EFFECT ON CONCRETE WITH ENGINEERED CEMENTITIOUS COMPOSITE USING POLYPROPYLENE FIBRE.

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Abstract- An Engineered Cementitious composite is a high ductile cementitious composite which possess high crack resistance, tensile strain capacity which surpasses property of normal concrete. Engineered Cementitious Composites are kind of a Fiber Reinforced Concrete, but in ECC the fiber percentage is optimized to get the better performance and absence of coarse aggregates reduces transition zone effect thus altering behaviour of ECC. In this experiment an attempt is made to study the interaction of poly propylene fibers with the matrix prepared by incorporating the mineral admixture Metakaolin. In this experiment flexural tests were carried out to examine the behaviour with different percentage of fibers.

Keywords - ECC, poly propylene fibers, metakaolin, super plasticizers

I. Introduction

Engineered Cementitious Composites (ECC also known as bendable concrete), developed in the last decade, may contribute safer, more durable and sustainable concrete infra-structure that is cost-effective and constructed with conventional construction equipment. With two percentage of short fibers, ecc has been prepared.

ECC is ductile in nature. Under flexure, normal concrete fractures in a brittle manner. In contrast, very high curvature can be achieved for ECC at increasingly higher loads, much like a ductile metal plate yielinding. Thus improving tensile strain capacity 3-7% for ECC containing 2% fiber by volume. Micromechanial interaction recounts macroscopic properties of the microstructure of composite and forms spine for ECC material design theory. Especially books for microstructure tailoring of ECC along with material optimization.

II. Objectives

A. To investigate the properties of ingredients of Engineered Cementitious composites (ECC)

B. To investigate the Mix Design of ECC

C. To investigate the hardened properties of the ECC

D. To check the ductile behavior of the concrete.

III. Ingredients of ECC Concrete

A. Cement

Cement is a binding material that sets and hardens independently, and can bind other materials together. It hardens and attains strength from chemical reaction with the water known as hydration. The grade 43 ordinary Portland cement is used for this research work.

B. Fine Aggregate

Normal dry river sand is used as a fine aggregate, the sand passing through IS 4.75mm sieve with fineness modulus of 2.87 and specific gravity of 2.62 is used as a fine aggregate.

C. Superplasticizer

Super plasticizer used is Melamine Formaldehyde Sulphonate. This is used to control rheological properties of fresh concrete. Super plasticizers are additives to fresh concrete which help in dispersing the cement uniformly in the mix. This is achieved by their deflocculating action on cement agglomerates by which water entrapped in the groups of cement grains is released and it is available for workability. Typically super plasticizer increase slump from say 5cm to about 18-20cm without addition of water. When used to achieve reduction in mixing water they can reduce water up to 15-20% and hence decrease W/C ratio by same amount. This results in increase in strength and other properties like density, water tightness. Where thin sections are to be cast super plasticizer can increase workability to pump able level and almost no compaction is required. This help in avoiding honeycombing. The permeability of concrete is a guide to its durability. Gross porosity is usually due to continuous passage in the concrete due to poor compaction or cracks which can be minimized by the use of super plasticizer, the incorporation of which provides increased workability maintaining low w/c ratio. It is reported that coefficient of permeability of cement paste reduces considerably with the reduction in w/c ratio. Thus super plasticizer can be used effectively to improve the properties of concrete and avoid defect. Melamine based Super plasticizer are used to assess their effectiveness in improving durability. Melamine based super plasticizer are reported to be the best and hence chosen for the research work..

D. 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.

F. Poly Propylene Fiber (PPF)

Fibers are normally used in concrete to control the cracking due to both plastic shrinkage as well as drying shrinkage. The function of the polypropylene fiber mixed into concrete is to avoid the creation of micro cracks in the concrete thus imparting ductility to it. Polypropylene fibers are used in concrete is to obtain a much better, and more stable surface and also more surface resistant piece of concrete. It reduces the danger of micro cracks dramatically thus increasing the life of the structure. Polypropylene fibers in concrete, is in diameter of range 22 to 35 micron by 19mm long, which reduces the flow of water through the concrete matrix thus preventing the ingress of water through the normal modes e.g. capillaries,porestructures,etc

G. Metakaolin

It's a pozzolonic additive/product which can provide many specific features. Its available in many different varities and qualities. The purity will define the binding capacity for free lime. Some of them also provide special reactivity.

Metakaolin is a valuable admixture for concrete and cement applications. Usuallly 8%- 20% (by weight) of Portland cement replaced by metakaolin. Such a concrete exhibits favorable engineering properties. The pozzolanic reaction starts soon and continues between 7 to 28 days.

IV. Material Properties

A. Property of cement

IS mark 43-grade cement was used for all ECC mixes. The cement used was fresh and without any lumps. Testing of cement was done as per IS:12269-1987. The various tests results conducted on the cement reported below,

Table I – Property of cement

SL no.	Property	Cement
1.	Fineness modulus	3.5%
2.	Consistency	32.5%
3.	Initial setting time	36mins
4.	Final setting time	10 Hours
5.	Specific Gravity	3.11

Table II – Property of polypropylene fiber

Sl no.	Property	PPF
1.	Tensile strength(MPa)	500~700
2.	Young's modulus(GPa)	6~7
3.	Fiber elongation(%)	20
4.	Specific gravity	0.91

Table III.Properties of Metakaolin

Sl no.	Property	Metakaolin
1.	Specific gravity	2.50 g/cm^3
2.	color	white
3.	Physical form	powder
4.	+325 Mesh(45µ) residue	<1.0%
5.	Average Particle size	<2.5µm

V. Mix Design

There is no standard procedure for calculating the mix design for ECC. The mix design procedure was mainly based on the micromechanical modelling of composite materials, various authors have proposed the different mix proportions of ECC based on workability criteria. The Std mix design procedure adopted by most of the scientists are the mix design proposed by Dr.Victor.c.li

Proportion Of Concrete:

The inital mix proportion was 1:0.8:1.19, PPF fiber 1% and super plasticizer dose was 1040.47 ml/bag an water to cementitious material ratio was 0.274. but by using this proportion workability was not achieved. Hence for second trail, the mix proportion was changed to 1:0.9:1.1 and PPF fiber Percentage increased to 1.2% by keeping same dose of super plasticizer and increasing water to cementitious material ratio to 0.3048. Third trial mix proportion was 1:1:1 and PPA fiber 1.2%, super plasticizer dosage was reduced to 600ml/bag and water to cementitious material ratio was 0.33. Forth trial mix proportion was 1:0.9:1.1, PPA fiber percentage 1.2%, super plasticizer dosage 600ml/bag along with water to cementitious material ratio was 0.3118. To achieve workability various trials were taken. In fourth proportion super plasticizer dose was reduced to obtain workability. For each trial mix, 3 cubes were casted and cured using the accelerated curing tank & were tested to obtain desired strength requirement. After testing cubes for each trial, the trail mix no. 3 was considered as most suitable & hence the final mix proportion. However in order to increase the

workability of concrete the water to cementitious ratio was increased to 0.35.

Casting Procedure of ECC- Concrete

The performance of the ECC Concrete was influenced by the mixing. This means that a proper & good practice of mixing can lead to better performance & quality of the ECC Concrete. The quality of the concrete is also influenced by the homogeneity of the mix material Flexural Test on Slab during the mixing & after the placement of fresh concrete. A proper mix of concrete is encouraged to the strength of concrete & better bonding of cement with the PVA fibers. Once the concrete mix design was finalized, the mixing was carried out. The mixing of ECC Concrete was carried out by using hand mixing. The procedure of hand mixing was as follows:-

Add sand, cement, 50% of fly ash & 50% water &super plasticizer.Add slowly remaining quantity of fly ash, water &super plasticizer. Once the homogenous mixture is formed, add the PVA fibers slowly. Mix all the constituents till the fibers are homogenously mixed in the matrix.

Table IV – Material proportioning for cube

	Ratio	Kg/m^3	Per cube
cement	1.0	587	166gms
metakaolin	1.2	704.6	199gms
sand	0.8	469.9	132.8gms
water	0.56	299.7	87.89ml
HRWR	0.012	17.31	5ml
Fiber (vol %)	0.02	Based on density of fiber	6.7gms for 2%ppa

Note: the water content for meta Kaolin based mix is 105ml.

VI. Testing of Specimens

A. Compression test on cubes

The test is done on 7^{th}, 14^{th}, 28^{th} day of curing to determine the compressive strength of concrete specimens as per IS: 516 – 1959. Three cubes are tested in each proportions and the average value of the three cubes are taken as their compressive strength. The compressive strength of the cube is determined by the following formula and expressed in terms of N/mm^2.

$$\text{Compressive strength} = \frac{Maximum\ load}{Area}$$

Table V – Compressive strength of cubes

Percentage of replacement	Compressive strength N/mm^2		
	At 7^{th} day	At 14^{th} day	At 28^{th} day
Conventional Concrete	20.5	25.4	32.33
1.0%	21.54	27.1	34.58
1.5%	24.27	29.5	38.85
2.0%	25.3	31.64	39.25

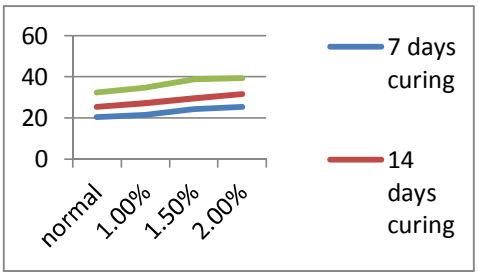

Fig.2 - Compressive Strength of cubes

B. Split tensile test on cylinders

The test is done on 7^{th}, 14^{th}, 28^{th} day of curing to determine their split tensile strength. The specimens are placed horizontally between the loading surface of the Compression testing machine and the load is applied till the specimens fails. The ultimate load at the time of the failure is noted down.

Horizontal compressive strength = $2p/\ LD$

Where p is the compressive load

L is the length of the cylinder

D is the diameter of the cylinder

Table VI – Split tensile strength of cylinders

Percentage of replacement	Tensile strength N/mm^2		
	7^{th} day	14^{th} day	28^{th} day
Conventional Concrete	2.49	2.68	3.25
1.0%	2.82	3.5	3.87
1.5%	3.56	3.81	4.12
2.0%	3.61	3.94	4.32

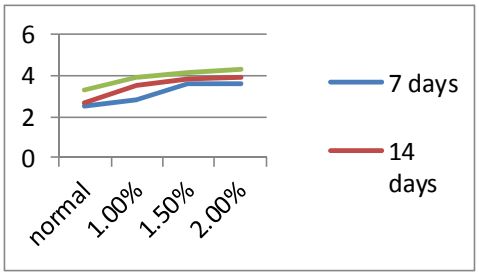

Fig.2 – Tensile strength of cylinders

VII. Conclusion

From the results obtained from the various tests, the following conclusions were made,

The experimental work had been carried out with Poly Propylene fibers with mineral admixtures as Metakaolin and the fiber is varied in between 1% to 2% .

The Metakaolin based mix requires more water.

Optimum percent of poly propylene fibers in metakaolin mix it is found at 2%.

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