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Strength Characteristics of Multi-Fiber Reinforced Concrete With Mineral Admixtures.

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Abstract: *a study had been made for the development of High Performance Concrete using mineral admixtures such as Fly-ash, Silica-fume and Metakoalin along with steel and Polypropylene fibers. In this connection series of concrete cubes, cylinders and beams. were casted with various mix proportions were tested as per IS 516-1959, IS 5816-1976 for getting Strength Characteristic of Concrete The compressive strength, strength of the plain concrete specimens without any mineral admixture & fibers have been compared with that of compressive-strength of composite concrete made up of mineral admixtures & fibers The addition of fly-ash, silica-fume & Metakoalin influences the overall behavior of this concrete, while the post-cracking residual strength is increased by the addition of steel fibers into the mix of 6 sets of concrete specimens were carried out, the main parameters that are varied are mineral admixtures additions, fiber-volume, water-binder ratio etc. Due to the addition of mineral admixtures & fiber volume into the mix, it gives very good performance & improves the strength characteristic of concrete.*

Keywords) *– flyash, silica fume, metakoalin, steel fibers, polypropylene fibers ,W/B ratio*

I. INTRODUCTION

High performance concrete can be defined as a concrete made with appropriate materials (SP, Silica fume, Fly ash and other admixtures) combined to provide excellent performance in some properties of concrete such as, high strength, high density, impermeability, durability and good resistance to prevailing environmental agents etc. The concrete made based on the necessity of satisfying the criteria proposed to be overcome over the limitations over a conventional concrete can be said as High performance concrete.

Since from1980's high performance concrete is mostly used as important material. They give high strength in compression more than 60Mpa obtained by adding a mixture of cement, with mineral admixture and super-plasticizers. The addition of mineral admixtures to the concrete gives better workability and durability. This admixture also gives good compactness to the cement paste. Silica-fume and super-plasticizers are used to achieve workability of the concrete.

II. MATERIALS USED AND METHODOLOGY

2.1 MATERIALS USED TO MAKE HPC

Cement, Fly ash, Silica fume, Metakaolin, Fine aggregate, Coarse aggregate, Super plasticizers, Water, Steel Fibers. Polypropylene Fibers.

2.2 METHODOLOGY

The present study deals with experimental investigations in which cement is partially replaced with the combination of 0%,15% & 30% of mineral admixtures like Metakoalin, Silica fume and Fly ash each by 5% & 10% and varying the steel fibers from 0.75% and 1.0%.The polypropylene fibers is kept constant for all the ratios (0.25%)

The Various Parameters adopted for the design of the concrete are

1. (A/B) Ratio = 2.50
2. (W/B) Ratio =0.30, 0.35, 0.40
3. Mineral Admixtures: Fly ash, Silica-fume and Metakoalin each of 0%,5% and 10% to the weight of cement.
4. Polypropylene Fibers: 0.25% (maintained constant for all ratios)
5. Steel fibers: 0.75% and 1.0%
6. Dosage of Super plasticizers: 0.6% to the weight of Binder.

2.3 SIMPLIFIED METHOD OF MIX PROPORTIONING USING ABSOLUTE VOLUME METHOD

2.3.1 Simple calculation of the quantities required for the mix with Aggregate-Binder Ratio 2.5 and Water Binder Ratio are 0.30, 0.35 and 0.40 for 5% each of Metakaolin, Silica Fumes, Fly Ash**.**

Table 1: Calculation: Materials per cubic meter of concrete for 0.30 W/B ratio (Kgs)

Sl	*Ingredients*	*volume per Cement bag (m3)*		*Materials in kg/m^3*	
1	*Cement*	$\frac{50x0.85}{3.08x1000}$ =	*0.0138*	$\frac{50x0.85}{0.077651}$ =	*547.32*
2	*Fly Ash*	$\frac{50x0.05}{1.90x1000}$ =	*0.00131*	$\frac{50x0.05}{0.077651}$ =	*32.91*
3	*Silica Fumes*	$\frac{50x0.05}{2.30x1000}$ =	*0.00108*	$\frac{50x0.05}{0.077651}$ =	*32.91*
4	*Metakaolin*	$\frac{50x0.05}{2.60x1000}$ =	*0.000961*	$\frac{50x0.05}{0.077651}$ =	*32.91*
5	*Water*	$\frac{50x0.3}{1.0x1000}$ =	*0.0150*	$\frac{50x0.30}{0.077651}$ =	*193.17*
6	*Coarse aggregate*	$\frac{50x0.6x2.5}{2.84x1000}$ =	*0.0264*	$\frac{50x0.6x2.5}{0.077651}$ =	*965.86*
7	*Fine aggregate*	$\frac{50x0.4x2.5}{2.62x1000}$ =	*0.0191*	$\frac{50x0.4x2.5}{0.077651}$=	*643.90*
Total volume =			*0.077651*		

Table 2 :Calculation: Materials per cubic meter of concrete for 0.35 W/B ratio (Kgs)

Sl	*Ingredients*	*volume per Cement bag (m3)*		*Materials in kg/m^3*	
1	*Cement*	$\frac{50x0.85}{3.08x1000}$ =	*0.0138*	$\frac{50x0.85}{0.079071}$ =	*537.49*
2	*Fly Ash*	$\frac{50x0.05}{1.90x1000}$ =	*0.00131*	$\frac{50x0.05}{0.079071}$ =	*31.61*
3	*Silica Fumes*	$\frac{50x0.05}{2.30x1000}$ =	*0.00108*	$\frac{50x0.05}{0.079071}$ =	*31.61*
4	*Metakaolin*	$\frac{50x0.05}{2.60x1000}$ =	*0.000961*	$\frac{50x0.05}{0.079071}$ =	*31.61*
5	*Water*	$\frac{50x0.35}{1.0x1000}$ =	*0.0175*	$\frac{50x0.35}{0.079071}$ =	*221.32*
6	*Coarse aggregate*	$\frac{50x0.6x2.5}{2.84x1000}$ =	*0.0264*	$\frac{50x0.6x2.5}{0.079071}$ =	*948.51*
7	*Fine aggregate*	$\frac{50x0.4x2.5}{2.62x1000}$ =	*0.0191*	$\frac{50x0.4x2.5}{0.079071}$ =	*632.34*
Total volume =			*0.079071*		

Table 3 :Calculation: Materials per cubic meter of concrete for 0.40 W/B ratio (Kgs)

Sl	*Ingredients*	*volume per Cement bag (m3)*		*Materials in kg/m3*	
1	*Cement*	$\frac{50x0.85}{3.08x1000}$ =	*0.0138*	$\frac{50x0.85}{0.082651}$ =	*514.21*
2	*Fly Ash*	$\frac{50x0.05}{1.90x1000}$ =	*0.00131*	$\frac{50x0.05}{0.082651}$ =	*30.24*
3	*Silica Fumes*	$\frac{50x0.05}{2.30x1000}$ =	*0.00108*	$\frac{50x0.05}{0.082651}$ =	*30.24*
4	*Metakaolin*	$\frac{50x0.05}{2.60x1000}$ =	*0.000961*	$\frac{50x0.05}{0.082651}$ =	*30.24*
5	*Water*	$\frac{50x0.4}{1.0x1000}$ =	*0.02000*	$\frac{50x0.4}{0.082651}$ =	*241.98*
6	*Coarse aggregate*	$\frac{50x0.6x2.5}{2.84x1000}$ =	*0.0264*	$\frac{50x0.6x2.5}{0.082651}$ =	*907.43*
7	*Fine aggregate*	$\frac{50x0.4x2.5}{2.62x1000}$ =	*0.0191*	$\frac{50x0.4x2.5}{0.082651}$ =	*604.95*
Total volume =			*0.082651*		

2.3.2 Simple calculation Aggregate-binder ratio 2.5 and water Binder ratio (W/B) are 0.30, 0.35 and 0.40 for 10% of each Metakaolin, Silica fume and Fly ash.

Table 4: Calculation: Materials per cubic meter of concrete for 0.30 W/B ratio (kgs)

Sl	*Ingredients*	*volume per Cement bag (m3)*		*Materials in kg/m3*	
1	*Cement*	$\frac{50x0.7}{3.08x1000}$ =	*0.0160*	$\frac{50x0.7}{0.0854}$ =	*409.83*
2	*Metakaolin*	$\frac{50x0.1}{2.60x1000}$ =	*0.0019*	$\frac{50x0.1}{0.0854}$ =	*58.54*
3	*Silica fume*	$\frac{50x0.1}{2.30x1000}$ =	*0.0022*	$\frac{50x0.1}{0.0854}$ =	*58.54*
4	*Fly ash*	$\frac{50x0.1}{1.90x1000}$ =	*0.0026*	$\frac{50x0.1}{0.0854}$ =	*58.54*
5	*Water*	$\frac{50x0.30}{1x1000}$ =	*0.0150*	$\frac{50x0.3}{0.0854}$ =	*175.64*
6	*Coarse aggregate*	$\frac{50x0.6x2.5}{2.70x1000}$ =	*0.0277*	$\frac{50x0.6x2.5}{0.0854}$ =	*878.22*
7	*Fine aggregate*	$\frac{50x0.4x2.5}{2.50x1000}$ =	*0.020*	$\frac{50x0.4x2.5}{0.0854}$ =	*585.48*
Total volume =			*0.0854*		

Table 5: Calculation: Materials per cubic meter of concrete for 0.35 W/B ratio (kgs)

Sl	Ingredients	volume per Cement bag (m3)		Materials in kg/m3	
1	*Cement*	$\frac{50x0.7}{3.08x1000}$ =	*0.0160*	$\frac{50x0.7}{0.0879}$ =	*398.18*
2	*Metakaolin*	$\frac{50x0.1}{2.60x1000}$ =	*0.0019*	$\frac{50x0.1}{0.0879}$ =	*56.88*
3	*Silica fume*	$\frac{50x0.1}{2.30x1000}$ =	*0.0022*	$\frac{50x0.1}{0.0879}$ =	*56.88*
4	*Fly ash*	$\frac{50x0.1}{1.90x1000}$ =	*0.0026*	$\frac{50x0.1}{0.0879}$ =	*56.88*
5	*Water*	$\frac{50x0.35}{1x1000}$ =	*0.0175*	$\frac{50x0.35}{0.0879}$ =	*199.08*
6	*Coarse aggregate*	$\frac{50x0.6x2.5}{2.70x1000}$ =	*0.0277*	$\frac{50x0.6X2.5}{0.0879}$ =	*853.24*
7	*Fine aggregate*	$\frac{50x0.4x2.5}{2.50x1000}$ =	*0.020*	$\frac{50x0.4X2.5}{0.0879}$ =	*568.82*
Total volume =			*0.0879*		

Table 6: Calculation: Materials per cubic meter of concrete for 0.40 W/B ratio (kgs)

Sl	Ingredients	volume per Cement bag (m3)		Materials in kg/m3	
1	Cement	$\frac{50x0.7}{3.08x1000}$ =	0.0160	$\frac{50x0.7}{0.0904}$ =	387.17
2	Metakaolin	$\frac{50x0.1}{2.60x1000}$ =	0.0019	$\frac{50x0.1}{0.0904}$ =	55.30
3	Silica fume	$\frac{50x0.1}{2.30x1000}$ =	0.0022	$\frac{50x0.1}{0.0904}$ =	55.30
4	Fly ash	$\frac{50x0.1}{1.90x1000}$ =	0.0026	$\frac{50x0.1}{0.0904}$ =	55.30
5	Water	$\frac{50x0.40}{1x1000}$ =	0.020	$\frac{50x0.4}{0.0904}$ =	221.24
6	Coarse aggregate	$\frac{50x0.6x2.5}{2.70x1000}$ =	0.0277	$\frac{50x0.6X2.5}{0.0904}$ =	829.64
7	Fine aggregate	$\frac{50x0.4x2.5}{2.50x1000}$ =	0.020	$\frac{50x0.4X2.5}{0.0904}$ =	531.91
Total volume =			0.0904		

IV RESULTS ANALYSIS

4.1 Compressive strength of composite concrete (Hardened concrete)

It is the important property of concrete in hardened state. Series of concrete cubes of standard dimensions (150 mm x 150mm x 150mm) were cast without admixtures and next by replacing cement (weight) by 15% of mineral admixtures i,e (Fly ash 5%, silica fume 5%, and metakoalin5%) and 30% of mineral admixtures i,e (Fly ash 10%, silica fume 10%, and metakoalin10%) and & Fibers with varying percentage of 1% & 1.25%.After 7 days and 28 days curing these cubes have been tested using compressive-testing machine and results are given in the below Tables.

4.2: Failure Cracks Pattern of Cubes for Different % of Fibers:

0% Fibers **0.75% Fibers**

1 % Fibers **1.25 % Fibers**

Figure 1: Schematic of compressive strength test

Table 7: Compressive-strength for Partial replacement of cement with (0%,15%,30%) of mineral admixtures for 1% fibers (0.75% S.F & 0.25% P.F) for 7 days

Trial mix	*Percentage of Mineral Admixtures*	*Compressive strength in Mpa*		
		W/B=0.30	*W/B=0.35*	*W/B=0.40*
1	*0%*	*53.11*	*49.33*	*47.18*
2	*15%*	*56.72*	*53.84*	*51.67*
3	*30%*	*48.45*	*46.11*	*45.06*

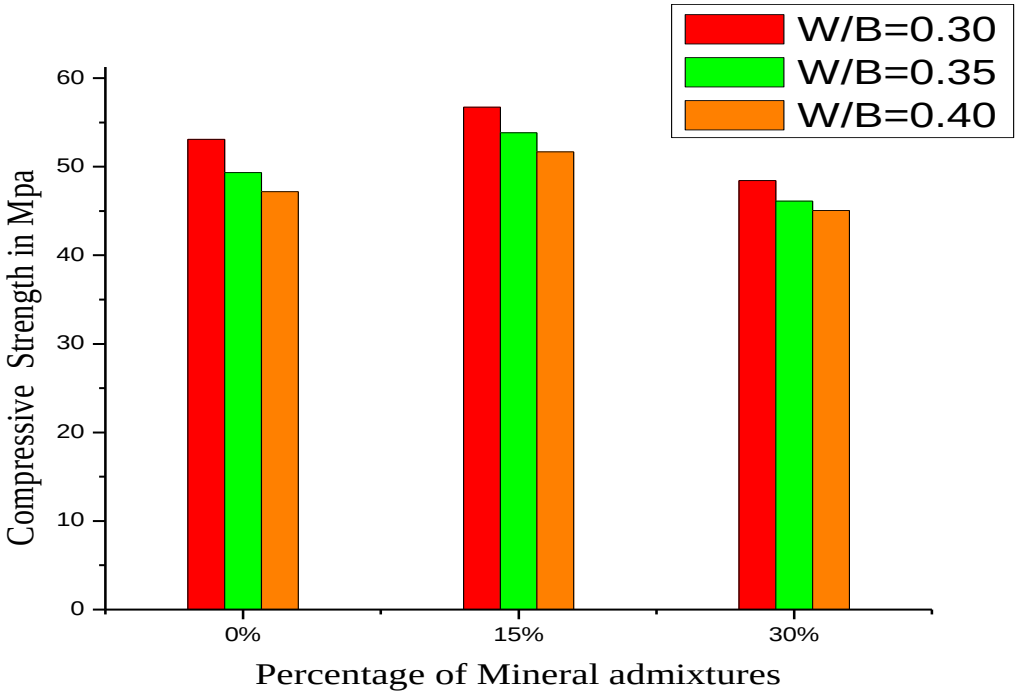

Figure 2: Compressive-strength for Partial replacement of cement with (0%,15%,30%) of mineral admixtures for 1% fibers (0.75% S.F & 0.25% P.F) for 7 days

Table 8 Compressive-strength for Partial replacement of cement with (0%,15%,30%) of mineral admixtures for 1% fibers (0.75% S.F & 0.25% P.F) for28 days

Trial mix	*Percentage of Mineral Admixtures*	*Compressive strength in Mpa*		
		W/B=0.30	*W/B=0.35*	*W/B=0.40*
1	*0%*	*58.66*	*57.45*	*55.11*
2	*15%*	*62.89*	*59.92*	*56.62*
3	*30%*	*53.68*	*51.55*	*49.66*

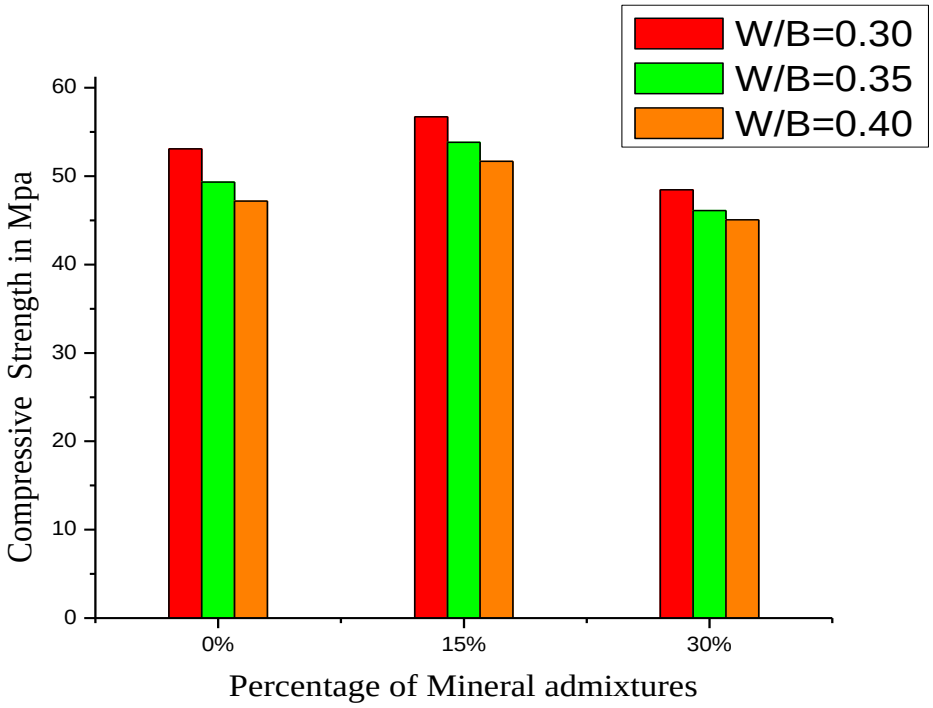

Figure 3: Compressive-strength for Partial replacement of cement with (0%,15%,30%) of mineral admixtures for 1% fibers (0.75% S.F & 0.25% P.F) for28 days

Table 9: Compressive-strength for Partial replacement of cement with (0%, 15%,30%) of mineral admixtures for 1.25% fibers (1% S.F & 0.25% P.F) for 7 days

Trial mix	*Percentage of Mineral Admixtures*	*Compressive strength in Mpa*		
		W/B=0.30	*W/B=0.35*	*W/B=0.40*
1	*0%*	*56.57*	*54.52*	*49.66*
2	*15%*	*60.44*	*58.24*	*56.82*
3	*30%*	*50.33*	*48.75*	*46.36*

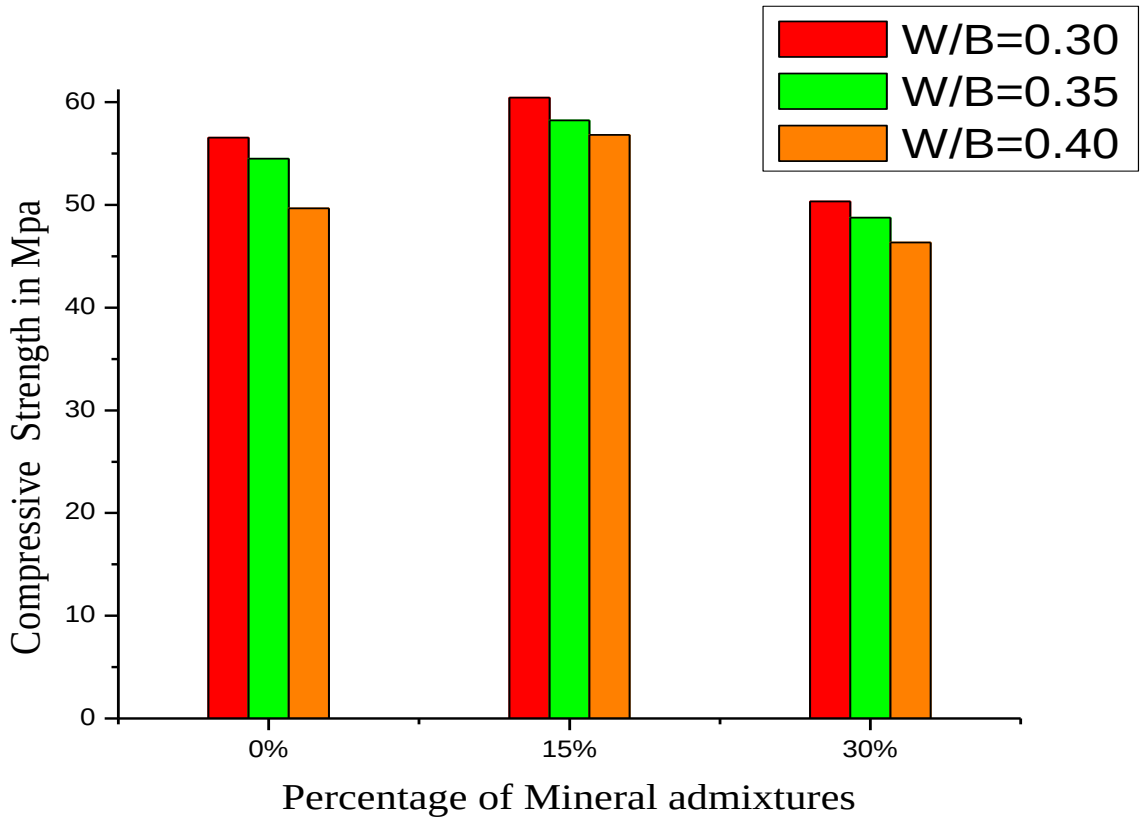

Figure 4: Compressive-strength for Partial replacement of cement with (0%, 15%,30%) of mineral admixtures for 1.25% fibers (1% S.F & 0.25% P.F) for 7 days

Table 10: Compressive-strength for Partial replacement of cement with (0%,15%,30%) of mineral admixtures for 1.25% fibers (1% S.F & 0.25% P.F) fibers for 28 days

Trial mix	*Percentage of Mineral Admixtures*	*Compressive strength in Mpa*		
		W/B=0.30	*W/B=0.35*	*W/B=0.40*
1	*0%*	*62.22*	*61.07*	*59.88*
2	*15%*	*65.33*	*64.12*	*62.91*
3	*30%*	*58.45*	*56.44*	*53.82*

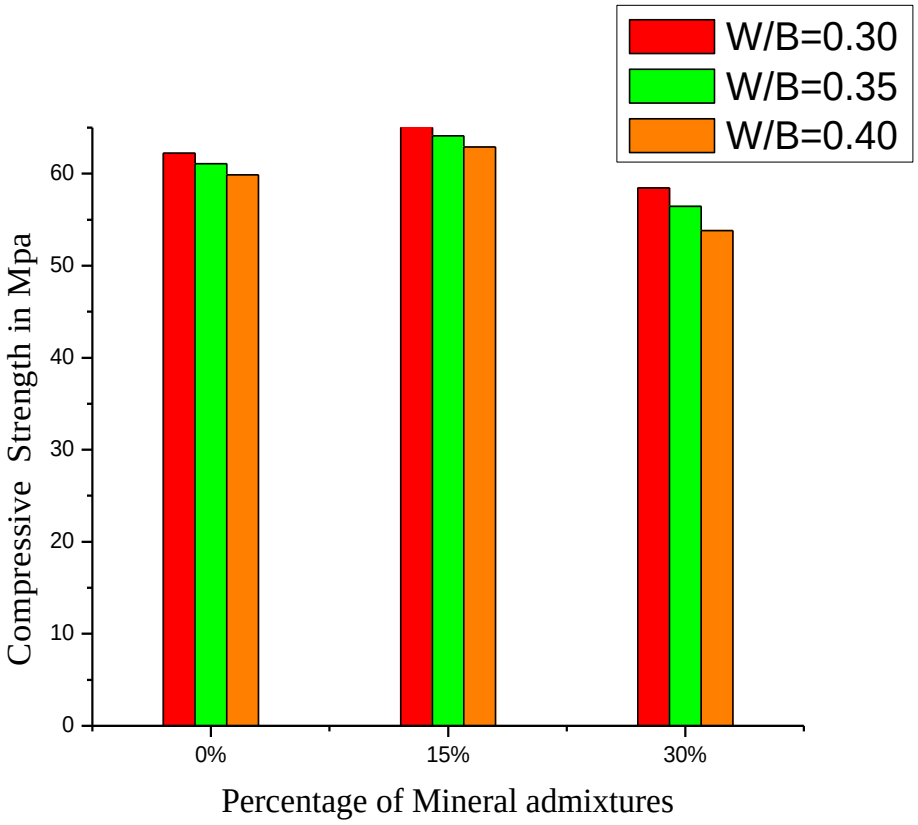

Figure 5 Compressive-strength for Partial replacement of cement with (0%,15%,30%) of mineral admixtures for 1.25% fibers (1% S.F & 0.25% P.F) fibers for 28 days

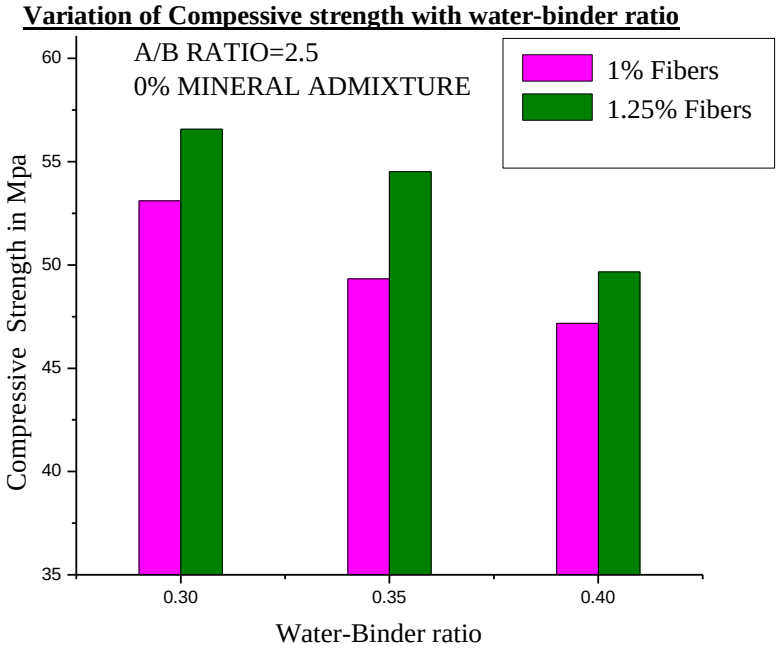

Figure 6: Compressive-strength vs. Water-Binder ratio with different fibers percentage with 0% mineral admixture for 7 days

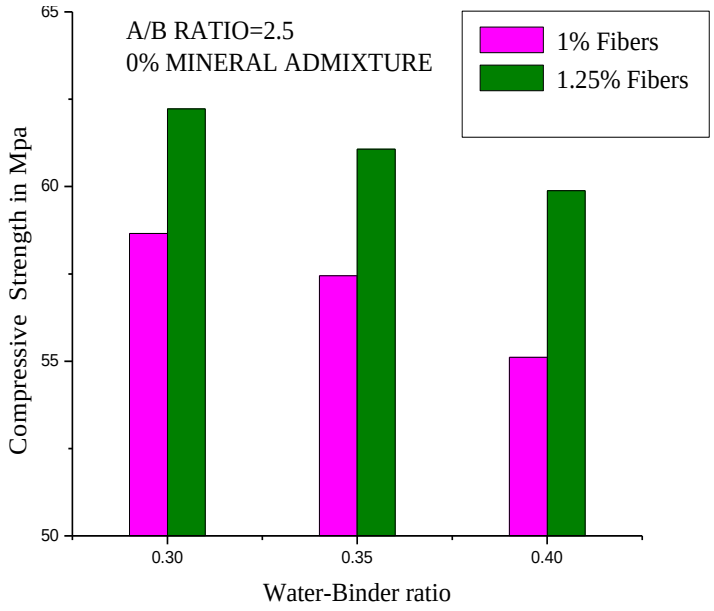

Figure 7: Compressive-strength vs. Water-Binder ratio with different fibers percentage with 0% mineral admixture for 28 days

V. CONCLUSION

Fibres increase the compressive-strength of the concrete and also resist sudden collapse in hardened state. From this work we observed that 85-90% of the strength was gained within 7 days when compared to 28 days strength. From this we can conclude that by adding mineral admixtures and Fibers we can gain early strength. Replacement of cement up to 15% with mineral admixtures for W/B 0.30 will improve the strength characteristics of concrete. The percentage increase in compressive strength is 6.8% and further increase in mineral admixture by 30%, the compressive strength gets reduced by 12.3% for 1.25% of fibers.

The experimental investigation indicate that the combined effect of steel and polypropylene fiber improve compressive strength of concrete. Also these studies indicate that multi fiber reinforced concrete with mineral admixtures appears to be a promising material in the case of structures which require high strength and ductility

The mineral admixtures like fly ash, silica fume are products of industrial waste and they have no further use in any production process. This remains as waste and should be disposed off. But these products have high cementitious properties which can replace cement to some extent.

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