water content of concrete is influenced by a number of factors, such as aggregate size, aggregate shape, aggregate texture, workability, water-cement ratio, cement and other supplementary cementitious material type and content, chemical admixture and environmental conditions. An increase in aggregates size, a reduction in water-cement ratio and slump, and use of rounded aggregate and water reducing admixtures will reduce the water demand. On the other hand increased temperature, cement content, slump, water-cement ratio, aggregate angularity and a decrease in the proportion of the coarse aggregate to fine aggregate will increase water demand.

From Table 2 of IS 10262-09,
Maximum water content for 20mm aggregate = 186 kg (for 25 to 50 mm slump value)
Therefore corrected water content for 100mm slump = 186 + (6/100) × 186 = 197 kg
As super plasticizer is used , water content reduction of 29% has been achieved.
Hence the arrived water content = 197 × 0.71 = 140 kg

4.7. CALCULATION OF CEMENT CONTENT

The cement and supplementary cementitious material content per unit volume of concrete may be calculated from the free water-cement ratio and the quantity of water per unit volume of concrete.

Water-cement ratio = 0.4
Cement content = 140
= 350 kg/m^3

From Table 5 of IS 456,
Minimum cement content for ‘severe’ exposure condition = 320 kg/m^3

350 kg/m^3 > 320 kg/m^3 , Hence O.K

4.8. PROPORTION OF VOLUME FINE AND COARSE AGGREGATE CONTENT

Aggregates of essentially the same nominal maximum size, type and grading will produce concrete of satisfactory workability when a given volume of coarse aggregate per unit volume of total aggregate is used. Approximate values for this aggregate volume are given in Table 3 of IS 10262-09 for a water-cement ratio of 0.5, which may be suitably adjusted for other water-cement ratios. It can be seen that for equal workability, the volume of coarse aggregate in a unit volume of concrete is dependent only on its nominal maximum size and grading zone of fine aggregate. Differences in the amount of mortar required for workability with different aggregates, due to differences in particle shape and grading, are compensated automatically by differences in rodded void content.

For more workable concrete mixes which is sometimes required when placement is by pump or when the concrete is required around congested reinforcing steel, it may be desirable to reduce the estimated coarse aggregate content determined above up to 10 percent.

From Table 3 of IS 10262-09,

volume of coarse aggregate per unit volume of total aggregate corresponding to 20mm aggregate and fine aggregate of zone I for water-cement ratio of 0.50 = 0.62.

In the present case water-cement ratio is 0.40.

As the water-cement ratio is lowered by 0.10, the proportion of volume of coarse aggregate is increased by 0.02.

Therefore corrected proportion of volume of coarse aggregate for water-cement ratio of 0.40 = 0.62+0.02 =0.64

Volume of fine aggregate content = 0.36

4.9. MIX CALCULATIONS

Quantities of coarse and fine aggregates are determined by finding out the absolute volume of cementitious material, water and the chemical admixture; by dividing their mass by their respective specific gravity, multiplying by 1/1000 and subtracting the result of their summation from unit volume. The values so obtained are divided into coarse and fine aggregate fractions by volume in accordance with coarse aggregate proportion already determined above. The coarse and fine aggregate contents are then determined by multiplying with their respective specific gravities and multiplying by 1000.

a) Volume of concrete = 1 m^3

b) Volume of cement = (mass of cement/specific gravity of cement) × (1/1000)
= (350/3.13) × (1/1000)
= 0.112 m^3

c) Volume of water = (mass of water/specific gravity of water) × (1/1000)
= (140/1) × (1/1000)
= 0.140 m^3

d) Volume of super plasticizer at 2% by mass of cement
= (mass of super plasticizer / specific gravity of super plasticizer) × (1/1000)
= (350×2/1.145×100) × (1/1000) = 0.006 m^3

e) Volume all in aggregate = a- (b+c+d)
=1- (0.112+0.140+0.006)
= 0.742 m^3

f) Mass of coarse aggregate = e × volume of coarse aggregate× specific gravity coarse aggregate × 1000 = 0.742×0.64×2.72×1000 = 1292 kg

g) Mass of fine aggregate = e × volume of fine aggregate × specific gravity of fine aggregate × 1000
= 0.742×0.36×2.68×1000
= 716 kg

4.10. MIX PROPORTIONS FOR TRIAL NUMBER

Cement = 350 kg/m^3

Water = 140 kg/m^3

Fine aggregate = 716 kg/m^3

Coarse aggregate = 1292 kg/m^3

Chemical admixture Water-cement ratio = 0.4

V.TEST RESULTS

5.1. WORKABILITY

The workability of various mixes was assessed by determining the slump value, compacting factor and flow index as per the IS 1199:1959 specification. Table(5.1) shows the values of slump, compacting factor for various mixes of concrete.

Table 5.1 Workability of various mixes

[49]GROUP	[50]COMPACTING FACTOR
[51]MS0	[52]0.8
[53]MS1	[54]0.77
[55]MS2	[56]0.76
[57]MS3	[58]0.74
[59]MS4	[60]0.74

The slump value of the control mix is found to be zero. As the fibre content in the mix increases, the slump remains zero. The results indicate that the fibre induced in to the concrete mix prevents the flow or collapse of slump by holding the matrix together. This is justified, as the presence of fibre causes obstruction to free flow and self compaction under gravity.

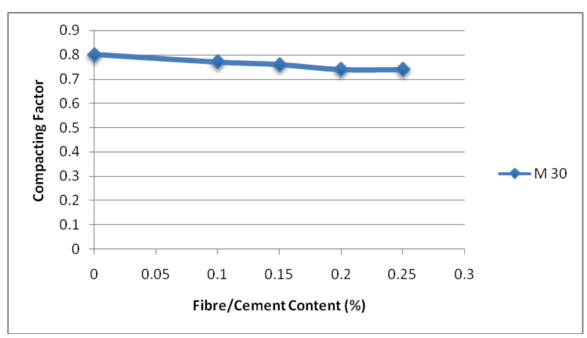

Fig 5.1 Relationship between Compacting Factor & Fibre/Cement Content

On the other hand, the compacting factor values obtained do not show reduction as evident as in the case of slump values. In the case of compacting factor test, even though the results does not yield a true representation of the workability, it clearly indicates that a certain amount of external work should be done on the fresh concrete to overcome the resistance offered by the fibre. Thus slump and compacting factor test is not sufficient to judge an optimum workable mix.

5.2. CUBE COMPRESSIVE STRENGTH

For each mix of ordinary concrete and HFRC, two cubes each of size 100mmX100mmX100mm were tested according to the IS516:1959 specifications, on the 3rd day, 7th day and 28thday of casting and the values obtained are given in table. The reduction in strength is justified as, when the percentage of fibre in the particular mix increases, the workability is affected as the filling ability reduces which in turn reduces the compaction and fibre content is not enough to bridge the micro cracks developed. For the M30 grade of concrete considered in this study. Addition of 0.2% fibre yielded the maximum strength after 28 day. So this percentage is considered optimum dosage in the view of compressive strength.

Table 5.2 Average 3 day, 7day & 28th day cube strength

[61] GROUP	[62] f 3 [63] (N/mm^2)	[64] f 7 [65] (N/mm^2)	[66] f 28 [67] (N/mm^2)
[68] MS0	[69] 32.50	[70] 42.25	[71] 45.75
[72] MS1	[73] 34.23	[74] 43.90	[75] 48.20
[76] MS2	[77] 38.12	[78] 46.34	[79] 52.50
[80] MS3	[81] 42.75	[82] 49.60	[83] 55.42
[84] MS4	[85] 36.25	[86] 44.00	[87] 49.25

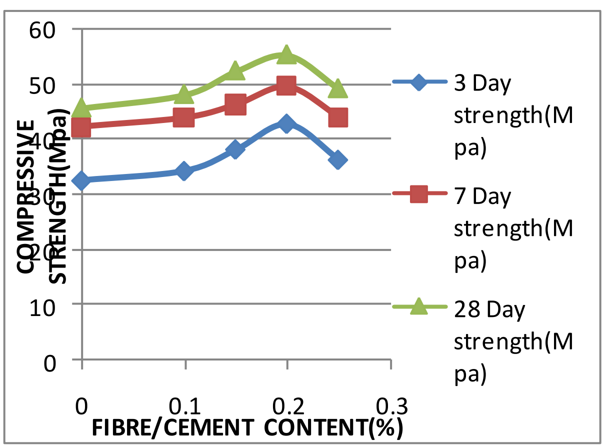

Fig 5.2 The variation of 3day, 7day & 28th day compressive strength with % of fibre content

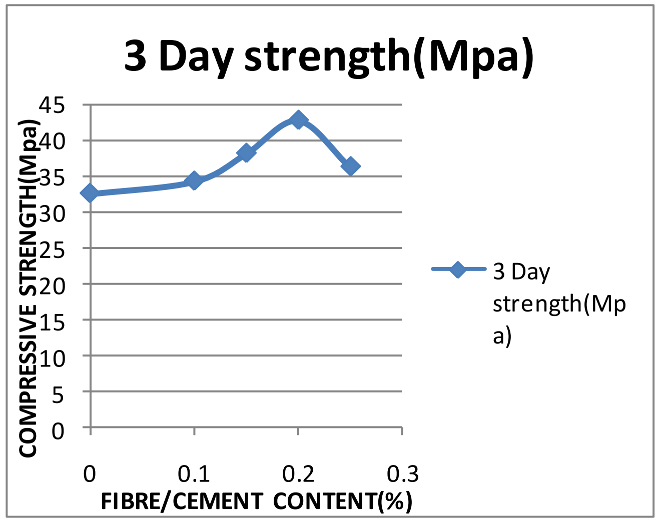

Fig 5.3 The variation of 3day compressive strength with % of fibre content

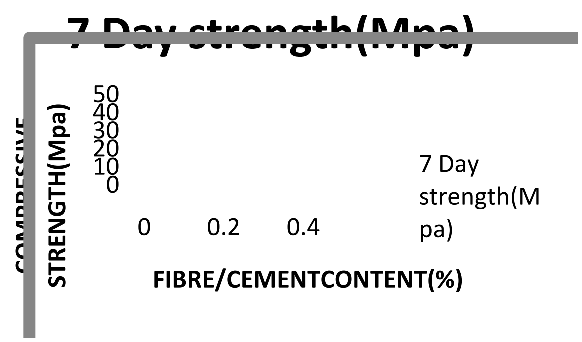

Fig 5.4 The variation of 7day compressive strength with % of fibre content

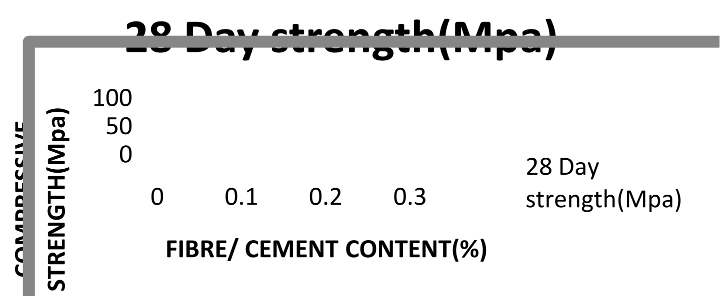

Fig 5.5 28th day compressive strength vs fibre/cement content

5.3. FLEXURAL STRENGTH

Beam specimens of size 100mmX100mmX500mm for determining the flexural strength as per IS 516:1959 specification. The results obtained are in table (5.3)

Table 5.3 flexural strength

[88] GROUP	[89] AVERAGE COMPRESSIVE STRENGTH *fca* [90] (N/mm^2)	[91] AVERAGE FLEXURAL STRENGTH *fcr* [92] (N/mm^2)	[93] $\frac{fcr}{\sqrt{fca}}$
[94] MS0	[95] 45.75	[96] 4.23	[97] 0.6253811
[98] MS1	[99] 48.20	[100] 4.90	[101] 0.7057852
[102] MS2	[103] 52.50	[104] 4.81	[105] 0.6638430
[106] MS3	[107] 55.42	[108] 5.26	[109] 0.7065655
[110] MS4	[111] 49.25	[112] 4.68	[113] 0.6668723

Flexural strength obtained for hybrid fibre specimens was more or less same as those for ordinary concrete. It is seen that the flexural strength decreases slightly for0.15%, fibre content in the mix, where as, a slight increase is noted in case of 0.2% fibre content in the mix. The reduction in flexural strength is due to the reduction in compaction effected by the introduction of fibre and the ineffectiveness of the fibre in resisting the high tensile stress developed at the extreme bottom layer during the flexural failure of the beam specimens. The maximum increase in flexural strength is obtained for the dosage of 0.2% fibre content for all the three mixes. The IS 456-2000 suggest that flexural strength, f_{cr} = $0.7\sqrt{fca}$ N/mm^2. TO arrive at such an empirical relation, the ratio $\frac{fcr}{\sqrt{fca}}$ is computed for the specimens. The minimum strength after 28th day obtained as fcr= $0.625\sqrt{fca}$. The variation of flexural strength with percentage of fibre is given in fig(5.6)

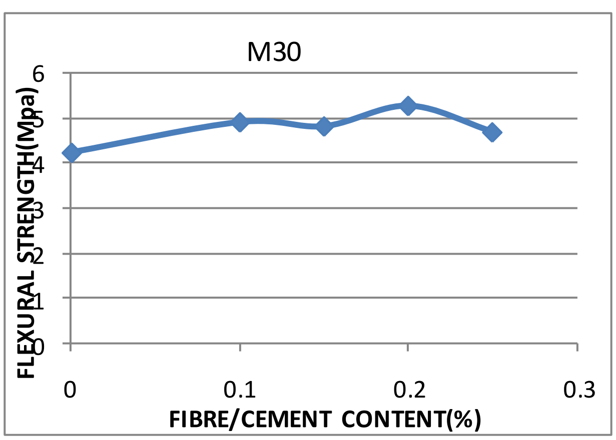

Fig 5.6 Flexural strength vs % fibres/cement content

5.4. SPLIT TENSILE STRENGTH

The cylindrical specimens (150x300mm) of the HFRC and ordinary concrete were tested for split tensile strength under uniform loading and the results obtained are shown in Table. It is seen that the FRC specimens have the tensile strength values that were lower than ordinary mixes. In the case of split tensile failure, the fibre across the entire splitting cross section is expected to be effective in resisting the splitting of cylinder into two pieces.

Table 5.4 Split tensile strength

[114] Group	[115] Average Compressive Strength f_{ca} (N/mm^2)	[116] Average Split Tensile Strength f_t (N/mm^2)	[117] $ft/\sqrt{fca}$
[118] MS0	[119] 45.75	[120] 2.97	[121] 0.439
[122] MS1	[123] 48.20	[124] 2.98	[125] 0.429
[126] MS2	[127] 52.50	[128] 3.23	[129] 0.445
[130] MS3	[131] 55.42	[132] 3.42	[133] 0.459
[134] MS4	[135] 49.25	[136] 3.10	[137] 0.441

The test shows a noticeable decrease in split tensile strength exhibited by HFRC compared to its ordinary mix. Comparison with average compressive strength revealed that the HFRC with maximum compressive strength exhibited minimum split tensile strength, f_t=$0.429\sqrt{fca}$. The variation of split tensile strength with percentage of fibre content is given in fig(5.7)

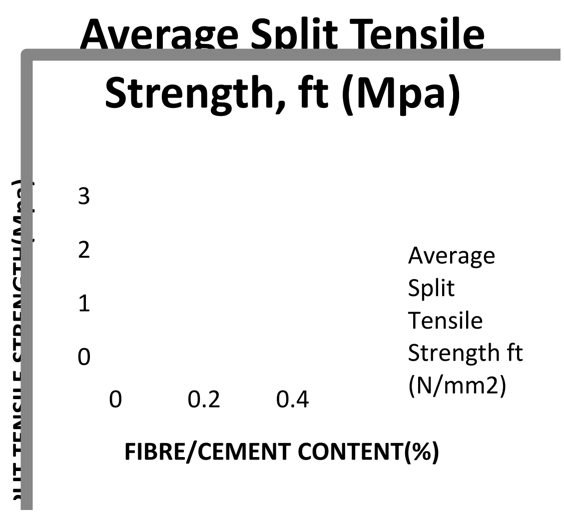

Fig 5.7 Split Tensile strength vs % fibres/cement content

5.5. MODULUS OF ELASTICITY

The values of modulus of elasticity obtained for various mixes of ordinary concrete and HFRC are presented in Table. From this table, it is clear that, as the percentage of fibre content increases, the modulus of elasticity also increases when compared to ordinary concrete, except for fibre dosage of .15%. This reduction in modulus of elasticity for 0.15% may be due to the reduction in compaction effected by the introduction of fibre and the low fibre content that is not sufficient to bridge the cracks. The increase in modulus of elasticity for other dosages is justified by the additional crack resistance offered by the rich fibre content in the matrix. The variation of modulus of elasticity with percentage of fibre content is given in fig(5.9).

Table 5.5 Modulus of elasticity

[138] Group	*[139]* f_{ca} **[140] (N/mm2)**	**[141] E [142] (N/mm2)**	**[143]** $E/\sqrt{fc}$
[144] MS 0	[145] 45.75	[146] 40266	[147] 5953
[148] MS 1	[149] 48.20	[150] 46822	[151] 6744
[152] MS 2	[153] 52.50	[154] 51396	[155] 7093
[156] MS 3	[157] 55.42	[158] 71777	[159] 9642
[160] MS 4	[161] 49.25	[162] 42585	[163] 6068

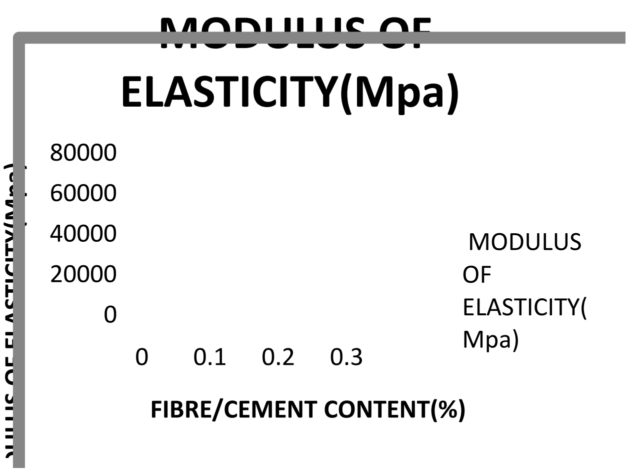

Fig 5.9 Modulus of elasticity vs % fibres/cement content

5.6. IMPACT RESISTANCE

Improved impact resistance is one of the important attributes of FRC. Depending upon the impacting mechanism and parameters, there are different tests among which the Drop weight test or repeated impact is the simplest one. According to this test, the impact resistance is characterized by a measure of number of blows in a repeated impact test to achieve a prescribed level of distress. This number serves as a qualitative estimate of the energy absorption capacity by the specimen at the levels of distress specified. The test can be used to compare the relative merits of different fibre-concrete composites and to demonstrate the improved performance of HFRC compared to conventional concrete.

As per the ACI 544-2R-89, the equipment for the drop weight impact test consists of

- A standard manually operated 4.54 kg compaction hammer with 457-mm drop.
- A 63.5 mm diameter hardened steel ball.
- A flat base plate with positioning bracket.

Concrete samples to be tested are of size 152 mm diameter and thickness 63.5 mm. The samples are coated on the bottom with a thin layer of petroleum jelly or heavy duty grease and placed on the base plate within the positioning legs with the finished (cast) face up. The positioning bracket is then bolted in place, and hardened steel ball is placed on top of specimen within the bracket. The drop hammer is placed with its base upon the steel ball and held there with just enough down pressure to keep it from bouncing off the ball during the test. The base plate should be bolted to a rigid base such as a concrete floor or cast concrete block. An automatic system with a counter may also be used. The hammer is dropped repeatedly, and the number of blows required to cause ultimate failure are both recorded. Ultimate failure is defined as the opening of cracks in the specimen sufficiently so that the pieces of concrete are touching there, out of four, positioning legs on the base plate. A general arrangement of drop weight test is illustrated in Fig

Table 5.6 impact values

[164] Sl. No	**[165] Mix**	**[166] No. of blows for first crack (x)**	**[167] No. of blows for Ultimate failure (y)**	**[168] (Y-X)**
[169] 1	[170] M1 S0	[171] 11	[172] 20	[173] 9
[174] 2	[175] M1 S1	[176] 18	[177] 36	[178] 18
[179] 3	[180] M1 S2	[181] 26	[182] 58	[183] 32
[184] 4	[185] M1 S3	[186] 48	[187] 97	[188] 49
[189] 5	[190] M1 S4	[191] 34	[192] 68	[193] 34

5.7. RESULT

In our study we find that during increase in fibre content the different mechanical properties of concrete such as compressive strength, impact resistance, modulus of elasticity, the tensile behavior are increasing upto a particular dosage of steel fibre(polyester fibre constant is constant) after that these properties are start to reducing. The results of different tests found that the optimum dosage of steel fibre in a HFRC containing 0.2%of volume of concrete polyester fibre is 0.2%. The comparative study with ordinary concrete is found that the compressive strength of both of them are similar after 28 days but the impact strength and modulus of elasticity of the HFRC is more better than the conventional mix.

VI. CONCLUSION

6.1 GENERAL

The main objective of present investigation was to experimentally study the mechanical properties of steel and polyester hybrid fibre reinforced concrete (HFRC) .Preliminary investigations are also conducted to arrive at an optimum dosage of steel fibre. The hardened concrete properties of HFRC were studied and also done a comparative study with conventional mix.

6.2 CONCLUSIONS

From the present experimental study the following conclusions are arrived.

- Optimum dosage of steel fibre is found to be 0.2% by weight of cement.
- Introduction of hybrid fibre into the concrete reduce the workability of the mix.
- Addition of hybrid fibre is found to be increased 28 th day strength, impact strength and better modulus of elasticity of concrete.
- Addition of fibre in concrete reduce the formation of internal micro cracks.

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