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Sustainable Development of Rigid Pavement by Using Polypropylene Fiber

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ABSTRACT

This paper presents facts about various research activities that are taking place around the world since the last one decade on development and study of behaviour of Engineered Cementitious Composites (ECC) using polypropylene fiber. Hence in this research work study the behavior of ECC using polypropylene fiber incorporating with Fly ash. In the prepared mix design o%, 1%, 2%, 3%, 4%, 5% of polypropylene fiber is used. Also 30%, 40% and 50% Fly ash is replaced with cement. The experimental study is to present the effect of addition of polypropylene fiber and replacement of Fly ash with cement on the behavior of concrete under compressive and tensile test.

Keywords: polypropylene fiber, ECC , fly ash, M20 mix design.

I. INTRODUCTION

Concrete is the most popular construction material, with more than 11.4 billion tons of concrete consumed annually worldwide. It has been reported that 2.2 billion tons of cement was produced in the year 2005. It was estimated that each ton of cement produced generates an equal amount of carbon dioxide, a major contributor for greenhouse effect and global warming. Ordinary Portland cement, though costly and energy intensive is the most widely used ingredient in the production of concrete mixes. Unfortunately, production of cement itself involves emission of large amounts of carbon dioxide into the atmosphere, a major contributor for greenhouse effect and global warming. Hence, it is inevitable either to search for another material or partly replace it by an alternate material. For example, Pozzolana is a natural or artificial material containing silica in a reactive form. It may be a siliceous or siliceous and aluminous material which in itself possesses little or no cementitious value. Pozzolana, in finely divided form and in the presence of moisture, reacts with calcium hydroxide at ordinary temperature and form compounds possessing cementitious properties.

Unlike some high performance FRC, ECC does not utilize large amounts of fiber. Also by deliberately limiting the amount of fibers, a number of proprietary studies have concluded economic feasibility of ECC in specific structural applications. Various fiber types can be used in ECC, but the detail composition must obey certain rules imposed by micromechanics considerations (Li, 1998; Kanda and Li, 1998). This means that the fiber, cementitious matrix, and theinterface (mechanical and geometric) properties must be of a correct combination in order to attain the unique behavior of ECCs. Thus ECC designs are guided by micromechanical principles. Most data so far has been collected on PVA-ECC (reinforced with PolyVinyl Alcohol fibers) and PE-ECC (reinforced with high modulus polyethylene fibers).

II. LITERATURE REVIEW

Ms. E. Ramya et.al [1] present the properties of ECC provides better properties in seismic resistance application. In this present work they investigate deflection and mechanical properties of ECC for different proportion of polypropylene fiber and compare with conventional concrete. Also find out the compressive strength and tensile strength of cube and cylinder.

Xiaoyan Huang et.al [2] in this paper reports the results of an initial attempt of using iron ore tailings (IOTs) to develop greener engineered cementitious composites (ECCs). ECC is a unique class of high-performance fiber-reinforced cementitious composites featuring high tensile ductility and durability. They replaced the cement with iron ore tailings (IOTs) to check the environmental sustainability of ECC. Mechanical property of ECC is check by the author.

III. MATERIAL

Ordinary Portland cement

Ordinary Portland cement (often referred to as OPC) is the general type of cement in use around the world, because it is the basic key ingredient for making concrete, mortar, stucco and most of the grouts specially prepared for specific purpose. It is made by intergrinding of argillaceous and calcareous materials.

Physical properties of OPC

Fineness

Particle fineness of Portland cement affects rate of hydration, which affects the rate of strength gain. Smaller is the particle size, the greater is the surface area-to- volume ratio, means more area is available for the reaction of water-cement per unit volume.

Soundness

The ability of a hardened cement paste to retain its shape after setting is known as soundness. The cement samples containing excessive amounts of free lime are subjected to volume change. Soundness of cement is determined by using Le chartliars equipment.

Consistency

The ability of cement paste to flow is known as consistency. The cement paste consistency is determined by using Vicat apparatus when the plunger penetrates by 10±1 mm and the corresponding water-cement ratio is reported as the Std consistency of cement.

Setting Time:

Initial setting time is defined as the time that elapsed from the instant of adding water until the pastes behave as plastic material thus offering resistance against the penetration. Whereas final setting time referred to be the time that is required for the cement paste to reach a certain state of hardness to bear some load and is tested by using Vicat apparatus.

Specific gravity:

The particle density which is measured by excluding the air between particles of OPC is found to be in the range of 3.1 to 3.25. The density of cement is determined by density bottle apparatus and here kerosene is used.

Sand

Good river bank sand in absence of any earthy matter and organic matter. Particles are angular in shape passing 250 micron and retaining 150 micron standard sieve. Sample is washed in water to get free from silty and earthy and other organic content and dried over a period of 48 hours of sunlight.

Water

Water which fits for drinking purpose is considered for mixing the ingredients, and should be free from suspended impurities and foreign matters such as acids, alkalis. Water plays two key roles in a concrete mix. Firstly, it chemically reacts with constituents of cement to form paste where paste holds aggregates in suspension phase until paste hardens. Secondly, it act as lubricant in mixing of ingredients.

Fly ash

In the coal powered power generating plants the exhaust gases which comes out after burning is treated with electrostatic precipitators and the fine particles that collected in it is known as flyash and the ash which doesn't comes out with the exhaust flue gases is termed bottom ash. Fly ash constitutes substantial amount of silicon dioxide (SiO_2) in the form of both amorphous and crystalline form and calcium oxide (CaO), both being effective ingredients in many coal-bearing rock strata.

Super plasticizer

This is used to improve the rheological properties of fresh concrete. Super plasticizers are the additives to fresh concrete which helps in dispersing constituents uniformly throughout the mix. This is achieved by their deflocculatiion action on cement particles by which water entrapped is released and is available for workability. Super plasticizer increases slump properties from 5cm to 20cm without addition of water and thereby reducing the water requirement by 15 to 20 percent. This results in improvement of vital properties like density, water tightness. Where sections are having closer reinforcements, the use of super-plasticizer increase workability and no compaction is required. The permeability of concrete is key property which contributes to durability ,the use of superplasticizer increases workability maintaining low water to cement ratio. The permeability of cement paste reduces considerably with reduction in water to cement ratio. Thus super plasticizer can be used effectively to improve various properties of concrete and to avoid defects like honeycombing.

Fibers

The high performance fiber reinforced cementitious composite is characterized by the presence of fibers in a less quantity compared to FRC .Generally the fiber used in ECC is PVA ,One of the remarkable characteristics of this fiber is capable of strong bonding with cement matrix. The layer of $Ca(OH)_2$ called as Interfacial transition zone is formed round PVA fiber and is formed as white part, and in case of poly propylene, and glass it is not observed . It is known PVA makes complex cluster with the metal hydroxide of cement matrix. It is pursued that Ca^+ and OH^- two different ions in the cement slurry are attracted by PVA fibers and makes layer of $Ca(OH)_2$ around the fibers and hence the $Ca(OH)_2$ layer plays an important role for bonding strength between the fiber and the matrix. However there is an absence of some surface coating around the Poly propylene fibers and glass fibers which are possessing high tensile strength but they are not coated with any epoxy and they are susceptible for alkali environment of matrix this makes us to do an experimental study by selecting these fibers.This paper present literature review on the performance of ECC material use for sustainable development of rigid overlay pavement. In this paper most of the literature shows the effect of ECC material in flexural and tensile test. Ordinary concrete is more costly then the ECC concrete. Also in the production of ordinary cement involves large amount of CO emission. When in the ECC concrete use pozzollanic material for replace the cement. So ECC is the greener concrete.

IV. MIX DESIGN

Compressive and tensile strength review was taken on the basis of experimental study. Mix design is prepare based on IS 10262-2009.

Constitute detail			M25					
			40% fly ash					
			0% P.P	1% P.P	2% P.P	3% P.P	4% P.P	5% P.P
Cement		Kg/m3	240					
Fly Ash		Kg/m3	160					
Sand		Kg/m3	858					
Coarse Aggregate	20 mm	Kg/m3	513					
	10 mm	Kg/m3	342					
fiber		gm	0	301	603	904	1205	1506
Admixture (SP)		Litre / m^3	5.2					
Water		m^3	0.161					
		Litre	161					
W/P ratio		-	0.40					

Constitute detail			M25					
			50% fly ash					
			0% P.P	1% P.P	2% P.P	3% P.P	4% P.P	5% P.P
Cement		Kg/m3	200					
Fly Ash		Kg/m3	200					
Sand		Kg/m3	852					
Coarse Aggregate	20 mm	Kg/m3	512					
	10 mm	Kg/m3	341					
fiber		g/m3	0	425	850	1274	1699	2124
Admixture (SP)		Litre / m^3	5.2					
Water		m^3	0.161					
		Litre	161					
W/P ratio		-	0.40					

GRADE	W/(C+FA) RATIO	FLY ASH	FIBER	SLUMP IN (mm)	Flow at T50 cm (sec)
M25	0.4	50%	0	683	3.2
			1	671	3.3
			2	670	3.8
			3	687	3.7
			4	714	4.1
			5	682	4.8
		40%	0	694	2.8
			1	692	3.1
			2	671	3.5
			3	673	3.6
			4	660	3.5
			5	652	4.2

V. EXPERIMENTAL RESULTS

Above table shows the slump test result.

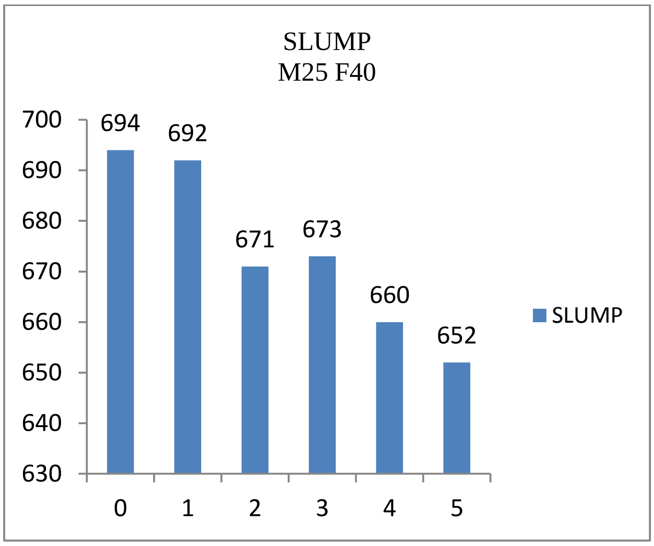

Figure 1: Slump Test M25 F40

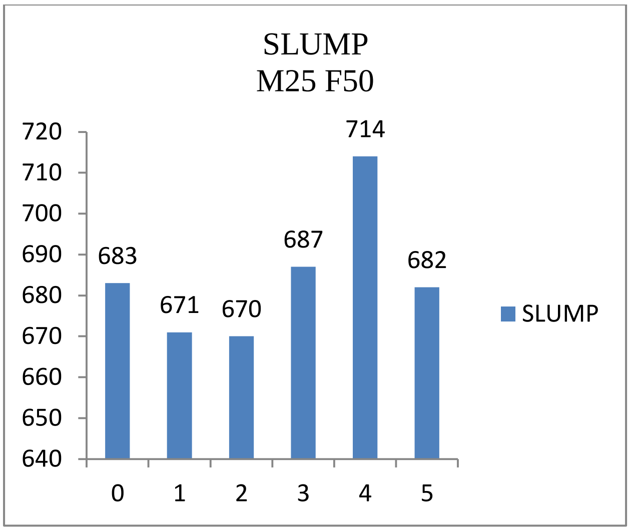

Figure 2: Slump Test for M25 F50

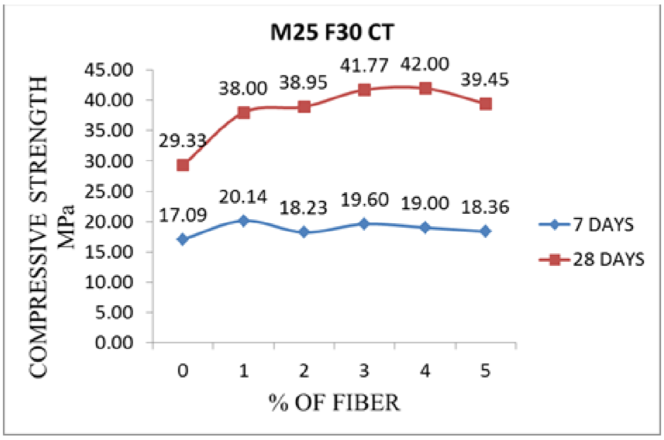

Figure 3: Comparison between 7 & 28-days compressive strength (MPa) for M25 F30

Figure 3 shows that there is an increase in compressive strength at 28 days as compared to 7 days and compressive strength achieved by using fly ash (30%) and polypropylene (5%) is 42.67 MPa at 28 days.

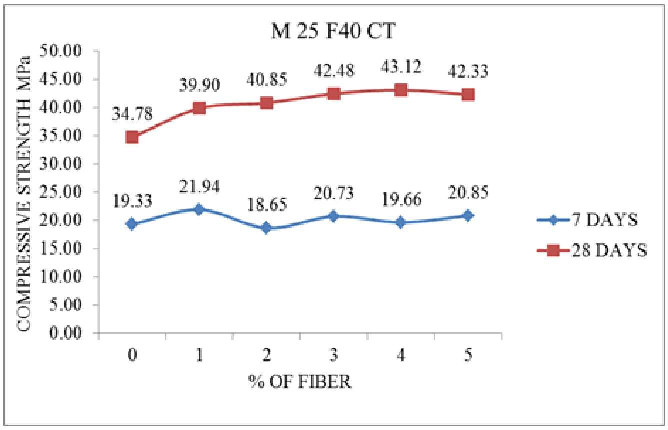

Figure 4: Comparison between 7 & 28-days compressive strength (MPa) for M25 F40

Figure 4 shows that there is an increase in compressive strength at 28 days as compared to 7 days and compressive strength achieved by using fly ash (40%) and polypropylene (4%) is 42.67 MPa at 28 days.

The result shows that in the 40% replacement of fly ash early strength of concrete is decreases but after 28 days strength is increases than the compressive strength is acceptable as per IS 456:2000 due to adding the polypropylene fiber and maximum compressive strength achieved by using fly ash (40%) and polypropylene (4%) is 43.12 MPa at 28 days.

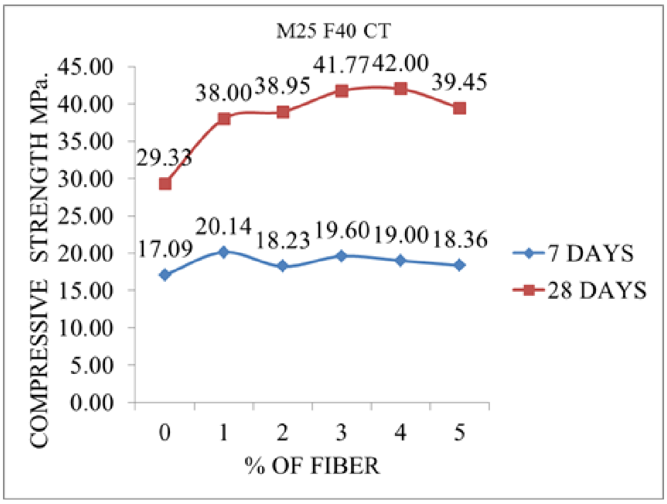

Figure 5: Comparison between 7 & 28-days compressive strength (MPa) for M25 F40

The result shows that in the 50% replacement of fly ash early strength of concrete is decreases but after 28 days strength is increases than the compressive strength is acceptable as per IS 456:2000 due to adding the polypropylene fiber and maximum compressive strength achieved by using fly ash (50%) and polypropylene (4%) is 42.00 MPa at 28 days.

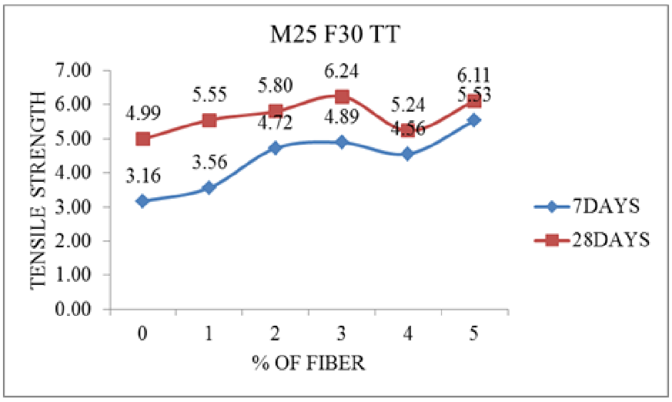

Figure 6: Comparison between 7 & 28-days tensile strength (MPa) for M25 F30

Figure 6 shows that the strength gain up to 28 days is higher than the tensile strength is acceptable as per IS 456:2000 and maximum tensile strength achieved by using fly ash (30%) and polypropylene fiber (3%) is 6.24 MPa. when the % of fiber increases tensile strength will be increases after 28 DAYS strength.

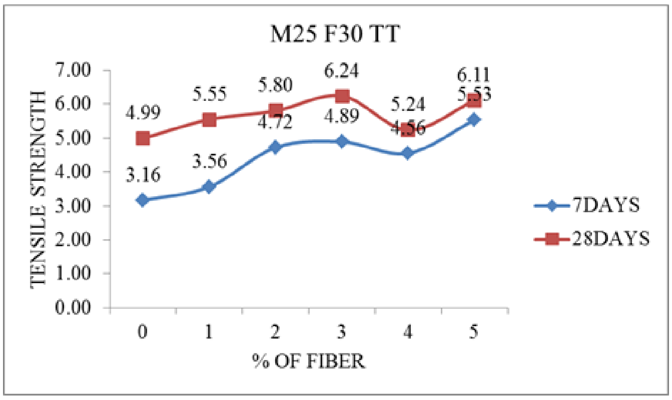

Figure 1: Comparison between 7 & 28-days tensile strength (MPa) for M25 F40

VI. CONCLUSION

This paper present literature review on the performance of ECC material use for sustainable development of rigid overlay pavement. In this paper most of the literature shows the effect of ECC material in flexural and tensile test. Ordinary concrete is more costly then the ECC concrete. Also in the production of ordinary cement involves large amount of CO emission. When in the ECC concrete use pozzollanic material for replace the cement. So ECC is the greener concrete. With addition of polypropylene fiber increasing the 28 days strength to be as high as 40 Mpa with 40% and 50% fly ash in concrete mix replacing cement.

VII. REFERENCES

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