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Experimental Study on Effect of Polypropylene fiber and steel fiber on properties of Concrete.

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Abstract -

Concrete is one of the most extensively used constructions maternal in the world. It is attractive in many applicators because it offers considerable strength at comparatively Low Cost. When general performance of concrete is substantially higher than normal cement concrete (NCC) .Such concrete is regarded as high performance concrete (HPC), So HPC is promising material for many decades. There fore in present study the mix design of M40 grade is considered along with polypropylene fibers (PP) steel fibers (SF), PP+ fly ash, S.F+FA, four values of volume fraction of SF & PP fibers were used i.e. 0.6%, 0.9%, 1.5% and 1.8% with replacement of fly ash by 15% weight of cement. On these various mixes tests are conducted to check the mechanical properties of concrete. Mix Result show that there is significant improvement In cracking behavior of concrete when steel fiber an used and formation of large number of finer cracks. So HPC gave ductility to structural members. Which is essential for seismic resisting design of structures?

Key words - HPC, PP fibers SF Fibers Fly ash.

Introduction - HPC is defined as concerts that meets special combinations of performances and uniformity requirements that cannot always be achieved routinely using conventional constituents and normal mixing, placing and curing practices. Ever since the term HPC was introduced into the industry, it had widely used in large scale concrete construction that demands high strength, high flow ability, and high durability.

A high strength concert is always a high performance concert but HPC is not always high strength concrete. Durable concert specifying a HSC does not ensures that a durable concert will be achieved.

HPC is a construction material which is being used in increasing volumes in recent years due to its long term performance, better rheological, mechanical and durability properties than NCC. HPC possess invariably high strength, reasonable workability and negligible permeability compared to NCC, preparation of HPC requires lower water binder ratio (W/b) and higher cement content. The HPC permits the use of reduced sizes of structural members, increased building height in congested areas and early removal of from work.

The use of HPC in pre-stressed concert construction makes greater span to depth ratio, transfer of prestress and application of service loads. Low permeability characteristics of HPC reduce the risk of corrosion of steel and attack of aggressive chemicals. This permits the use of HPC in marine/offshore structures, Nuclear power plants, bridges, places of extreme and adverse climatic condition, Eventually HPC reduces maintenance and repair cost.

Fly ash-(FA)- Is a organic, non combustible residue of coal after burning in power plant. In this work FA is replaced by 15% of weight of cement and mix design is done as per I.S. 10262-2009. The HPC mixes are tested experimentally for compression, split tension, flexure and workability. The performance of design mixes is very good & accordingly test results are reported.

Steel Fiber - These are available unperforated, corrugated or with wide end for better bending. The fibers can be placed single or in the form of mats. The main field of application of steel fibers is gunned concrete, tunnel construction & highly loaded Industrial floors. The addition of steel fibers in creases the tensile strength of normal and high strength concrete. It also has positive effect on tension stiffening behavior, formation of cracks, toughness and long-term deformations.

Properties of concrete Improved by steel fibers

- **Flexural strength –** It is improved up to 3 times more compared to conventional concrete.
- **Fatigue Resistance**- Almost 1.5 times increase in fatigue strength.
- **Impact Resistance**- Greater resistance to damage in case of heavy impact.
- **Permeability**- The material is less porous if fibers are added in limited percentage.
- **Abrasion Resistance**- Improves abrasion & spalling resistance of normal concrete.
- **Shrinkage**- Shrinkage cracks can be eliminated.
- **Corrosion**- It may affect the material but it will be limited in certain areas.

Advantages of HPC

1. Reduction in member size, results in increase plinth area and direct saving in concrete volume
2. Reduction in self-weight causes saving in foundation cost.
3. Reduction in form work area as member sizes are reduced also due to early age gaining in strength.
4. Use full in construction of high-rise building which saves cost in real-estate in congested areas.
5. Reduces axial shortening of supporting compression member.
6. Large spans are possible saves number of foundation.
7. Reduction in slab thickness and beam sizes which are major components of weight so saves cost of majority of structures.
8. Superior long term service performance under static, dynamic and fatigue loading.
9. Low creep and shrinkage.
10. Improves stiffness which increases modulus of elasticity of concrete.
11. Higher resistance to freezing & thawing, chemical attack & significantly improves long term durability and crack propagation.
12. Reduced maintenance cost.

Why concrete is strong in compression & weak under tension-

Concrete is strong in compression, as the aggregate efficiently carries the compressive load, however it is **week in tension** as the cement holding the aggregate in place can crack allowing the structure to fail ,So Reinforcing bars, glass fibers, plastic fibers are used to carry tensile loads.

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Polypropylene fibers-

In the past several years an increasing number of contractors have placed concrete containing polypropylene fibers. Fiber manufactures have promoted the material as a practical alternative to the use of welded wire fabric for control of shrinkage and temperature cracking. Addition of fiber in concrete reduces shrinkage, inhibits shrinkage cracking, reduces permeability and improves impact and abrasion resistance, there is however, conflicting data concerning the effect of polypropylene fibers. On the properties of concrete.

Experimental Programme.

The mix design for **M40** grade of concrete is done in accordance with **I.S. 10262-2009**. The quantity of ingredient materials and mix proportions as per design is as follow.(Ref.Table No-1)

Avg. Compressive. Strength of Various mixes when only fibers are used

Sr No.	No. of Day	Plain Concrete	Polypropylene fibers			
			0.6%	0.9%	1.5%	1.8%
1	7	35.25	41.78	44.44	44.59	42.52
2	28	50.05	53.93	59.11	67.26	63.41
3	56	53.25	56.30	61.33	70.22	66.52

Sr	No. of Days	Plain Concrete	Steel fibers			
			0.6%	0.9%	1.5%	1.8%
1	7	35.25	44.44	45.05	44.59	44.74
2	28	50.05	55.26	56.44	53.04	47.56
3	56	53.25	59.08	60.33	59.92	59.84

Table No-1
Quantity of material per-cubic of concrete

Sr	Materials	Weight Kg/m^3
1	Cement	440
2	River sand	405
3	Crushed sand	400
4	Coarse Aggregate - 10 mm	392
5	Coarse Aggregate - 20 mm	705
6	Water	167
7	Admixture	4.4
8	W/c Ratio	0.38
9	Fiber %	0.6,0.9,1.5,1.8%

Slump test-Results (Ref.Graph 1)

Sr. No	ID Mark	Slump in mm
1	T-1(0.6%PP)	165
2	T-1(0.9%PP)	180
3	T-1(1.5%PP)	175
4	T-1(1.8 %PP)	170
5	T-2(0.6%PP+FA)	175
6	T-2(0.9%PP+FA)	160
7	T-2(1.5%PP+FA)	170
8	T-2(1.8%PP+FA)	175
9	T-3(0.6%SF)	170
10	T-3(0.9%SF)	175
11	T-3(1.5%SF)	180
12	T-3(1.8%SF)	175
13	T-4(0.6%SF+FA)	165
14	T-4(0.6%SF+FA)	170
15	T-4(0.6%SF+FA)	175
16	T-4(0.6%SF+FA)	170

Avg. Compressive Strength of Various Mixes When Fly ash is used

Sr. No.	No. of Days	Plain Concrete	Polypropylene fibers			
			0.6%	0.9%	1.5%	1.8%
1	7	35.25	39.70	40.74	39.70	36.00
2	28	50.05	53.19	56.59	53.19	58.52
3	56	53.25	56.30	59.41	58.44	61.48

Sr. No.	No. of Days	Plain Concrete	Steel fibers			
			0.6%	0.9%	1.5%	1.8%
1	7	35.25	36.15	36.74	36.59	37.33
2	28	50.05	55.41	57.19	57.78	58.67
3	56	53.25	59.26	60.89	61.93	62.22

Flexural Strength for Normal Concrete:-

Sr.	ID Mark	Avg. Flexural strength(Mpa)		
		7 Days	28 Days	56 Days
1	Plain Concrete	3.5	4.41	4.5

Table 2: Flexural Shear Strength

Sr.	ID Mark	Flexural shear Strength (Mpa)		
		7 Days	28 Days	56 Days
1	Plain Concrete	0.375	0.472	0.482

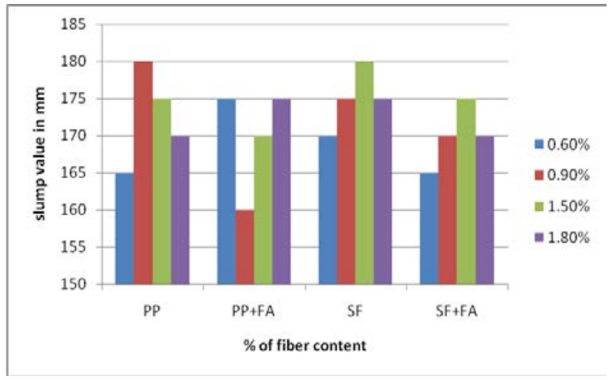
Table-3. Flexural strength

Sr	ID Mark	Avg. Flexural strength(Mpa)		
		7 Days	28 Days	56 Days
1	T-1(PP) (0.6%)	4.1	5.3	5.6
2	T-2(PP) (0.9%)	4.4	5.9	6.1
3	T-3(PP) (1.5%)	4.4	6.7	7.0
4	T-4(PP) (1.8%)	4.2	6.3	6.6
5	T-5(PP+FA) (0.6% +fly ash	3.9	5.3	5.5
6	T-6(PP+FA) (0.9%)	4.0	5.6	5.9
7	T-7(PP+FA) (1.5%)	3.9	5.3	5.8
8	T-8(PP+FA) (1.8%)	3.6	5.8	6.1
9	T-9(SF) (0.6%) Steel fiber	4.4	5.5	5.9
10	T-10(SF) (0.9%)	4.5	5.6	6.0
11	T-11(SF) (1.5%)	4.4	5.3	5.9
12	T-12(SF) (1.8%)	4.4	4.7	5.9
13	T-13(SF+ FA) (0.6%)	3.6	5.5	5.9
14	T-14(SF+ FA) (0.9%)	3.6	5.7	6.0
15	T-15(SF+ FA) (1.5%)	3.7	5.8	6.1
16	T-16(SF+ FA) (1.8%)	3.8	5.9	6.3

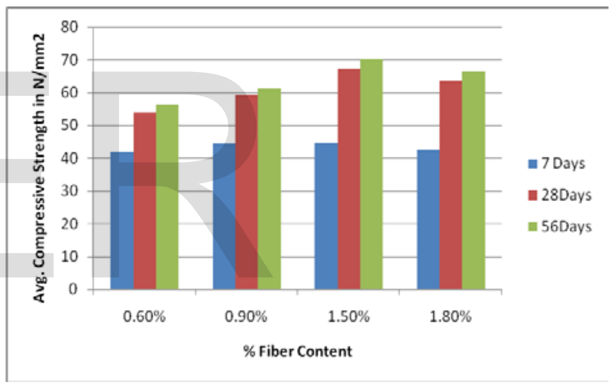
Table 4 Flexural Shear Strength

Sr	ID Mark	Flexural Shear Strength(Mpa)		
		7 Days	28 Days	56 Days
1	T-1(PP) (0.6%)	0.439	0.53	0.6
2	T-2(PP) (0.9%)	0.471	0.632	0.653
3	T-3(PP) (1.5%)	0.471	0.717	0.75
4	T-4(PP) (1.8%)	0.45	0.675	0.707
5	T-5(PP+FA) (0.6% +fly ash	0.417	0.53	0.589
6	T-6(PP+FA) (0.9%)	0.428	0.6	0.632
7	T-7(PP+FA) (1.5%)	0.417	0.53	0.621
8	T-8(PP+FA) (1.8%)	0.385	0.621	0.653
9	T-9(SF) (0.6%) Steel fiber	0.471	0.589	0.632
10	T-10(SF) (0.9%)	0.428	0.6	0.642
11	T-11(SF) (1.5%)	0.471	0.53	0.632
12	T-12(SF) (1.8%)	0.471	0.503	0.632
13	T-13(SF+ FA) (0.6%)	0.385	0.589	0.632
14	T-14(SF+ FA) (0.9%)	0.385	0.610	0.642
15	T-15(SF+ FA) (1.5%)	0.396	0.621	0.653
16	T-16(SF+ FA) (1.8%)	0.407	0.632	0.675

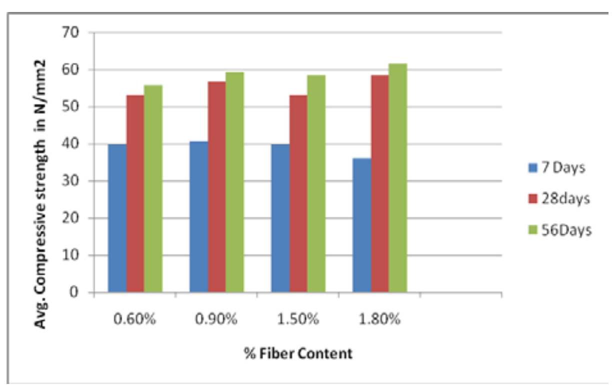
Graph 1 - % Fiber Content Vs Slump Value



Graph-2 Avg. Compressive strength of Polypropylene Fiber Vs % Fiber Content



Graph-3 Avg. Compressive strength of Polypropylene Fiber + Fly Ash Vs % Fiber Content



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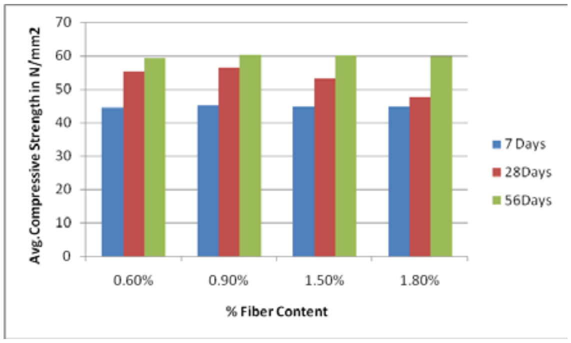
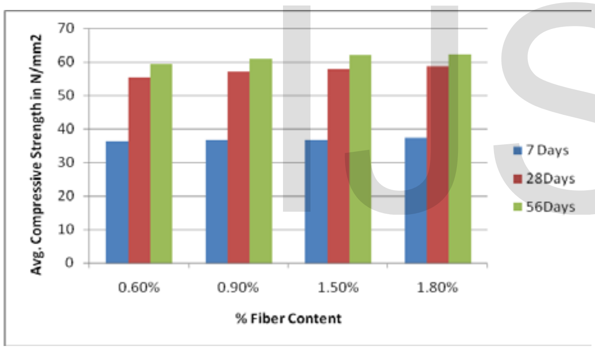
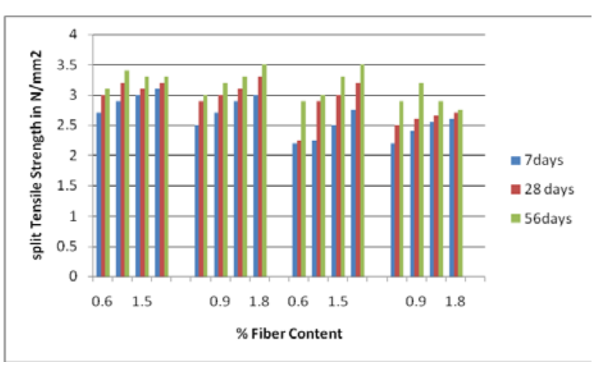
Graph-4 Avg. Compressive strength of Steel Fiber Vs % Fiber Content



Graph-5 Avg. Compressive strength of Steel Fiber + Fly Ash Vs % Fiber Content



Graph-6 Split Tensile strength Vs % Fiber Content



CONCLUSIONS

Following are the conclusion based on experimental results

- Compressive Strength increase by about 33% when 1.5% PP fibres are used compare to plain concrete.
- Compressive strength increase by about 16% when 1.8%PP+15% FA is used compare to plain concrete.
- Compressive strength increase by about 13% when 0.9% SF is used compare to plain concrete.
- Compressive strength increase by about 17% when 1.8%SF+15% FA is used compare to plain concrete.
- Flexural strength increase by about 51.92%at 28 days when 1.5%PP fibres used, where as it increases by about 27% when 0.9% SF is used.
- Split tensile strength increase by 43.47% at 28 days when 1.8% PP + 15%FA is used, where as it increases by 39% when 1.8% SF is used.
- Modulus of Elasticity of concrete increases by about 29.66% when 1.5%PP fibers are used where as it increases by 18.78% when 0.9% SF is used.

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