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Experimental Investigation on Behaviour of Hybrid Fiber Reinforced Concrete Beams

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ABSTRACTThe normal conventional concrete has less compressive and tensile strength so to enhance the performance of the concrete some kinds of fibers are added to the concrete gain required strength. This research work presents the effect of fibers on high strength rein forced concrete beams with and without fibers. The study parameters for the investigation included ultimate load, ultimate deflection and flexural strength. The fibers used in the investigation are steel fibers and polyolefin fibers. Fibers are added to the concrete not only to increase tensile strength but also to control the crack and to change the behavior of cracked material by bridging across the cracks.The hybrid fibers of various combinations in polypropylene fiber is 0.1%, 0.25%, 0.5% and steel fiber 0.5%, 0.75%, 1.0%are decided to use in concrete mix. The workability of hybrid fiber reinforced concrete mix will be increased by addition of super plasticizer.

KeyWords: Polypropylene fiber, Steel fiber and Super plasticizer.

I. INTRODUTION

The normal conventional concrete has less compressive and tensile strength so to enhance the performance of the concrete some kinds of fibers are added to the concrete gain required strength. This research work presents the effect of fibers on high strength rein forced concrete beams with and without fibers. The study parameters for the investigation included ultimate load, ultimate deflection and flexural strength. The fibers used in the investigation are steel fibers and polyolefin fibers. Fibers are added to the concrete not only to increase tensile strength but also to control the crack and to change the behavior of cracked material by bridging across the cracks.The hybrid fibers of various combinations in polypropylene fiber is 0.1%, 0.25%, 0.5% and steel fiber 0.5%, 0.75%, 1.0%are decided to use in concrete mix. The workability of hybrid fiber reinforced concrete mix will be increased by addition of super plasticizer.

1.1 CONCRETEMATERIALS

Theconcretemixtureconsistsofthefollowingingredients,

1. Cement
2. Coarseaggregate
3. Fineaggregate
4. fiber
5. Super plasticizer
6. water
7. steel

OBJECTIVEOFPROJECT

The main objective of this research include

1. Developing Hybrid fiber reinforced concrete mixes which is suitable for structural applications.
2. Testing the mixes of Hybrid fiber reinforced concrete for compressive strength, split tensile strength, flexural strength and Deflection of Beam.
3. Comparing the results and finding the optimum percentage of hybrid fibers.
4. The objective of the present investigations is investigating the workability, mechanical and flexural characteristics of concrete for various proportions of two different fibers and comparing the results with conventional concrete. The investigation is aimed in finding out the Compressive strength of cube, Split tensile strength of cylinder, Flexural strength of prism, and Load Vs Deflection of Beam.

II. LITERATURESURVEY

Abhishek Kumar Singh, Anshul Jain [2] et.al. Discuss the objective of this research is to investigate and compare the compressive and flexural strength of concrete for various mixture proportion of concrete. Fiber reinforced concrete is a most widely used solution for improving tensile and flexural strength of concrete. Various types of fibers such as steel, polypropylene, glass and polyester are generally used in concrete. In this research, the effect of inclusion of polypropylene and steel fibers on the compressive and flexure properties of fiber reinforced concrete was studied. Polypropylene and Steel fibers with different levels of reinforcement index were investigated with pre-designed concrete mixtures consisting of various polypropylene fibers dosages of 0% to 0.45 % and steel fibers of 0% to 2% by volume of concrete. The performance characteristics of polypropylene and steel fibers were dependent on the optimum fiber dosage up to 0.45% and 2% since fiber addition resulted in loss of workability. Compressive strength of material increases with increasing fiber content. Strength enhancement ranges from 8% to 16% for PFRC.

Ahsan Habib, Razia Begum [15] et.al., saysan investigation has been carried out into synthetic fibers (glass, nylon, and polypropylene fibers) effects on the mechanical properties of mortars (cement: sand composition (1:1.5). Addition of fibers in to the mortars increases the compressive strength of mortar composites except glass fiber. On the other hand, tensile and flexural strength have little influence with the addition of fibers. Increasing the size of the fibers also increases the strength of the mortars but a little extent. Among the fibers, nylon containing mortar composite shows promising mechanical strength that could be easily used as low cost partitioning wall, false ceiling, and other household purpose in the developing countries. We have presented a plausible explanation in accordance with fiber reinforced composite polymer. Other physical properties of the fibers containing mortars were also studied and discussed.

Amir M. Alani, Derrick Beckett [8] et.al.,discussthe existing design code for Concrete Industrial Ground Floors, TR34, by the Concrete Society states that ‘‘Macro synthetic fibers provide some post-cracking or residual moment capacity but with significantly lower performance than steel fibers. They are not known to be used in industrial floor construction’’. This paper presents results of an on-going investigation undertaken by the authors concerning the mechanical and physical properties of fiber reinforced concrete ground slabs at an industrial scale. This paper focuses and presents results concerning the punching shear failure of a 6.00 m, 6.00 m, 0.15 m synthetic fiber reinforced ground supportedslab. The paper demonstrates clearly the methodology adopted and the infrastructure used throughout this investigation. The presented results show clearly that the punching shear failure values obtained in this investigation are comparable to values reported for the steel fiber slabs under similar conditions. This work could potentially question the validity of the above statement in TR34. The significance of this research also is in the size of the slab investigated, as there is very limited work, if any, reported within the literature.

Joaquim A.O. Barros, Lúcio A.P [11] et.al., says discrete steel fibers can increase significantly the bending and the shear resistance of concrete structural elements when Steel Fiber Reinforced Concrete (SFRC) is designed in such a way that fiber reinforcing mechanisms are optimized. To assess the fiber reinforcement effectiveness in shallow structural elements failing in bending and in shear, experimental and numerical research were performed. Uniaxial compression and bending tests were executed to derive the constitutive laws of the developed SFRC. Using a cross-section layered model and the material constitutive laws, the deformational behaviour of structural elements failing in bending was predicted from the moment-curvature relationship of the representative cross sections. To evaluate the influence of the percentage of fibers on the shear resistance of shallow structures, three point bending tests with shallow beams were performed. The applicability of the formulation proposed by RILEM TC 162-TDF for the prediction of the shear resistance of SFRC elements was evaluated. Inverse analysis was adopted to determine indirectly the values of the fracture mode I parameters of the developed SFRC. With these values, and using a softening diagram for modelling the crack shear softening behaviour, the response of the SFRC beams failing in shear was predicted.

Milind V.Mohod [4] et.al., says cement concrete is the most extensively used construction material in the world. The reason for its extensive use is that it provides good workability and can be moulded to any shape. Ordinary cement concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Internal micro cracks, leading to brittle failure of concrete. In this modern age, civil engineering constructions have their own structural and durability requirements, every structure has its own intended purpose and hence to meet this purpose, modification in traditional cement concrete has become mandatory. It has

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been found that different type of fibers added in specific percentage to concrete improves the mechanical properties, durability and serviceability of the structure. It is now established that one of the important properties of Steel Fiber Reinforced Concrete (SFRC) is its superior resistance to cracking and crack propagation. In this paper effect of fibers on the strength of concrete for M 30 grade have been studied by varying the percentage of fibers in concrete. Fiber content was varied by 0.25%, 0.50%, 0.75%, 1%, 1.5% and 2% by volume of cement.

CEMENT

Portland pozzolanic cement (PPC) of Fly ash based is used for casting concrete and the specific gravity of cement was found to be 3.05.

PROPERTIES OF CEMENT

S. No	PROPERTIES	VALUES
1	Fineness	10%
2	Initial setting time	30min
3	Final setting time	2-3hours
4	Standard consistency	33%
5	Specific gravity	3.05

FINE AGGREGATE
The fine aggregate (sand) used was clean dry river sand conforming to IS 383:1970. The sand was sieved to remove all pebbles. The specific gravity was found to be 2.61.

PROPERTIES OF FINE AGGREGATE

S. No	PROPERTIES	VALUES
1	Specific gravity	2.61
2	Bulk density	1653.06 Kg/m^3
3	Surface moisture	0.11%
4	Water absorption	1%
5	Soundness	0.90%
6	Fineness modulus	2.64

COARSE AGGREGATE
Hard granite broken stones of 20 mm size were used as coarse aggregate conforming to IS 383: 1970. The specific gravity is 2.64

PROPERTIES OF COARSE AGGREGATE

S. No	PROPERTIES	VALUES
1	Specific gravity	2.64
2	Bulk density	1350 Kg/m^3
3	Surface moisture	0.086%

4	Water absorption	0.5%
5	Soundness	0.55%
6	Fineness modulus	4.17

FIBER

STEEL FIBER

Steel fibers are filaments of wire, deformed and cut to lengths, for reinforcement of concrete, mortar and other composite materials. It is a cold drawn wire fiber with corrugated and flatted shape.

SYNTHETIC FIBER

Synthetic fibers have attracted more attention for reinforcing cementitious materials in the recent years. In this part emphasis is given on Polypropylene fibers as they were used throughout the experimental program.

PROPERTIES OF FIBRE

S. No	**PROPERTIES**	**STEEL FIBER**	**POLYPROPYLENE FIBER**
1	Length (mm)	30	15
2	Diameter (mm)	0.5	0.1
3	Shape	Crimped	Straight round
4	Aspect ratio	60	150
5	Density (g/cm3)	7.8	0.9
6	Elongation at break	3.2	8.1
7	Tensile strength (MPa)	1500	800

SUPER PLASTICIZER

Super Plasticizers, also known as high range water reducers, are chemicals used as admixtures where well-dispersed particle suspensions are required. These polymers areused as dispersants to avoid particle aggregation, and to improve the flowcharacteristics (rheology) of suspensions such as in concrete applications.

Polycarboxylate ether super plasticizer (PCE) work differently from sulfonate based super plasticizers, giving cement dispersion by steric stabilisation, instead of electrostatic repulsion. This form of dispersion is more powerful in its effect and gives improved workability retention to the cementitious mix.

WATER

Potable tap water available in laboratory with pH value of 7.0 ± 1 and confirming to the requirement of IS 456 - 2000 was used for mixing concrete and curing the specimen as well.

STEEL

The High yield strength deformed steel bars of 10 mm diameter are used for main reinforcement and 8 mm diameter bars are used for shear reinforcement.

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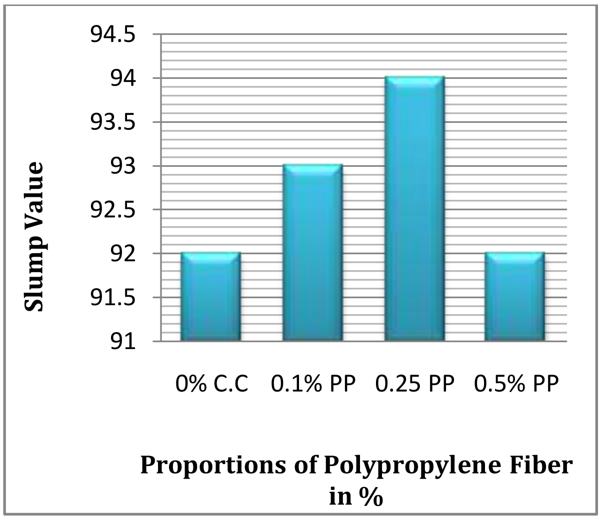
SLUMP VALUE OF FRESH CONCRETE

S. No	Proportion		Slump Value (mm)	
	PP Fiber	Steel Fiber	PP Fiber	Steel Fiber
1	0	0	92	92
2	0.1	0.5	93	90
3	0.25	0.75	94	89
4	0.5	1.00	92	85

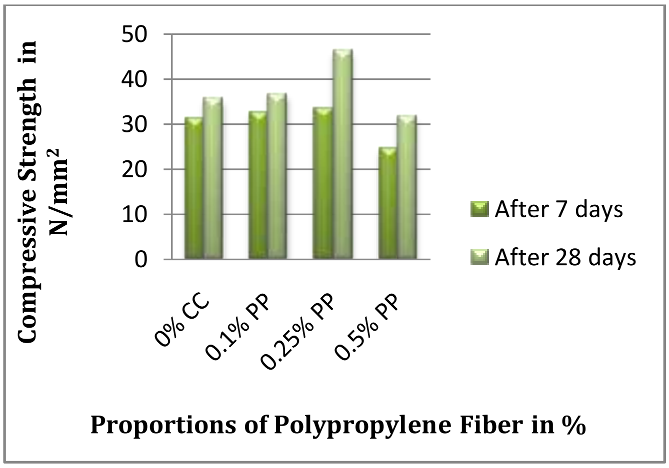
SLUMP VALUE OF FRESH CONCRETE FOR POLYPROPYLENE FIBRE

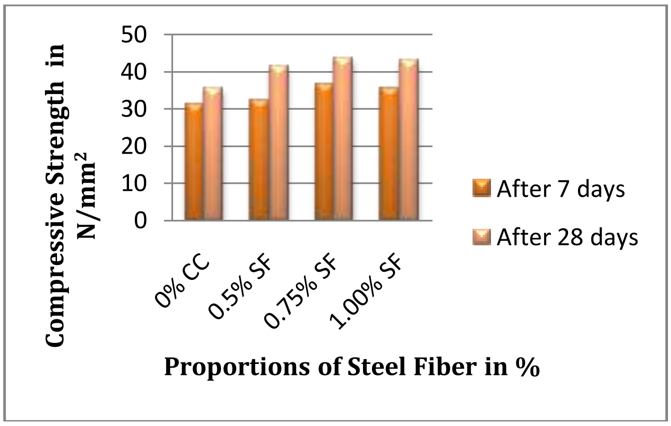


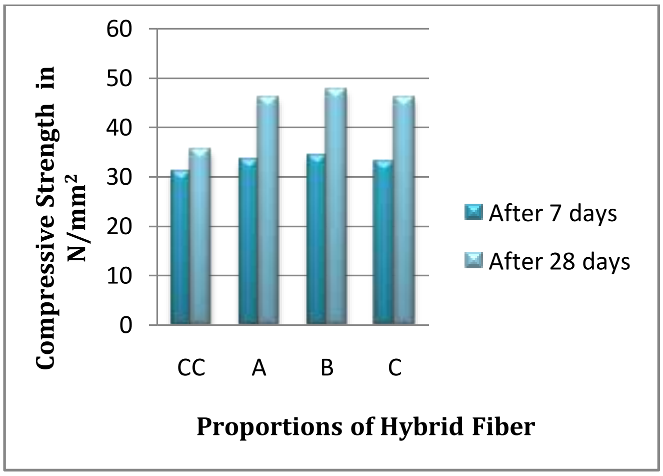
COMPRESSIVE STRENGTH
COMPRESSIVE STRENGTH OF HYBRID FIBER

S. No	Proportions		Compressive Strength in N/mm^2			
	PP Fiber	Steel Fiber	After 7 days	After 7 days	After 28 days	After 28 days
1	0	0	31.11		35.42	
2	0.1	-	32.44	-	36.53	-
3	0.25	-	33.33	-	46.13	-
4	0.5	-	24.44	-	31.55	-
5	-	0.5		32.08		41.24
6	-	0.75		36.53		43.55

7	-	1.0		35.24		42.75

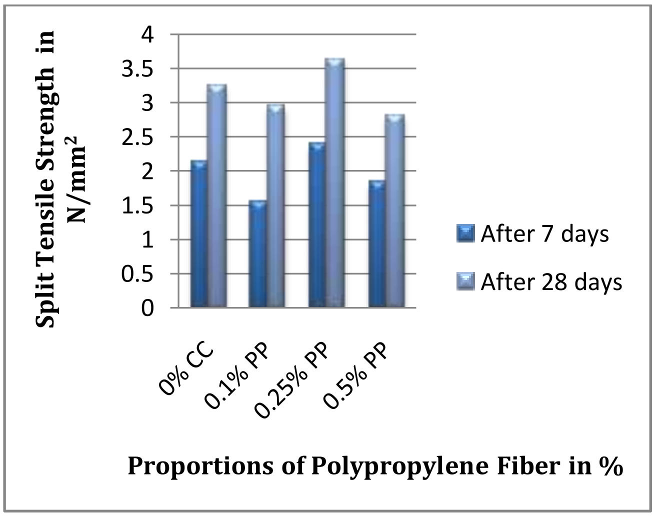






S. No	**Proportions**				**Compressive Strength in N/mm^2**	
	Designation	PP Fiber	Steel Fiber	Volume fraction Vf (%)	After 7 days	After 28 days
1	CC	0	0	0	31.11	35.42
2	A	0.2	0.8	1.0	33.23	45.98
3	B	0.25	0.75	1.0	34.44	47.77
4	C	0.3	0.7	1.0	32.92	46.13

SPLIT TENSILE STRENGTH



S. NO	**Proportions**		**Split Tensile Strength in N/mm^2**			
	PP Fiber	Steel Fiber	After 7 days	After 7 days	After 28 days	After 28 days
1	0	0	2.12		3.25	
2	0.1	-	1.55	-	2.94	-
3	0.25	-	2.4	-	3.64	-
4	0.5	-	1.83	-	2.82	-
5	-	0.5	-	2.97	-	3.46
6	-	0.75	-	3.12	-	3.8
7	-	1.0	-	3.06	-	3.75

Split Tensile Strength of Polypropylene Fiber after 7th and 28th days

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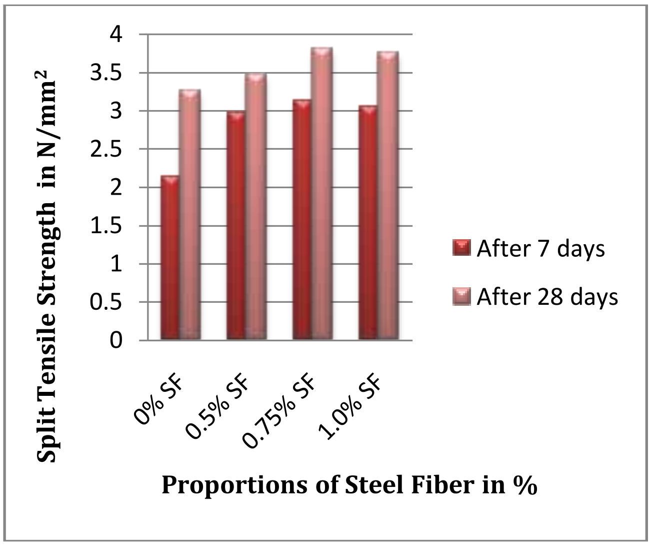

S. No	Proportions			Flexural strength in N/mm^2	
	PP Fiber	Steel Fiber	Volume fraction Vf (%)	After 7 days	After 28 days
1	0	0	0	6.38	9.14
2	0.2	0.8	1.0	6.12	9.32
3	0.25	0.75	1.0	6.78	9.81
4	0.3	0.7	1.0	6.5	9.5

SPLIT TENSILE STRENGTH FOR HYBRID FIBER

S. No	Proportions				Split Tensile Strength in N/mm^2	
	Designation	PP Fiber	Steel Fiber	Volume fraction Vf (%)	After 7 days	After 28 days
1	CC	0	0	0	2.12	3.25
2	A	0.2	0.8	1.0	2.67	3.41
3	B	0.25	0.75	1.0	2.98	3.7
4	C	0.3	0.7	1.0	2.79	3.56

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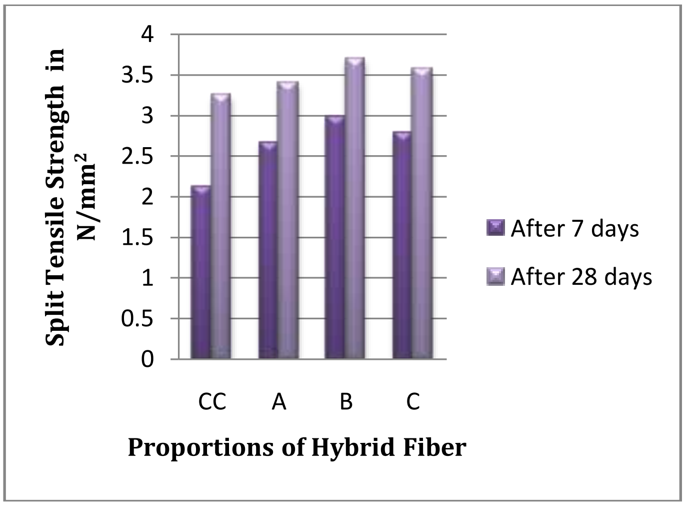
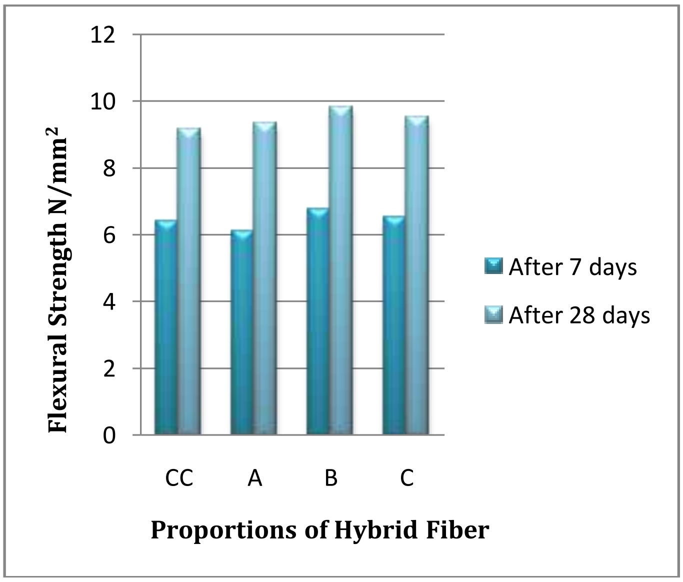


FLEXURAL STRENGTH FOR HYBRID FIBER



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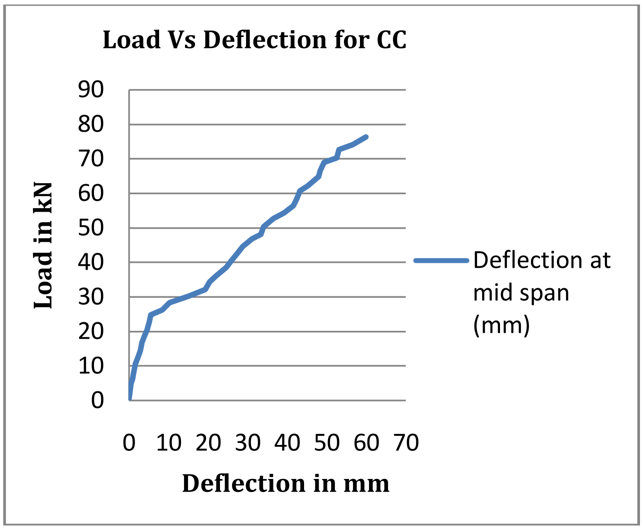
BEAM DEFLECTION FOR CONVENTIONAL CONCRETE

Test results of Load Vs Deflection for Conventional Concrete Beam

S. No	Load (KN)	Deflection at mid span (mm)	Deflection at L/3 of span (mm)	Stiffness (N/mm)	Remarks
1	0	0	0	0	
2	2.2	0.282	0.261	7.80	
3	4.8	0.624	0.532	7.69	
4	6.3	0.951	0.786	6.62	
5	8.1	1.264	1.096	6.40	
6	10.5	1.728	1.456	6.07	
7	12.1	2.180	1.854	5.55	
8	14.4	2.981	2.548	4.83	
9	16.7	3.391	2.936	4.92	
10	18.9	4.080	3.451	4.63	
11	20.2	4.580	3.982	4.41	
12	22.5	5.091	4.432	4.41	
13	24.7	5.570	4.954	4.43	
14	26.1	8.482	7.402	3.07	
15	28.3	10.254	8.946	2.75	
16	30.2	15.156	13.358	1.99	
17	32.1	19.360	16.875	1.65	
18	34.3	20.391	18.936	1.68	
19	36.1	22.080	20.451	1.63	
20	38.5	24.580	22.982	1.56	
21	40.6	25.951	23.786	1.56	
22	42.3	27.264	25.096	1.55	First crack
23	44.5	28.728	26.456	1.54	
24	46.7	31.156	29.358	1.49	
25	48.1	33.360	31.875	1.44	
26	50.3	34.091	32.432	1.47	
27	52.7	36.570	34.954	1.44	
28	54.2	39.282	37.261	1.37	
29	56.4	41.624	39.532	1.35	
30	58.3	42.482	41.402	1.37	
31	60.7	43.254	42.946	1.40	
32	62.1	45.180	44.854	1.37	
33	64.8	47.981	46.548	1.35	

34	66.5	48.360	47.875	1.37	
35	68.9	49.391	48.936	1.39	
36	70.3	52.580	50.982	1.33	
37	72.6	53.091	51.432	1.36	
38	74.1	56.624	54.532	1.30	
39	76.3	59.951	56.786	1.27	Ultimate load

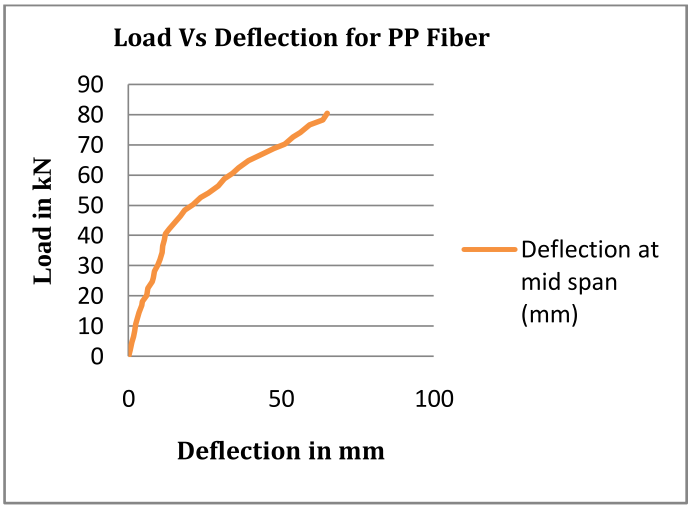


BEAM DEFLECTION FOR POLYPROPYLENE FIBER REINFORCED CONCRETE

Load Vs Deflection for Polypropylene Fiber ReinforcedConcrete Beam

S. No	Load (KN)	Deflection at mid span (mm)	Deflection at L/3 of span (mm)	Stiffness (N/mm)	Remarks
1	0	0	0	0	
2	2.2	0.580	0.412	3.79	
3	4.8	1.091	0.937	4.39	
4	6.6	1.624	1.268	4.06	
5	8.3	1.951	1.569	4.25	
6	10.7	2.282	1.965	4.68	
7	12.1	2.624	2.458	4.61	
8	14.5	3.482	2.848	4.16	
9	16.9	4.254	3.639	3.97	
10	18.3	4.580	4.154	3.99	
11	20.2	5.951	4.989	3.39	
12	22.5	6.264	5.234	3.59	
13	24.7	7.728	5.954	3.19	
14	26.1	8.091	6.402	3.22	
15	28.2	8.570	6.946	3.29	
16	30.2	9.482	8.853	3.18	
17	32.1	10.254	9.875	3.13	
18	34.5	10.951	10.026	3.15	
19	36.6	11.264	10.531	3.24	
20	38.7	11.728	11.122	3.29	
21	40.6	12.180	11.786	3.33	
22	42.3	13.282	12.096	3.18	
23	44.9	15.624	13.056	2.87	

24	46.5	16.981	14.358	2.73	
25	48.4	18.391	16.075	2.63	First crack
26	50.3	21.080	17.432	2.38	
27	52.7	23.580	21.456	2.23	
28	54.1	26.156	23.261	2.06	
29	56.4	29.360	25.235	1.92	
30	58.8	31.391	28.402	1.87	
31	60.7	34.080	31.659	1.78	
32	62.4	36.156	35.854	1.72	
33	64.8	39.360	37.265	1.64	
34	66.6	43.091	40.656	1.54	
35	68.9	47.570	42.352	1.44	
36	70.3	51.180	46.265	1.37	
37	72.6	53.981	49.326	1.34	
38	74.2	56.360	51.987	1.31	
39	76.7	59.391	53.654	1.29	
40	78.3	63.654	56.234	1.23	
41	80.5	65.145	60.945	1.23	Ultimate load

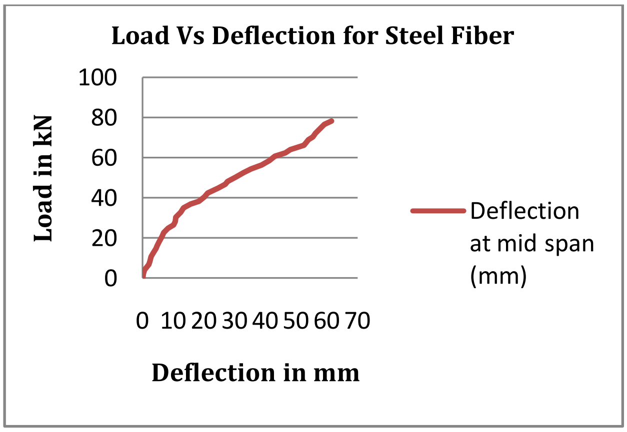


BEAM DEFLECTION FOR STEEL FIBER REINFORCED CONCRETE

Load Vs Deflection for Steel Fiber Reinforced Concrete Beam

S. No	Load (KN)	Deflection at mid span (mm)	Deflection at L/3 of span (mm)	Stiffness (N/mm)	Remarks
1	0	0	0	0	
2	2.3	0.261	0.154	8.81	
3	4.1	0.615	0.348	6.66	
4	6.9	1.928	0.875	3.57	
5	8.6	2.392	1.936	3.59	
6	10.7	2.742	2.358	3.90	
7	12.5	3.451	2.875	3.62	
8	14.9	4.365	3.432	3.41	
9	16.1	4.628	3.954	3.47	
10	18.3	5.451	4.358	3.35	
11	20.9	6.280	5.875	3.32	
12	22.7	6.880	5.636	3.29	

13	24.9	8.287	6.451	3.00	
14	26.6	9.987	8.548	2.66	
15	28.1	10.546	9.936	2.66	
16	30.3	10.742	10.451	2.82	
17	32.7	12.392	10.982	2.63	
18	34.9	13.365	12.261	2.611	
19	36.8	15.628	13.532	2.35	
20	38.2	18.380	15.786	2.07	
21	40.6	20.137	17.096	2.01	
22	42.3	21.261	19.456	1.98	
23	44.9	24.615	21.854	1.82	First crack
24	46.7	26.928	23.432	1.73	
25	48.2	27.621	26.954	1.74	
26	50.2	30.280	27.402	1.65	
27	52.4	32.880	28.946	1.59	
28	54.3	35.287	32.982	1.53	
29	56.4	38.863	35.786	1.45	
30	58.6	41.254	39.096	1.42	
31	60.7	43.165	41.456	1.40	
32	62.4	46.576	43.261	1.33	
33	64.1	48.137	46.532	1.33	
34	66.2	52.621	49.402	1.25	
35	68.8	53.987	51.946	1.27	
36	70.3	55.546	52.982	1.26	
37	72.2	56.380	51.432	1.28	
38	74.9	58.254	54.532	1.28	
39	76.6	59.165	56.786	1.29	
40	78.2	61.576	59.484	1.26	Ultimate load



BEAM DEFLECTION FOR HYBRID FIBER REINFORCED CONCRETE

Load Vs Deflection for Hybrid Fiber Reinforced Concrete Beam

S. No	Load (KN)	Deflection at mid span (mm)	Deflection at L/3 of span(mm)	Stiffness (N/mm)	Remarks

1	0	0	0	0	
2	2.8	0.261	0.224	10.72	
3	4.2	0.615	0.462	6.82	
4	6.1	0.928	0.685	6.57	
5	8.9	1.365	1.043	6.52	
6	10.2	1.628	1.356	6.26	
7	12.7	2.380	1.764	5.33	
8	14.9	3.137	2.218	4.74	
9	16.1	3.621	2.756	4.44	
10	18.3	4.280	3.271	4.27	
11	20.5	4.880	3.682	4.20	
12	22.7	5.287	4.132	4.29	
13	24.9	5.987	4.654	4.15	
14	26.2	6.546	5.158	4.00	
15	28.4	6.742	5.916	4.21	
16	30.5	7.392	6.484	4.12	
17	32.7	9.863	7.402	3.31	
18	34.9	13.254	11.946	2.63	
19	36.8	16.165	14.358	2.27	
20	38.6	20.576	17.875	1.87	
21	40.9	22.451	19.432	1.82	
22	42.3	24.280	21.271	1.74	
23	44.9	27.880	23.682	1.61	
24	46.7	30.287	27.132	1.54	
25	48.1	33.137	29.218	1.45	First crack
26	50.5	36.621	31.756	1.37	

27	52.4	38.987	33.654	1.34	
28	54.6	40.546	36.158	1.34	
29	56.8	41.742	39.916	1.36	
30	58.3	43.451	41.432	1.34	
31	60.7	46.365	44.043	1.30	
32	62.4	49.628	46.356	1.25	
33	64.1	52.380	49.764	1.22	
34	66.1	55.254	51.946	1.19	
35	68.6	58.165	54.358	1.17	
36	70.5	59.576	55.875	1.18	
37	72.9	61.261	57.224	1.18	
38	74.1	64.615	59.462	1.14	
39	76.5	67.928	63.685	1.12	
40	78.3	68.392	64.484	1.14	
41	80.7	71.863	66.402	1.12	
42	82.1	75.365	69.043	1.08	
43	84.3	77.628	73.356	1.08	Ultimate load

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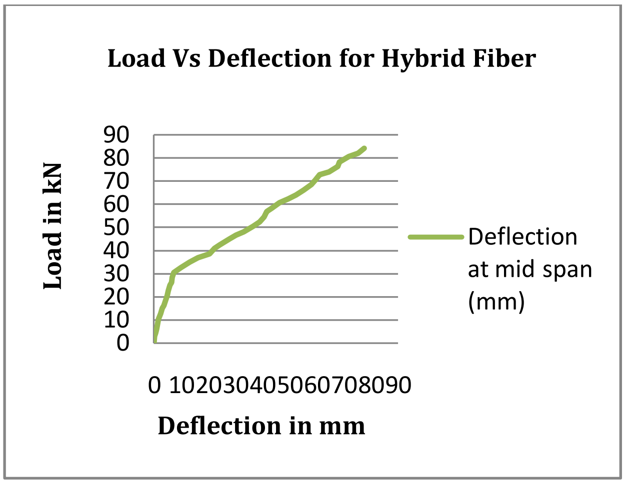

III. CONCLUSION

From the Experimental Investigation it is concluded that,

1. In addition of polypropylene fiber, the crack formation had been arrested and mechanical and flexural properties of concrete achieve 30% higher than conventional concrete at lower volume fraction of fiber (0.25%).
2. In addition of Steel fiber, mechanical and flexural properties of concrete achieve 33% higher than conventional concrete at higher volume fraction of fiber (0.75%).
3. The hybrid fiber reinforced concrete at the volume fraction of 1% enhances compressive strength by 34%, split tensile strength by 15% and flexural strength by 10% compared to conventional concrete.
4. The hybrid fiber reinforced beam at volume fraction of 1% (0.25%PP & 0.75%SF) shows higher deflection when compared to convention concrete beam.

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