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PERFORMANCE EVALUATION OF PET-POLYPROPYLENE HYBRID FIBER REINFORCED CONCRETE

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Abstract -Concrete is a versatile construction material which sustains in every condition in construction but concrete too has some bitter properties like, weak in tensile strength, it is almost 10% of its compressive strength. It has been recognized that the addition of discrete Fiber materials which are added in small percentage to concrete during mixing process, effectively arrested the micro cracks, increase impact resistant of concrete, compressive strength, tensile strength and flexural strength, dynamic properties of concrete etc. The research study is to investigate the benefits of PET – PP (Polyethylene Terephthalate - Polypropylene fibers) hybrid fibers in concrete.M35 grade concrete with the use of waste PET fibers and polypropylene fibers with different volume fractions of concrete volume is studied in this experimental work. The Workability of concrete mix is decreased with increase in percentage of PP in concrete. The strength of concrete mix is increased for the mixes which has higher percentage of PET fibers and lesser percentage of PP fibers. M3 (0% PP) and 1% PET fibers) is most economical which has less cost per unit strength but it contain only PET fibers.

Key Words:Discrete Fiber material,Polyethylene Terephthalate, Polypropylene fibers, Workability.

1. INTRODUCTION

Concrete is widely used as a construction material in civil engineering works for decades.It can mould in any shape and size without any difficulty. All ingredients used in concrete are used in natural form and the properties of concrete can be changed by adding some special natural or artificial materials. Concrete give good workability, high compressive strength, less tensile strength, less flexural strength, less resistant to cracking ,impermeability, durability ,heavyweight, shrinkage etc. Some of properties of concrete gives good results and some of properties have average or poor results. To improve the properties, the concrete is prepared with mixing some additional materials rather than basic materials.

Different type of fibers has been used to obtain fiber reinforced concrete (FRC) but not all of them can be effectively and economically used. Each fiber has its own characteristic properties and limitations.Discrete fibers may be circular or flat in shape and it can be described by aspect ratio (ratio of length to diameter). Different types like steel fibers, polypropylene and nylon fibers, asbestos fibers, glass fiber, carbon fiber etc, are made in industries under controlled conditions and supplied to the concrete industries. With the use of these fibers the cost of concrete becomes very high as compare to normal concrete, To reduce the cost of concrete engineers& researchers focus on utilization of industrial waste material in concrete manufacturing.

Plastics are world widely used in form of PET bottles (Polyethylene Terephthalate).These wastes are either stored and land filled without knowing detrimental effects on the environment. It is observed that, these plastic wastes has good chemical resistant, durability, lightweight, and suggested to use of these PET bottles for concrete manufacturing in the form of Fibers of different length and sizes.In the present study PET waste is used to replace polypropylene fibers in a concrete mix in different proportions to investigate its effects on the performance of the concrete. The performance is evaluated in terms of effect on workability, strength, and economy of PET-Polypropylene hybrid fiber reinforced concrete.

2. MATERIAL PROPERTIES

Properties of material used in the study is presented along with the procedure of various test conducted on different mixes are:-

2.1 Cement: -43 grade OPC cement used in this study confirming to BIS 8112-1989.

TABLE 2.1:- Physical properties of cement

Characteristics	Units	Result obtained	Value specified as per IS 8112-1989
Soundness (le-chateliar)	mm	4mm	Max 10mm
Specific gravity	N.A	3.15	Should be more then 3
Normal consistency	%	30	30
Initial setting time	Minutes	37	Not less than 30 minutes
Final setting time	Minutes	550	Not more than 600 minutes
Compressive strength 1) 3 days 2) 7 days 3) 28 days	MPa	 21.20MPa 32.87MPa 43.48MPa	 23MPa 33MPa 43MPa

2.2 Coarse aggregates: -Locally available Crushed stones size between all in one ≤ 20 mm is used.

TABLE 2.2:- Physical properties of coarse aggregate

Characteristics	Results obtained
Fineness modulus	7.498
Specific gravity	2.67
Bulk Density (Kg/m^3)	1.46 g/cm^3

2.3 Fine aggregates: - Local available river silver sand used in this experimental works.

TABLE 2.3:- Physical properties of fine aggregate

Characteristics	Results obtained
Fineness modulus	2.32
Specific gravity	2.63

2.4 Fibers: - Two types of fibers are used in experimental work:-

1) Waste plastic bottles fibers (PET) prepared with cutting of waste plastic bottles. It is converted into pallets of 19 mm long and 3 mm wide in dimensions. The whole material is prepared manually with scissors.

FIGURE 2.1:- PET fibers

TABLE 2.5:- Physical properties of PET fibers

Characteristics	Results obtained
Material	Waste plastic bottles
Specific gravity	1.31
Density(loose) Kg/m3	1097 Kg/m3
Length	19 mm
Color	Opaque White gray
Absorption	Nil

TABLE 2.6:- Specific gravity of PET fibers (by pycnometer)

Mass empty dry pycnometer W, (grams)	608
Mass of pycnometer full of water W1, (grams)	1510
Mass of pycnometer +aggregate +water W3, (grams)	1522
Mass of surface dry aggregates W2, (grams)	50
Bulk specific gravity =W2/W2-(W3-W1)	1.31

2) ECONO-NET Polypropylene fibers monofilaments by FORTA are used in this experimental works with dimensions 19 mm long.

FIGURE 2.2:- Polypropylene fibers

TABLE 2.7:- Physical properties of polypropylene fibers

Characteristics	Results obtained
Material	Virgin homopolymer polypropylene
Specific gravity	0.91
Density(loose) Kg/m3	907.3 Kg/m3
Tensile strength	90-110ksi(620-758 Mpa)
Length	19 mm
Color	White
Acid/alkali resistance	Excellent
Absorption	Nil
Compliance	A.S.T.M C-1116

2.5 Water: - Portable drinking water is used for mixing of concrete.

3. EXPERIMENTAL WORK

3.1 Mixing of material : - Six different M 35 grade concrete mixes will be prepared for this experimental study.The detail of mixes is given in table below:-

TABLE 3.1:- Concrete Mixes designation

S. No	concrete mix	Total volume fraction (V_f)in concrete	Total volume fraction (VF) of PP	Total volume fraction (VF) of PET fibers
1	M1	No fibers	No fibers	No fibers
2	M2	1%	1%	0%
3	M3	1%	0%	1%
4	M4	1%	0.5%	0.5%
5	M5	1%	0.25%	0.75%
6	M6	1%	0.75%	0.25%

TABLE 3.2:- Weight of fibers for various % age in mixes

1% PP	1% PET	0.5% PP	0.5% PET	0.25% PP	0.25% PET	0.75% PP	0.75% PET
9.1 kg	13.1 kg	4.55 kg	6.55 kg	2.75 kg	3.275 kg	6.825 kg	9.825 kg
$1M^3$	$1M^3$	$1M^3$	$1M^3$	$1M^3$	$1M^3$	$1M^3$	$1M^3$

The numbers of samples used for different tests are shown in table below:-

TABLE 3.3:- Numbers of samples

Type of test	Size of cubes	Total Nos. of cubes	Nos. of cubes for 7 days testing	Nos. of cubes for 28 days testing.
Compressive strength.	Cube 150mm*150 mm*150mm	36	18	18
Flexural strength.	Prism 100mm*100 mm*500mm	36	18	18
Split tensile strength	Cylinder Diameter 100mm , length 200mm	36	18	18

3.2 Workability of concrete mix: -The workability tests are done as per recommended IS CODE 1199-1959 guidelines with the help of slump cone apparatus.

TABLE 3.4:- Experimental outcome (Slump test)

Type of Mix	Slump in mm	Remarks
M1	20 mm	Control Mix
M2	5 mm	With 1% PP fibers
M3	14 mm	With 1% PET fibers
M4	10mm	With 0.5%PP fibers +0.5%PET fibers
M5	12mm	0.25%PP fibers +0.75%PET
M6	8mm	0.75%PP fibers +0.25% PET

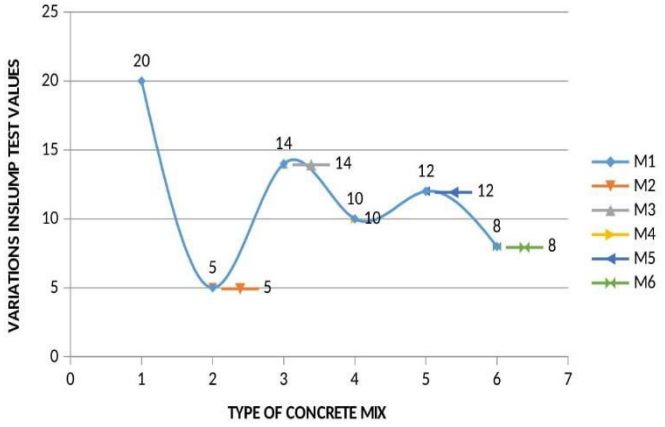

FIGURE 3.1:- Slump tests results curve (All values in mm)

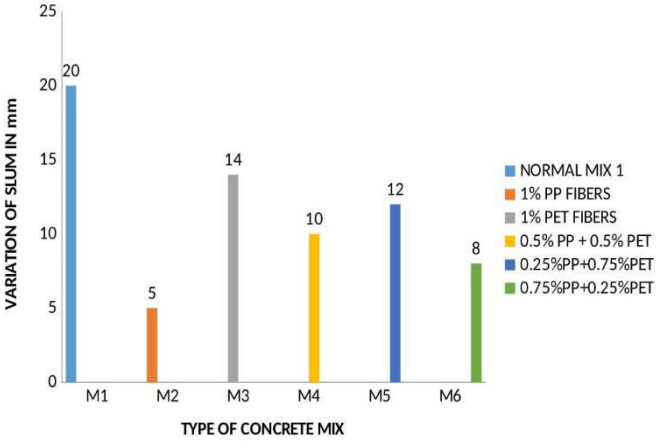

Chart 3.1:- Slump test results (All values in mm)

- ***Results*** **:-**As the concrete is added with different fibers, workability of concrete is reduced with respect to workability of mix containing no fibers. It is due to increase in friction between fibers and aggregates in concrete. Further it is noted that concrete with more percentage of Polypropylene fibers shows less workability**.**

3.3 Strength test :- For testing strength of mix, different strength tests are performed like compressive strength test, split tensile test, flexural strength test etc. For compressive and flexural strength IS code 516-1959 guidelines and for split strength IS code 5816-1999 guidelines are followed.

3.3.1 Compressive strength test (CS test):- The compressive strength of different concrete mixes is observed with compression testing machine. It is observed after 7 days and 28 days of casting of each different mix.

TABLE 3.5:- Compressive strength results analysis

Type of concrete mix	M1	M2	M3	M4	M5	M6
CS after 7days	28.83	29.06	29.13	28.88	29.22	28.85
CS after 28 days	42	42.29	44.13	42.56	45.39	42.72
% increase in strength after 7 days	0%	0.79 %	1.04 %	0.17 %	1.35 %	0.06 %
% increase in strength after 28 days	0%	0.69 %	5.07 %	1.33 %	8.07 %	1.71 %

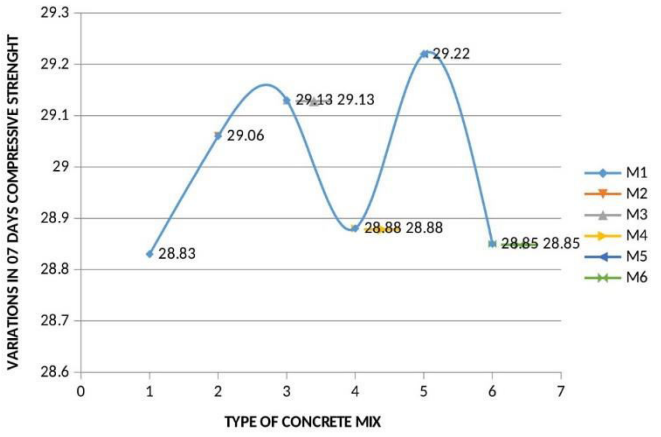

FIGURE 3.2:- 07 Days CS curve (N/mm^2)

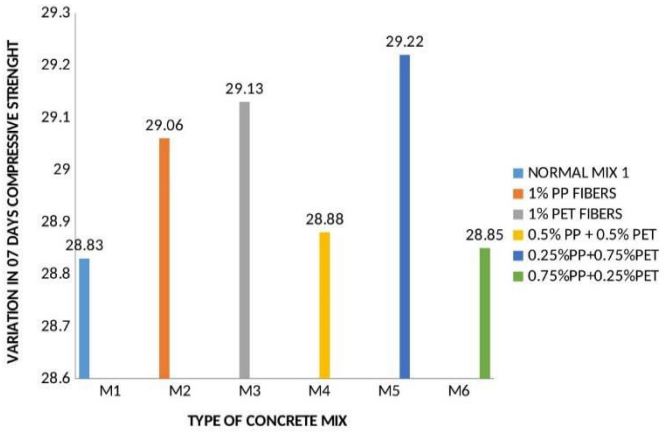

Chart 3.2:- 07 Days CS of different mixes (N/mm^2)

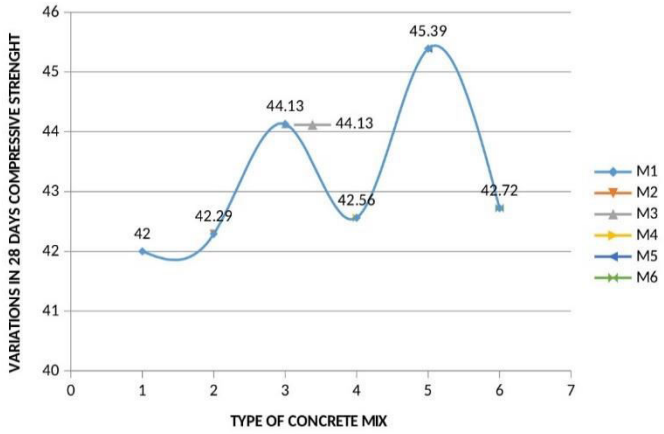

FIGURE 3.3:- 28 Days CS curve

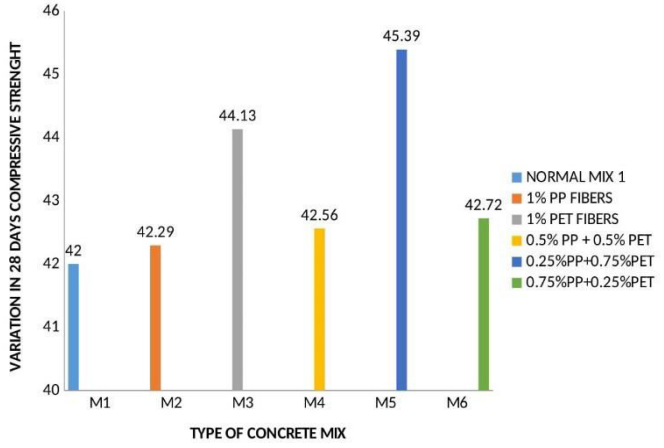

Chart 3.3:- 28 Days CS of different mixes (N/mm^2)

- ***Results:-***The compressive strength varied with different combination of PET and PP fibers. It is observed that in 7days result, M5 shows maximum increase in strength w.r.t design mix i.e. 1.35 % and in 28 days result, M5 again shows maximum increase in compressive strength i.e. 8.07 % w.r.t design mix. The maximum 28 days strength of design mix is 42 N/mm^2 and for M5 is 45.39 N/mm^2. So the M5 (containing 0.25% PP fibers and 0.75% PET fibers) concrete mix results more strength then design value of compressive strength that is 35N/mm^2 so it can recommended for use.

3.3.2Split tensilestrength test (ST strength test):-The split tensile strength test is done as per IS code 5816-1999 guidelines and observed for different concrete mixes for 7days and 28 days results.

TABLE 3.6:- Split tensile results analysis

Type of concrete mix	M1	M2	M3	M4	M5	M6
STstrength after 7days	2.74	2.92	2.99	2.97	3.07	2.94
STstrength after 28 days	4.03	4.19	4.45	4.31	4.61	4.25
% increase in strength after 7 days	0%	6.56 %	9.12 %	8.39 %	12.40 %	7.29 %
% increase in strength after 28 days	0%	3.97 %	10.42 %	6.94 %	14.39 %	5.45 %

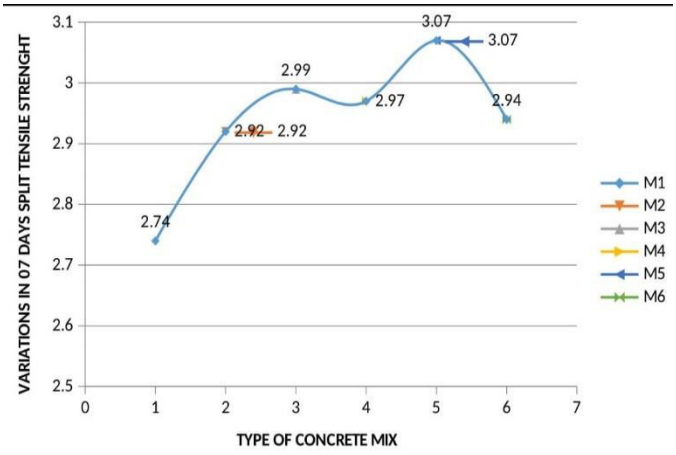

FIGURE 3.4:- 07 Days ST strength curve (N/mm^2)

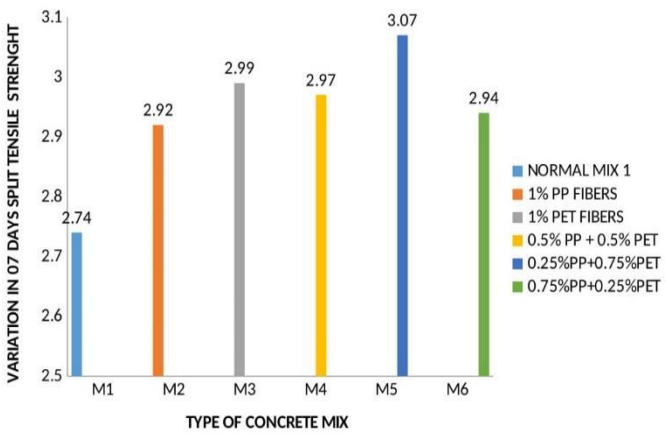

Chart 3.4:- 07 Days ST strength of different mixes (N/mm^2)

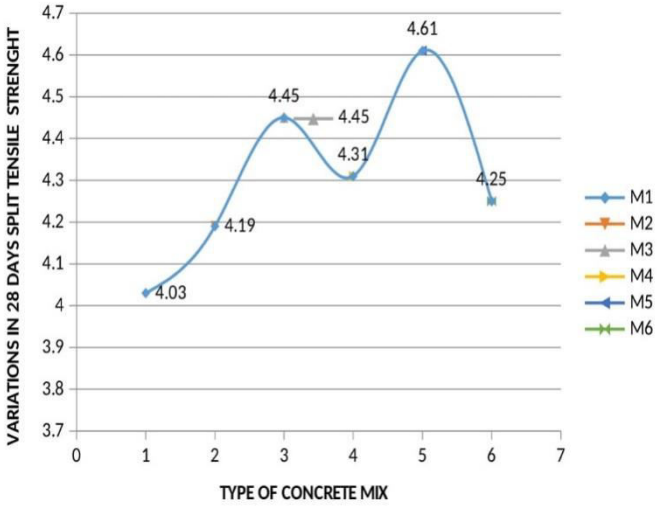

FIGURE 3.5:- 28 Days ST strength curve

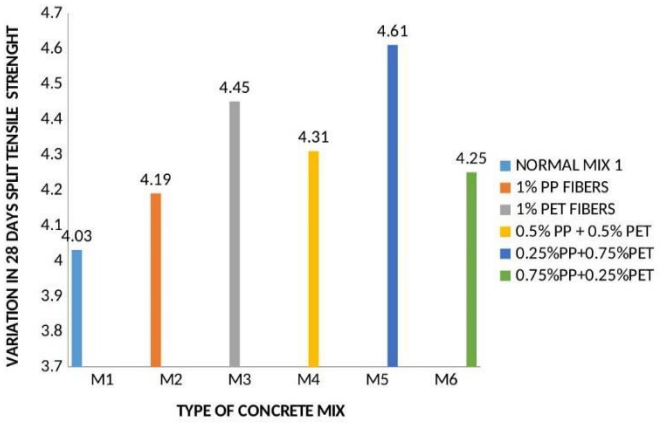

Chart 3.5:- 28 Days STstrength of different mixes (N/mm^2)

- ***Results*:-**ForM2 concrete mix, split tensile strength is increased by 6.56 % and for M3 mix it is increased by 9.12 % and for other three mixes M4, M5 & M6 it is increased by 8.39 %, 12.04 % &7.29 %. Similarly for 28 days results of split tensile strength test is analyzed and found that in mix M2 it is increased by 3.97% &for mix M3, M4, M5 & M6 it is increased by10.42 %, 6.94 %, 14.39 & 5.45 %. Hence the mix

M5 which contain 0.25 % PP fibers and 0.75 % PET fibers gave more strength at 28 days observation.

3.3.3Flexural strength test (FS test):-Flexural strength is also observed after 7 days and 28 days of casing of mixes.

TABLE 3.7:- Flexural strength results analysis

Type of concrete mix	M1	M2	M3	M4	M5	M6
FS after 7days	2.75	3.26	3.33	3.04	3.39	3.26
FS after 28 days	4.53	4.69	4.72	4.57	5.12	4.58
% increase in strength after 7 days	0%	18.54 %	21.09 %	10.54 %	23.27 %	18.54 %
% increase in strength after 28 days	0%	3.53 %	4.19 %	0.88 %	13.02 %	1.10 %

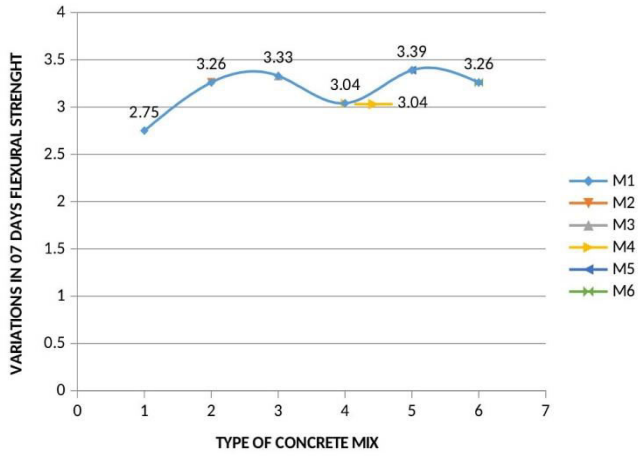

FIGURE 3.6:- 07 Days flexural strength curve (N/mm^2)

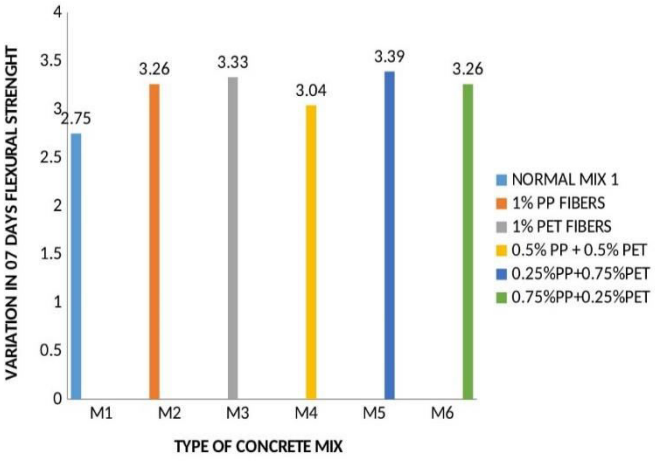

Chart 3.6:- 07 Days FS of different mixes (N/mm^2)

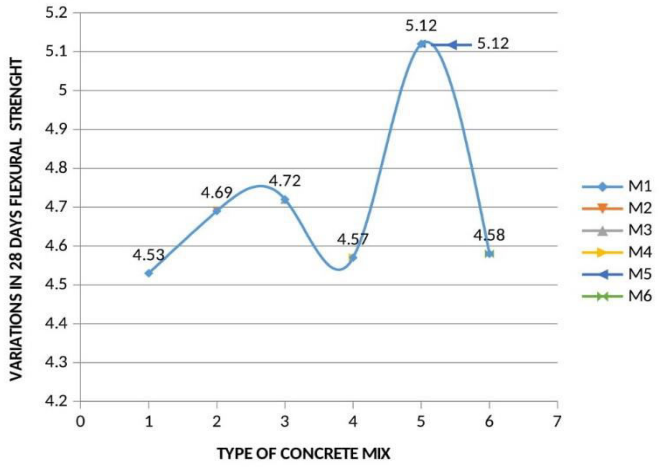

FIGURE 3.7:- 28 Days FS curve

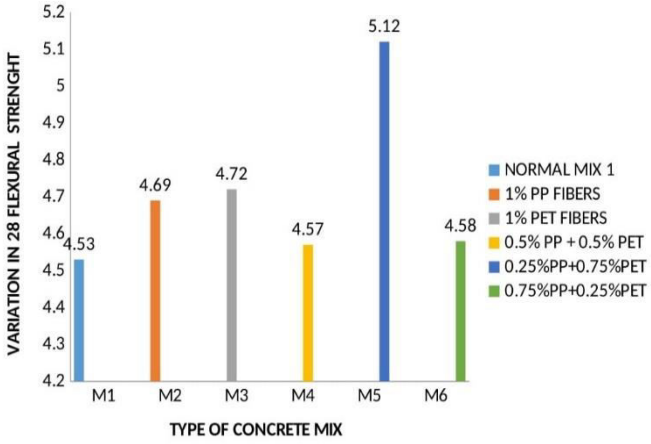

Chart 3.7:- 28 Days FS of different mixes (N/mm^2)

- ***Results*:-**Maximum flexural strength is obtained in mix M5 which contains 0.25% of PP fibers and 0.75% of PET fibers. It is observed that the beams without fibers show brittle failure and the failure is sudden without any sign of pre-deflection on sample. The beams with fibers shows long deflection before failure and it is also observed that cracks are propagated slowly from bottom to upper end of the prism beam.

4. CONCLUSIONS

1) The Workability of concrete mix is decreased with increase in percentage of Polypropylene fibers in concrete. PET fibers also reduce the workability but it is lesser than the workability reduced by Polypropylene fibers in concrete.

2) The strength of concrete mix is increased for the mixes which has higher percentage of PET fibers and lesser percentage of PP fibers. The Strength of concrete mix containing PET and PP fibers is less than the Concrete mix with hybridized fibers etc. The maximum percentage of fibers that can be used in concrete is 1%, which is selected from previous research papers and the hybridization is also done in this 1% range. Mix M5 gave maximum strength in this study which contain 0.75% PET and 0.25% PP fibers in concrete mix.

3) M3 is most economical which has less cost per unit strength but it contain only PET fibers, On the other hand the maximum strength gave by mix M5 is higher than all mixes and its cost is also less than design mix concrete hence it can also recommended for economical point of views.

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