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Analysis of Concrete with Different Ratio of Fiber

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ABSTRACT- There is no denying fiber reinforced concrete's (FRC) value in a variety of civil engineering applications. A wide variety of applications, including slabs on grade, architectural panels, precast goods, offshore buildings, structures in seismic zones, thin and thick repairs, crash barriers, footings, hydraulic structures, and many more, have successfully used fiber reinforced concrete to date. As a practical means of enhancing concrete's performance, Fiber Reinforced Concrete (FRC) is gaining popularity. Now, fibers are being specified for use in concrete slabs, pads, loading docks, thin unbonded overlays, tunnels, bridge decks, and pavements. These applications of fiber-reinforced concrete are getting more and more well-liked and function exceptionally well. Concrete with fibrous reinforcement, or fiber-reinforced concrete (FRC), has a higher structural integrity. Short, isolated fibers that are evenly spaced out are present.

KEYWORDS- Steel Fiber Reinforced Concrete, tensile strength, compressive strength.

I. INTRODUCTION

The term "fiber reinforced concrete" refers to concrete that, in addition to cement, water, and aggregate, also contains either discontinuous, evenly distributed, or discrete fiber. It is a composite that may be produced by using either a singular kind of fiber or a combination of other types of fibers in conjunction with the traditional concrete mixture [1]. There are many different types of fibers, including natural fibers, synthetic fibers, glass fibers, steel fibers, and natural fibers. It is possible to achieve optimization of mechanical and conductivity properties by combining different kinds, types, and sizes of fibers, such as in the case of polypropylene fiber (PP) and steel fiber (S). This is one of the attractive advantages of hybrid fiber systems, which also include the following: The term "Hybrid Fiber Reinforced Concrete" (HFRC) refers to a material that is made by combining several distinct kinds of fibers, each of which has its own unique set of material properties. These fibers continue to be bonded together when they are added to concrete, but they keep their individual identities and characteristics. In this work, the hybridization of fibers, which is another name for the process of merging fibers, is explored for an M40 grade concrete at a volume percentage of 0.5 percent. Casts of a control material and three hybrid fiber composites were created by combining steel and polypropylene fibers in varying amounts. Tests of compressive strength, split tensile strength, and flexural strength were carried out, and the results of these tests were examined to see how they were associated with the fiber combinations described above. In this study, we identify fiber combinations that demonstrate the greatest compressive, split tensile, and flexural strength of concrete based on our findings from experimental tests[2].

The materials that are used are composed of fine aggregate, coarse aggregate, and regular Portland cement of grade 53. The concrete mix that was used was of the M25 grade, and it included a variable number of fibers. The casting and testing will be done in hybrid fiber reinforced concrete specimens using a variety of mixing percentages, such as 0-2 %. Casting and testing will be done on a total of five specimens, including RCC, GFRC, SFRC, HFRC1, HFRC2, and companion specimens. In accordance with the procedure suggested by Indian standards, the specimens are put through strength tests lasting seven days, fourteen days, and twenty-eight days, and its behavior is investigated when it is subjected to compression and stress. The findings give a comparison between control concrete, glass fiber reinforced concrete, steel fibber reinforced concrete, and hybrid fiber reinforced concrete. Vikrant Research on the performance of hybrid fiber reinforced concrete in terms of its mechanical properties (HFRC). Adding a crack resistor to concrete, which would be tiny fibers tightly spaced and equally spread throughout the material, would significantly enhance the qualities of the concrete. Fiber Reinforced Concrete is the name given to this kind of concrete. The use of more than one kind of reinforcement fiber in concrete creates what is known as hybrid fiber reinforced concrete. In this investigation, we make use of both polypropylene and steel fibbers. The utilization of fibers has allowed for the reinforcement of materials that are weaker under tension than they are in compression

II. MATERIALS

Cement: -This study used 53-grade Ordinary Portland cement (Ultra tech - Brand), which is like ASTM Type I. Also, several other attributes were tested to see whether they met IS: 4031-1988, and it turned out that they did, as well as IS: 12269-1987[3]. The chemical and physical characteristics of the cement are tabulated in Table 1, and Figure 1 shows X-ray pictures of the cement taken using energy dispersive spectroscopy.

Table 1: Characteristics of the cement

S. No.	Element	Weight (%)	Atom (%)
1.	Composition: 33.43 %; 50.45 % Oxygen	Composition: 33.43 %; 50.45 % Oxygen	Composition: 33.43 %; 50.45 % Oxygen
2.	Ca 46.86 28.24	Ca 46.86 28.24	Ca 46.86 28.24
3.	6.007.0023 g/mol C	6.007.0023 g/mol C	6.007.0023 g/mol C
5.	Its chemical formula is Si 6.24 5.37 Silicon.	Its chemical formula is Si 6.24 5.37 Silicon.	Its chemical formula is Si 6.24 5.37 Silicon.

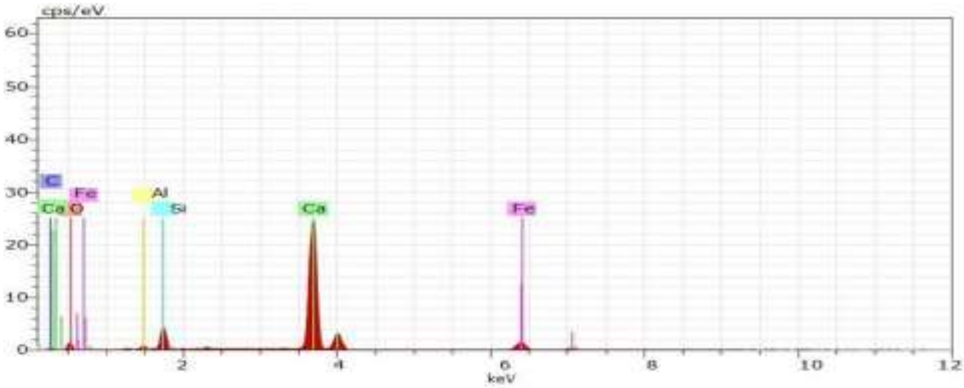

Figure 1: Energy dispersive X-ray scan images of cement

Fine Aggregate: The fine aggregate with a fineness modulus of 2.58, a specific gravity of 2.62, and a bulk density of 1.65 g/cm3 was used as the experimental raw material, and it was gathered from the Cauvery riverbed close to Tiruchirappalli. Sand that has been tested and verified to be from zone III is totally dry and stored in a chamber until it is used to cast samples. Crushed rock quality must be regarded carefully in accordance with IS-383:1970[4]. Coarse Aggregate. Crushed granite with a maximum size of 20 mm and 12 mm according to IS 383-1970 is utilized as the coarse aggregate brought together from Quarry (Srinivasa blue metals, Reddiyar chatram, Dindigul). Coarse aggregate has a specific gravity of 2.75, a bulk density of 1.54 g/cm3, and a fineness modulus of 6.74.

Water: The water used in the concrete has been tested, and it has been shown to be pure and devoid of any common contaminants. Impurities like this may be found in intrinsic water and are known to negatively impact the qualities of concrete, most notably the setting and hardening times[5]. It has also been shown that the water utilized in the concrete is of an unofficial nature. Cement relys on the presence of water in order to hydrate. It is assumed that potable water would be sufficient for IS 456-2000-compliant concreting; nevertheless, excess water is the primary source of drying shrinkage cracks.

Polypropylene Fiber: It is a synthetic carbon polymer produced as continuous monofilaments with a mutual circular cross section that may be cut to the necessary length, or as tape with a rectangular cross section. India is home to both the manufacturing facility, Radhakrishna Chemical Malady West Associate, and the acquiring company, Moon Optical, Madurai. Polypropylene fibers in figure 2 are notoriously difficult to deal with due to their low tensile strength and modulus of elasticity. Further, they may reduce the possibility of plastic settling due to water evaporation by inducing interference with the capillary forces that regulate how water flows to the top of concrete. Polypropylene may be made translucent when uncolored, and it may be less expensive than polystyrene, acrylic, and other plastics; nevertheless, it cannot be made as clear as these materials[5]. Polypropylene, however, may be dyed to the point of transparency. They use pigments or make it opaque to get this effect. Polypropylene has superior fatigue resistance compared to similar materials. Even though perfectly isotactic polypropylene has a melting point of 171 degrees Celsius, the melting point of commercially available isotactic polypropylene is only 160 degrees Celsius to 166 degrees Celsius. Properties of polypropylene fiber in table 2.

Figure 2: Polypropylene fiber

Table 2: Properties of polypropylene fiber

Properties	Poly-Propylene Fiber
Length (mm)	12
Density (kg/m^3)	176
Aspect ratio	317
Modulus of elasticity (GPa)	3.5
Tensile strength (MPa)	400
Elongation at break (%)	> 100

Steel Fiber: Types of steel fibers include those that are straight, unhooked, paddled, deformed, crimped, and uneven. The different crimped types of steel fiber utilized in this industry are shown in Figure 3 and properties in table. Most steel fibers will be made from carbon steel or stainless steel. Length may be anything from 6.4 mm to 76 mm and width from 1 mm to 76 mm.distance between 0.25 and 0.75 mm. The steel fibers are defined by a helpful characteristic called the aspect ratio. An object's aspect ratio is defined by the ratio of its length to its diameter. It might be anything from twenty to one hundred. The yield strength of steel fibers must be at least 50,000 psi to satisfy the specifications set out by ASTM A 820. (345 Mpa)[6]. When employed in varied proportions to the entire volume of concrete, the crimped form of steel fiber used for this project has a length of 30 millimeters and a thickness of less than half a millimeter. Viewable features of crimped steel fiber are shown in table 3

Figure 3. Steel fiber

Table 3: Properties of crimped steel fiber

S.NO	Property	Values
1	Young's Modulus. GPa	200
2	Thermal Conductivity, 1%	1% 2.74
3	Tensile Strength, MPa	345 to 3000
4	Aspect Ratio	50 to 100
5	Ultimate Elongation, %	3 to 10
6	Equivalent Diameter, mm	0.15 to 1.00
7	Specific Gravity, kg/m^3	7840

III. TESTING METHODS

- Compaction factor test.
- Slump test.
- Split Tensile Test.
- Flexural Test.
- Deflection Test.

- **Compaction factor test:** This test was initially developed for use in the laboratory, but it also has the capability of being used outside of the lab. It is more accurate, and it is especially helpful for concrete mixes that have extremely poor workability. These are the kind of mixes that are often used when concrete is going to be compacted by vibration. This approach is applicable to plain and air-entrained concrete that is prepared using lightweight, normal weight, or heavy aggregates that have a nominal maximum size of forty millimetres or less. Aerated concrete and no-fines concrete, on the other hand, are not suitable for this method. The device for compacting factors consists of a trowel and a scoop of about 150 millimetres in length. A balance with a capacity of up to 25 kilograms and a sensitivity of 10 grams is described. Tools and containers for mixing, such as a concrete mixer, weights and a weighing device, a tamper with a diameter of 16 millimetres and a length of 600 millimetres, a ruler, etc[7].
- **Slump test:** Slump cones are formed using a mold made of galvanized metal that is 1.6 millimeters thick and takes the shape of the lateral surface of the frustum of a cone with a base that is 200 millimeters in diameter, a top that is 100 millimeters in diameter, and a height that is 300 millimeters [8]. Both the bottom and the top of the mold are open, and they are parallel to one other.
- **Split Tensile Test:** In the laboratory, cylinders with a diameter of 15 centimeters and a height of 30 centimeters are cast. The test is performed by positioning a cylindrical specimen horizontally between the loading surface of a compression testing machine. The load is then applied along the vertical diameter of the cylinder until it fails. During the time that the load is being applied along the generatrix, an element that is located on the vertical diameter of the cylinder is being stressed horizontally. Tensile strength for cylinder =2P/nld. where, P is the compressive load on the cylinder l is the length of the cylinder; d is diameter of the cylinder.
- **Flexural Test**: The capacity of a material to withstand load-induced deformation is referred to as its flexural strength. This property, which is a mechanical characteristic for brittle materials and is also known as modulus of rupture, bending strength, or fracture strength, is another name for flexural strength. depicts a flexure testing equipment that is used to examine the performance of beams measuring 150 by 150 by 1200 millimeters[9]. The specimen is only held in place by the machine's two rollers, which are at a distance of 600 mm apart, and there is a bearing located 50 mm from each support. The load is going to be applied to the beam by two rollers that are going to be positioned above the beam with a distance of 200 millimeters between them. The load is delivered at a consistent pace in such a way that the extreme fibers' stress rises at a rate of 0.7N/mm2/min, which means that the rate of loading must be 4 kN/min. The weight is gradually raised until the specimen cracks under the pressure. The highest possible value of the load that is being applied is tallied. It is important to make a note of the look of the fracture faces of the concrete as well as any other distinctive characteristics.
  Flexural strength for Prism= (FL/bd2)
- **Water Absorption Test:** The results of water absorption for the CC, SC4, PPC4 and HYC5 mixes are presented in the Table 8. The CC mixes with higher paste contents are bound to have higher absorption [10]. The water absorption is majorly influenced by the paste phase. This can be found that the Plain CC showed higher absorption than HYC5. It is due to the addition of hybrid fibers. And, it is noted that all CC mixes have more than 5% water absorption.

IV. RESULTS

A. *Compaction Factor Test Result*

The compaction factor test values of different mix proposition of fibbers are given in table 4. Control specimens were marked as CC. Steel fiber specimens were marked as S; Polypropylene specimens were marked as P; and mix of steel with polypropylene, named as hybrid, were marked as H.

Table 4: compaction factor test values of different mix proposition of fibres

S. No	Notation	Steel fiber by volume of concrete (%)	Polypropylene fiber by volume of concrete (%)	Slump value
1	CC	0.25	0	1.933333
2	S1	0.5	0	1.633333
3	S2	0.75	0	1.333333
4	S3	0.583333	0.083333	1.333333
5	S4	0.333333	0.25	1.466667
6	P1	0	0.5	1.533333
7	P2	0	0.75	1.3
8	P3	0.083333	0.666667	1.35
9	P4	0.166667	0.583333	1.4
10	H1	0.333333	0.333333	1.516667
11	H2	0.416667	0.416667	1.266667
12	H3	0.583333	0.333333	1.216667
13	H4	0.5	0.5	1.1
14	H5	0.5	0.5	1.15
15	H6	0.25	0.75	1.1

B. Slump Test Results

The slump test values of different mix proposition of fibers are given in table 5. Control specimens were marked as CC. Steel fiber specimens were marked as S; Polypropylene specimens were marked as P; and mix of steel with polypropylene, named as hybrid, were marked as H [11].

C. Compression Test Results

There were three different curing times tracked: 7 days, 14 days, and 28 days. CC indicated a control sample[12]. Specimens made of steel fiber were labeled as SC, those made of polypropylene as PPC, and those made of a hybrid material composed of steel and polypropylene as HYC. During the compression test, the results at 7, 14, and 28 are provided in Table 5. compressive strength test in figure 4.

Table5: Lump test values at 7, 14 and 28 days

S. No	Notation	Steel fiber by volume of concrete (%)	Polypropylene fiber by volume of concrete (%)	Compaction factor
1	CC	0.375	0	0.89
2	S1	0.5	0	0.873333
3	S2	0.75	0	0.85
4	S3	0.583333	0.083333	0.853333
5	S4	0.333333	0.25	0.86
6	P1	0	0.5	0.87
7	P2	0	0.75	0.853333
8	P3	0.083333	0.666667	0.853333
9	P4	0.166667	0.583333	0.856667
10	H1	0.333333	0.333333	0.86
11	H2	0.416667	0.416667	0.84
12	H3	0.583333	0.333333	0.82
13	H4	0.5	0.5	0.803333
14	H5	0.5	0.5	0.8
15	H6	0.25	0.75	0.8

Table 6: Compression test values at 7, 14 and 28 days

S.No	Notation	Percentage of Fibers		7 Days Strength		14 Days Strength		28 Days Strength	
		Steel	PP	Load in kN	Comp.St	Load in kN	Comp. St	Load in kN	Comp.St
1.	CC	0	0	365.06	16.22	485.53	21.57	730.04	32.44
2.	SC1	0.25	0	370.10	16.44	492.23	21.87	740.20	32.88
3.	SC2	0.5	0	379.73	16.89	505.04	22.46	759.46	33.78
4.	SC3	0.75	0	390.64	17.36	519.55	23.08	781.28	34.72
5.	SC4	1	0	398.62	17.71	530.16	23.55	797.24	35.42
[illegible]	PPC1	0	0.25	368.10	16.36	489.57	21.76	736.20	32.72
[illegible]	PPC2	0	0.5	377.73	16.78	502.38	22.32	755.46	33.56
8.	PPC3	0	0.75	390.00	17.33	518.70	23.05	780.00	34.66
9.	PPC4	0	1	397.89	17.69	529.19	17.69	795.78	35.38
10.	HYC1	0.25	0.25	510.82	21.62	529.19	28.75	1021.64	41.72
11.	HYC2	0.25	0.5	501.22	19.66	666.63	26.15	1002.44	39.32
12.	HYC3	0.5	0.25	524.00	24.58	697.05	32.69	1048.00	43.32
13.	HYC4	0.5	0.5	513.45	22.82	682.88	30.35	1026.90	42.23
14.	HYC5	0.75	0.25	526.60	26.56	700.37	35.32	1053.30	45.64
15.	HYC6	0.25	0.75	509.22	20.86	677.26	27.74	1018.44	40.62

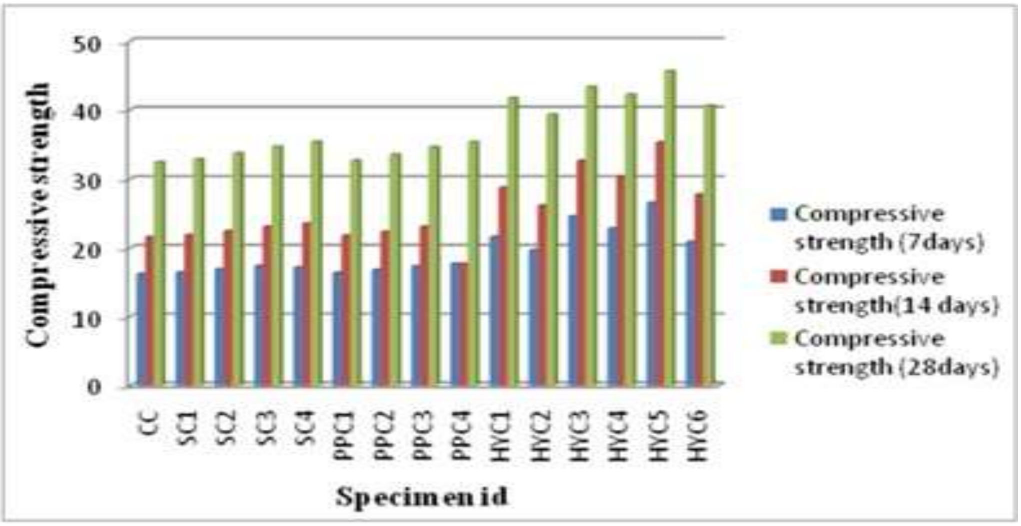

Figure 4: Compressive strength of controlled and fiber added concrete cubes

D. Split Tensile Test Results

Split tensile strength results obtained for different specimens cast are discussed as below. Curing periods of 7 days, 14 days and 28 days were observed. Control specimens were marked as CCL. Steel fiber specimens were marked as SCL[13]; polypropylene specimens were marked as PPCL; and mix of steel with polypropylene, named as hybrid, were marked as HYCL. The split tensile test values at 7, 14, 28 are given in Table 7. split tensile test with graph in figure 5.

Table 8: Split tensile test values at 7, 14 and 28 days

S.No.	Notation	Percentage of Fibers		7 Days Strength		14 Days Strength		28 Days Strength	
		Steel	PP	Load in kN	Split. St	Load in kN	Split. St	Load in kN	Split. St
1.	CCL	0	0	252.22	3.57	289.62	4.10	324.99	4.60
2.	SCL1	0.25	0	257.87	3.65	298.85	4.23	334.17	4.73
3.	SCL2	0.5	0	262.82	3.72	305.21	4.32	340.53	4.82
4.	SCL3	0.75	0	272.00	3.85	315.09	4.46	350.42	4.96
5.	SCL4	1	0	274.83	3.89	319.34	4.52	360.31	5.10
6.	PPCL	0	0.25	254.34	3.60	293.20	4.15	328.52	4.65
7.	PPCL2	0	0.5	259.99	3.68	296.73	4.20	332.06	4.70
8.	PPCL3	0	0.75	262.82	3.72	307.33	4.35	342.65	4.85
9.	PPCL4	0	1	272.00	3.85	12.98	4.43	347.59	4.93
10.	HYCL1	0.25	0.25	302.38	4.28	337.71	4.78	373.03	5.28
11.	HYCL2	0.25	0.5	289.66	4.10	325.70	4.61	361.02	5.11
12.	HYCL3	0.5	0.25	303.80	4.30	339.12	4.80	375.15	5.31
13.	HYCL4	0.5	0.5	317.92	4.50	358.90	5.08	394.23	5.58
14.	HYCL5	0.75	0.25	353.25	5.29	409.06	5.79	445.80	6.31
15.	HYCL6	0.25	0.75	275.53	3.90	312.27	4.42	347.59	4.92

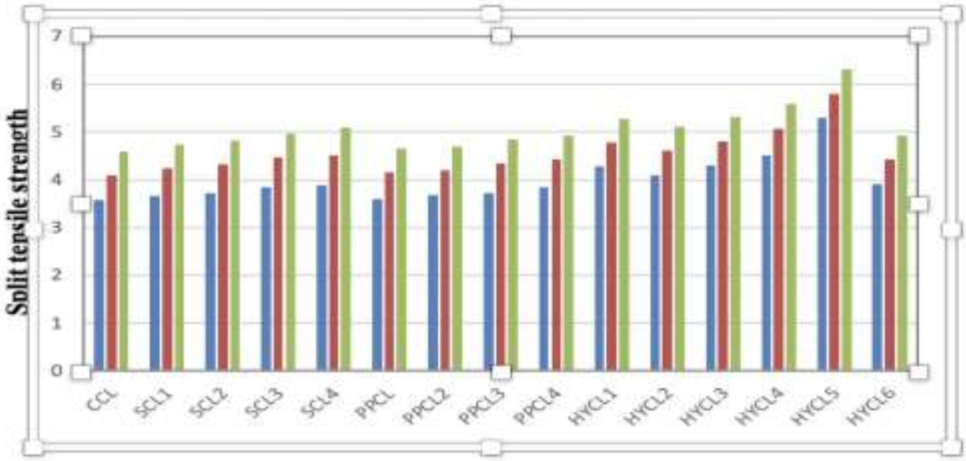

Figure 5: Split tensile strength of controlled and fiber added concrete cylinders

E. Flexural Test Results

From these observations, the deflection and maximum crack were realized in the way of the investigation. The first crack emerged in the control beams of CB at 12 kN flexural cracks had appeared along the beam[14]. It was crystal approach that the beam breakdown in flexure had minimal energy assimilation well before the breakdown.

The average ultimate load of control beams is 30 kN. Similarly initial crack for steel fiber reinforced concrete beam, polypropylene fiber RC beam and Hybrid of fiber RC beam is 23, 20, 18, 21, 10.5, 13.5, 12, 16, 18, 10, 17, 18, 21, and 17 respectively and ultimate for those beams were 46, 48, 49, 45, 38, 43, 40,45, 47, 45.5, 46, 51, 52, and 43 respectively. It's represented in the Table 8.and graph in figure 6.

Table 9: Flexural test values at 28 days

S.No.	Initial Crack Load in kN	Initial Deflection in mm	Ultimate Crack Load in kN	Ultimate Deflection in mm
CB	12	1.25	30	2.1
SB1	23	1.05	46	3.5
SB2	20	1.15	48	3.2
SB3	18	1.25	49	3.4
SB4	21	1.20	45	2.1
PPB1	10.5	1.40	38	3.5
PPB2	13.5	1.15	43	2.30
PPB3	12	1.20	40	2.60
PPB4	16	1.05	45	2.80
HYB1	18	1.00	47	2.5
HYB2	10	0.8	45.5	2.4
HYB3	17	1.00	46	2.8
HYB4	18	1.15	51	3
HYB5	21	0.80	52	2.1
HYB6	17	0.95	43	3.5

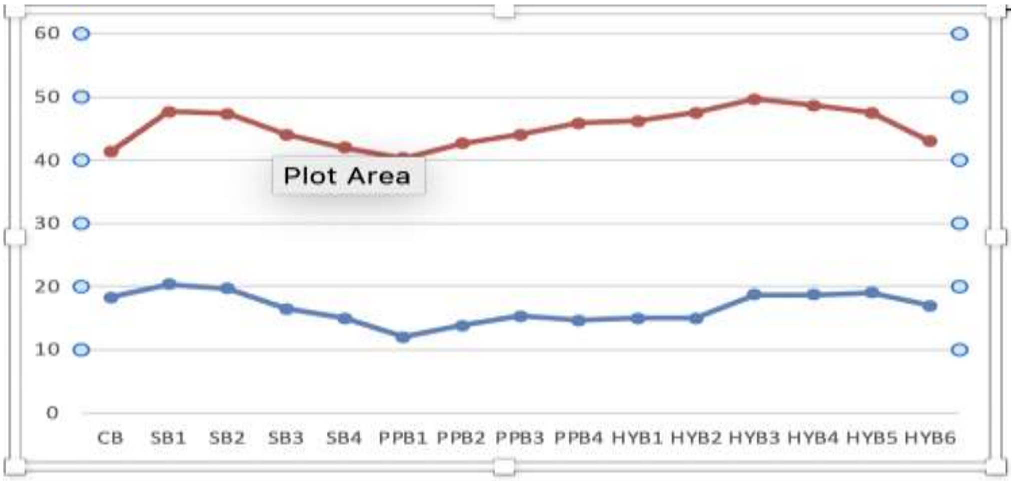

Figure 6: Load vs. deflection in controlled and fiber added concrete beam

F. Deflection Test Result

The result of deflection in Table 9**.**

Table 9: Test result of deflection

	CC EXP.	SCS EXP.	PPCS EXP.	HYCS EXP.
Load at first crack (kN)	12	21	16	21
Load at failure (kN)	30	45	45	52
Deflection atfirst crack (mm)	1.25	1.2	1.05	0.8
Ultimate Deflection (mm)	2.1	2.1	2.8	2.1

V. CONCLUSION

In this chapter presents the conclusion is based on the experiments carried out intensively. Besides, the study is intended to the scope for future research. The effect of including fiber, hybrid fiber in CC for strength and durability characteristics explores the unfavorable environment[15]. As a result, it is concluded that the usage of HY5 (S 0.75% + PP 0.25%) hybrid fibrous CC mix at optimum dosage level in CC improved the performance ratio in terms of strength of concrete. Besides, It is also concluded that the make use of HY5 in structural members reveals more ductile and energy absorption that are required for beam elements in earth quake resistance and in the high praise of multi storied structures. The above effects state that the possibilities to decrease the obstruction of steel reinforcement in beams become easier in using this high ductile hybrid material and to reduce the difficulties in construction. So, it is obvious that the cost of the hybrid CC is not that much higher, and it could be sufficient for the usage of construction of all kind of structures[16].

In this investigation, mineral admixture is utilized for making CC. Thus, the investigation can be done on other types of mineral admixtures like silica fume, ground granulated blast furnace slag, metakaolin etc., x Investigation may be taken out to study the effect of fiber orientation on the behavior of hybrid CC. x The different combination of hybrid fibers like carbon, basalt, etc., can be used instead of polypropylene [17]. x Also, an exploration on air permeability, fire, and freeze-thaw resistance, etc., may be conducted in another scenario to study the effect of durability properties. x Investigation may be undertaken to study the effect of hybrid CC on pre-stressed concrete elements. x Analysis may be undertaken to study the effect of hybrid CC on the behavior of beams with openings and different shear span – depth ratio.

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