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Article

Effect on Tensile Strength of ECC by Partial Replacing Cement with Slag Sand

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A B S T R A C T

Bendable concrete also known as Engineered Cementitious Composite (ECC) is class of High Performance Fiber Reinforced Cementitious Composite (HPFRCC) next to the DUCTAL. The aim of this study is to investigate the properties of ECC with normal Cement Concrete (CC) & also the effect of partial replacement of cement by 10%, 20%, 30% by slag sand less than 500 micron. Then it is tested of split tensile strength. The splitting test is much used method to determine the tensile strength of concrete which greatly affect the extent & size of cracking in structure.

Keywords: Engineered Cementitious Composite, Slag Sand, PVA Fibers, Cement Concrete, HPFRC

Introduction

ECC is developed by Dr. Victor. C. Li at the University of Michigan. ECC is made up from basic ingredients cement, silica sand, Poly Vinyl Alcohol (PVA) Fiber, superplastisizer. Fly ash, slag, silica fume is also used with cement to increase paste content.

Engineered Cementitious Composite (ECC) is application at construction sites. It should also check the possibility of partial replacement of cement and sand with slag sand obtained as waste product by the iron industries to developed in 2001 by Vector . C. Li to increase the ductility of the normal Cement Concrete (CC). It is class of High Performance Fiber Reinforced Cementitious Composite (HPFRCC) with high ductility 3-5%.

Figure 1.Poly Vinyl Alcohol Fiber

Literature Review

There have been various theoretical and practical modelling performed on the topic of Engineering Cementitious Composite (ECC) some of the studies performed in this field. The study on Ductile concrete using ECC by U.L.Deshpande in 2016, then performs experimentally on concrete by partial replacement on cement by coarse aggregate was carried out by J.Mohammed abdul. In 2015, Badrinarayan Rath & Deo had studied on review on possibility of Sustainable Engineered Cement concrete. Dr. A. W. Dhawale & joshi had studied on ECC for Structural Applications. Before that Dr.Victor C. Li in 2007 had studied ECC Material, Structural, and Durability Performance. After studying the literature on Engineering Cementitious Composite it has been reviewed that there is less literature available on ECC and also as it is new concept to make concrete ductile many research is going on in Japan, USA and others. But it has less scope in Indian construction industry due to availability of PVA fiber. The problem and objective were formulated accordingly.

Methodology

In present study is an experimentally approach, the aim of work to prepare concrete (mortar) known as Engineered

Cementitious Composite which has high strain capacity, flexible, less hazardous light in weight.

Materials

Cement: Cement used is generally Ordinary Portland Cement with flyash or Portland Pozzolona Cement (PPC). PPC of 53 grades is used.

Silica Sand: Sand is naturally occurring granular material composed of finely divided rock and mineral particle. Silica sand is used passing from 1.18mm sieve is used. Its density is about 2.6.Properties of Silica sand is given below in Table I.

Table 1.Properties of silica sand

Colour	Brown/ Yellowish
SiO_2	96.90%
Fe_2O_3	0.29%
Al_2O_3	1%
K_2O	0.07%
Turbidity	<100
Hardness	6-7 Mohr
Attrition loss	Below 1% in 100 Hrs backwashing
Acid Solubility	Below 2% (24Hrs in 20% HAL)
Density of sand	2.65gm/cc

Poly Vinyl Alcohol (PVA) fiber: PVA fiber has high strength and modulus of elasticity compared to other general organic fiber. It is of length 5- 6 mm length with elongation 6-10 % . One of remarkable property is strong bond with cement matrix because of formation of layer of Ca(OH)2 called Interfacial Transition Zone , which not observed in other fiber such as Poly Propylene (PP) Fiber. PVA fiber from China was used.

Super Plasticizer: This is utilized to control reological properties of fresh concrete Zentoament FBV was used as superplastisizer

Water: Potable water is suited and used for concrete mix. It should be free from alkali, oil, grease or other impurity.

Slag Sand: Slag sand is waste product from the iron industry Slag sand is also sieved from 1.18 mm sieve.Slag sand from Bhagvati Ferro Metal Pvt. Ltd , Sinnar is used. Properties of slag sand is given below.

Table 2.Properties of slag sand

Loss on Ignition at 900^0C	5.20%
Silica	44.25%
Alumina	9.10%
Iron Oxide	24.10%
Calcium Oxide	4.60%
Magnesium Oxide	0.40%
Chromium Oxide	NIL
Total Alkalis	2.80%
Magnese Oxide	8.10%
Phosphorous Pentaoxide	0.32%

Figure 2.Slag Sand

Mix proportion of ECC

The mix design for ECC Concrete is basically based on micromechanics. PVA fiber is order of thousands of nanometre in diameter and few millimetre in length. However the micromechanics based mix design requires pull test to be carried on the PVA fibers, which is not possible in the laboratory. Hence the ideal mix proportion given in the literature of ECC-ECC Concrete was used as the guidelines to determine the proportion of various constituents in the concrete. The ideal Mix proportion which was taken as reference is given below in Table 3.

Figure 3.ECC Cylinders

Table 4.Mix proportion

Mix	Cement	Sand	Slag	PVA (%)	Super-plasticizer (%)	W/C ratio
ECC	1	1	0	1.5	2	0.35
ECC 10	0.9	1	0.1	1.5	2	0.35
ECC 20	0.8	1	0.2	1.5	2	0.35
ECC 30	0.7	1	0.3	1.5	2	0.35

Results

Tensile Test

The tensile strength of concrete is one of the basic and important properties which greatly affect the extent and size of cracking in structures.

Moreover,the concrete is very weak in tension due to its brittle nature. Hence. it is not expected to resist the direct tension. So, concrete develops cracks when tensile forces exceed its tensile strength.

Therefore, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack.

Furthermore, splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete.The procedure based on the ASTM C496 (Standard Test Method of Cylindrical Concrete Specimen) which similar to other codes lik IS 5816 1999.

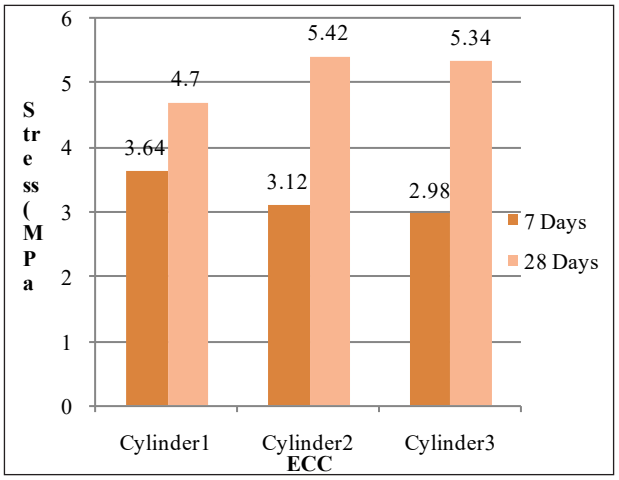

Figure 4.ECC Cube strength after 7 days and 28 days

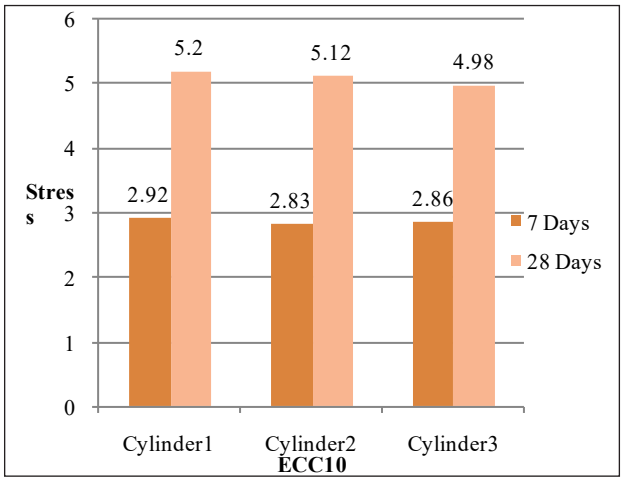

Figure 5.ECC10 Cube strength after 7 days and 28 days

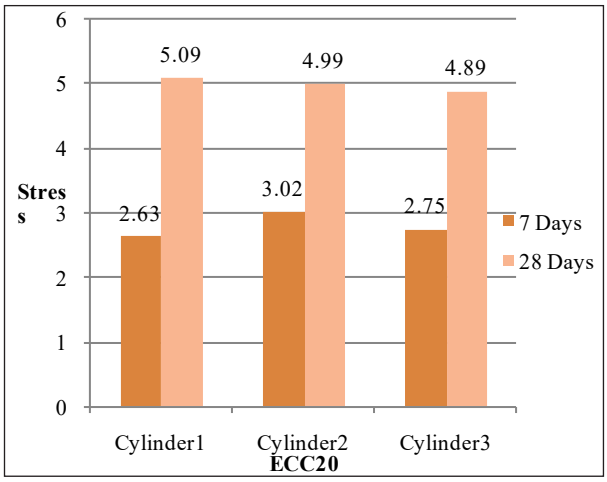

Figure 6.ECC20 Cube strength after 7 days and 28 days

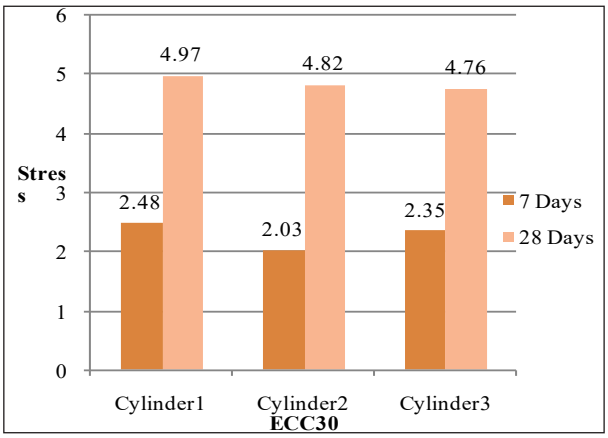

Figure 7.ECC30 Cube strength after 7 days and 28 days

Table 4.ECC, ECC10, ECC20 and ECC30 cylinder strength after 7 days and 28 days

	7 days (Average)	28 days (Average)
ECC	3.38	5.15
ECC10	2.87	5.10
ECC20	2.8	4.99
ECC30	2.28	4.85

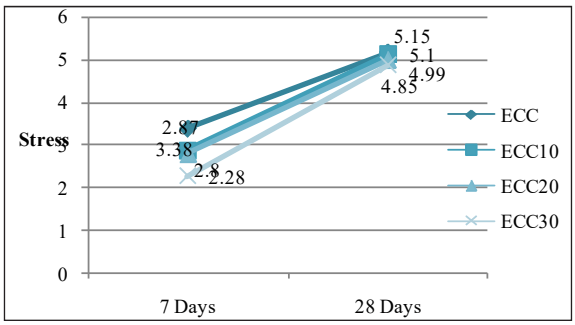

Figure 8.Comparison of Split tensile strength for ECC, ECC10, ECC20, ECC30 after 7 days and 28 days

Conclusion

The split tensile strength of ECC 10 is 84.91% of ECC after 7 days and 99.02 % after 28 days.The split tensile strength of ECC 20 is 82.84 % of ECC after 7 days and 96.89 % after 28 days.The split tensile strength of ECC 30 is 67.45 % of ECC after 7 days and 94.17 % after 28 days. Using slag sand as replacement of silica sand and partial replacement of cement decreases the cost and also keep the strength equal to ECC. ECC proved to be equal in strength that of CC in compression but split tensile strength increases.

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