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Study on New Hydrid Engineered Cementitious Composites for Structural Application

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Abstract*: *This paper investigates about the effects of polyvinyl alcohol (PVA) fibres, polypropylene fibers, steel and glass fibers on the workability, compressive and tensile strength of engineered cementitious composite (ECC). The key parameter discussed in this study is the reinforcing index. Strength increases in the member when mixed with PVA, PP, Glass and Steel fibers.higher the ECC, higher the strain capacity of any member. Cubes and dog legged specimens are casted for various mix proportion, tests are carried out. Results showed that hybrid ECC mix attained the reasonable improvement in the mechanical properties.

1. INTRODUCTION:

Engineered Cementitious Composite (ECC) is also called **bendable concrete**, is an easily molded mortar based composite reinforced with specially selected short random fibers mainly polymer fibers. It acts like a ductile metal than a brittle glass . Unlike regular concrete, ECC has a strain capacity in the range of 3–7 %, compared to 0.01% for ordinary Portland cement (OPC). ECC is characterized by a tensile hardening and multiple cracking behavior. In order to attain high ductile Ecc with addition of small fiber content of 2% or less is used.Micromechanical material design is the most convenient method employed to prepare high bendable composite.it is the interaction between fiber, matrix and interface, these properties allow ECC to withstand high tensile flexural and shear load as well as to increase its ductility.The ductilebehaviorallowsECCto createclosely spacedmicro crackswithvery specificwidth. Because ofits micro- crackingbehavior,ECCis highly durable,corrosionresistanceandresistanceto thepenetration ofaggressiveliquids.ECC has the property ofself-healing, the unreacted cementitiousparticlesaftercrackingandexposedtohydration and create a cementitiousproduct,whichwill extendandfill thecracks havingspecificwidths.

2. EXPERIMENTAL DETAILS:

2.1. MATERIALS:

Cement used was ordinary Portland cement (53 grade). Fly ash used was lowcalcium fly ash (ASTM class F) which was obtained from Mettur Thermal power plant. The fine aggregate used was natural sand (river sand) and it sieved with 4.75mm sieve to remove larger particles. Fibers used are polyvinyl alcohol fiber (PVA), polypropylenefiber (PP), and steel fiber (SE), glass fiber (GE) .The properties of these fiber are shown in table 1.

Table 1: Physical Properties of Fibers

S. NO	PROPERTY	PVA	PP	GLASS	STEEL
1	DENSITY	1300 g/cc	900 g/cc	2.54g/cc	7.85 g/cc
2	DIAMETER	39µm	37µm	17Micron m	3 Micron m
3	LENGTH	12mm	6mm	10mm	12mm
4	ELONGATION	6%	23%	3.5%	4.5%
5	COLOUR	WHITE	WHITE	WHITE	GREY

2.2. MIX PROPORTIONING:

Mix proportion based on ECC thesis. Following table gives a typical mix design of ECC with self consolidating casting properties.

Table 2:Various Mix Proportion of Engineered Cementitious Composite

S.NO	MIX	CEMENT	F.A	SAND	S.P	W/C	PVA	PP	GLASS	STEEL
1	M1	0.7	0.3	0.36	0.9	0.35	2.0%	-	-	-
2	M2	0.7	0.3	0.36	0.8	0.35	1.3%	0.7%	-	-
3	M3	0.7	0.3	0.36	0.8	0.35	1.3%	-	0.7%	
4	M4	0.7	0.3	0.36	0.9	0.35	1.3%	-	-	0.7%

2.3. MIXING AND CASTING:

Firstly cement and sand is mixed dryly. Following this fly ash is mixed with this mixture. Water and S.P are mixed in a jar and added to the mix .Finally fibers are added to the mix and

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thoroughly mixed in mixer machine. Then the mix is casted in various mould .After one day the mould is demoulded and cured in water.

2.4. CURING:

The moulds were then demoulded after 24 hours and were left in room temperature until testing. The average temperature recorded during the curing period of the specimen was 23oC.Conventional Cement concrete specimen are demoulded after24 hours and allowed to curing.

3. RESULT AND DISCUSSION:

3.1. MINI SLUMP CONE TEST:

Mini Slump Test is conducting both Conventional and adding Fiber by various percentages. Spread diameter is varied when adding fiber. For Conventional Spread diameter is more compared to fiber adding. The Figure 3 shows comparison of Mini Slump spread with and without Fiber.

With Fiber

Without Fiber

Figure1. Slump Cone Flow Test

TABLE 3 Minimum Slump Test Result for Conventional ECC

S.NO	SUPERP LASTICI ZER	MINI SLUMP SPREAD(mm)	
		5 mins	60 mins
1	0.5	70	45
2	0.6	95	52
3	0.7	100	58
4	0.8	120	66
5	0.9	125	74
6	1.0	128	76
7	1.10	130	77
8	1.20	128	75
9	1.30	127	76

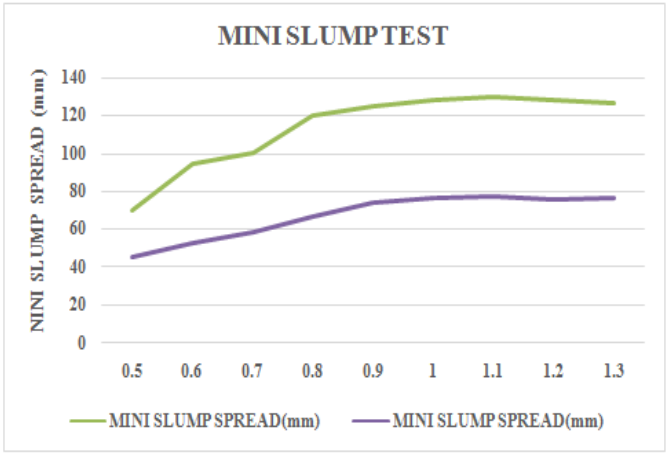

Figure 2.Mini Slump Spread for Various Time Period

From figure 2 it is observed that the slump value get increased when super plasticizer increased.First the slump get increased upto to a specific point and then decreases. This shows the optimum SP value. At which mix exhibit high workability

3.2. COMPRESSIVE STRENGTH:

The compression test on cubes were conducted according to Indian Standard specifications (IS: 516– 1959). Figure 1shows the compressive strength of various mix.

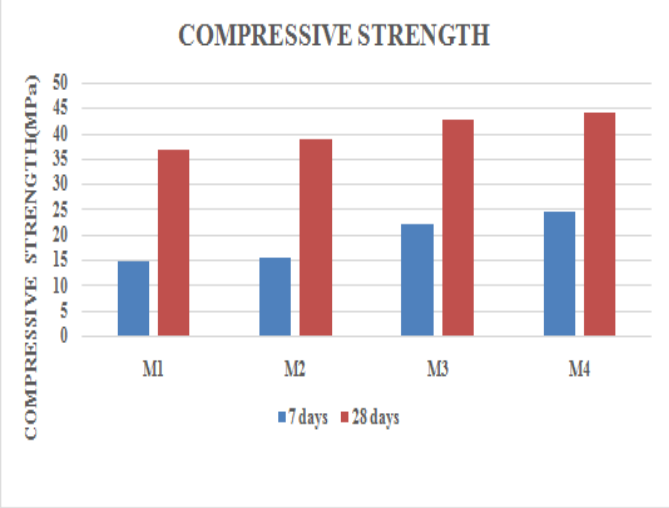

Figure 3.Compressive Strength for Various Mix

DAYS	M1	M2	M3	M4
7 days	14.8	15.4	22.0	24.6
28 days	36.6	38.8	42.6	44.2

From the figure 3, it is clearly seen that the 28 days strength higher than 7 days strength. The strength of M2 mix is 6% higher thanM1mix. Similarly strength of M4 mix is 3% higher than M3 mix. This is due to polypropylene and steel fibers which exhibit high strain capacity.

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3.3. DIRECT TENSILE STRENGTH:

For tensile strength test Dog Bone Specimen is used.The size of dog bone specimens of 330mm x 160 mm x 13 mm.When the mixing process is complete, the fresh workable and cohesive mixture was poured into the moulds for each specimen, which was then vibrated on a vibrating table. The dog bone specimens were demoulded after staying 48hours.

Figure 4 Direct Tensile Strength on Dog Legged Specimen

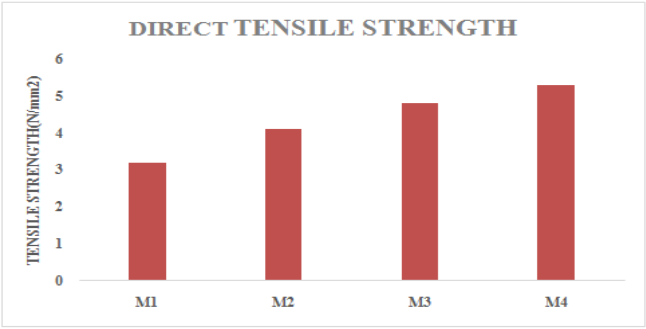

Figure 5.Direct Tensile Strength For Various Mix

DAYS	M1	M2	M3	M4
28 days	3.2	4.1	4.8	5.3

From the figure 5 it is seen that tensile strength of M2 mix is 20% greater than M1 mix, M3mix is 50% greater than M1 mix, M4mix is 65% greater than M1mix. Glass fiber shows high tensile strength than PP. Similarly Steel fiber shows greater strength because of its higher elongation property.

4. CONCLUSION:

- This study has experimentally explored the mechanical properties of a new fiber-reinforced Engineered Cementitious Composite (ECC) reinforced with Glass Fibers, Steel Fibers, PP Fibers, and PVA Fibers respectively. It can be seen from this study that hybridation in ECC produces greater strength.
- It is also observed that the fiber dispersion in both ECC matrixes was distributed evenly in the fractured section and bridging of the fiber was in action in the cracks.
- An ECC mixture proportion with satisfactory in workability and strength aspects. Among the Fibers used Glass Fiber showed better result by the increased strength when compared to the mono fiber ECC and other mixes. The increased Strength may be due to the young's modulus of the Glass Fiber.

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