# Comparative Study of ECC and CC on basis of compression and tensile strength.

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**ABSTRACT**

*Bendable concrete also known as Engineered Cementitious Composite (ECC) is class of High Performance Fiber Reinforced Cementitious Composite (HPFRCC) next to the DUCTAL.ECC is new emerging material from last decade developed by Vector .C. Li at University of Michigan in 2001.It has property of strain hardening.It's main constituent is Poly Vinyl Alcohol (PVA) fiber .Because of so small diameter about thousands of millimetre and 5-6 mm length it form homogeneous matrix. Thus instead of showing Griffith crack it shows steady state cracking. The aim of this study is to investigate the properties of ECC with normal Cement Concrete(CC) based on micromechanical design with low fiber volume fraction less than 2%.Cubes and cylinders of both ECC and CC are cast and tested for compression and tensile strength.The results of ECC are compare with normal CC and graphs are ploted.*

**Keyword:** - *Engineered Cementitious Composite , ECC, PVA FIBERS, Cement Concrete, HPFRCC*

## 1. INTRODUCTION

Ordinary Cement Concrete (CC) has high compressive strength and thus it is strong in compression but with very low tensile strength. CC is brittle in nature, so to reduce its brittleness use of short steel fibers start since 1960. This development has continued with the addition of variety of fiber as glass, natural fiber, carbon, synthetic.

Beginning as early in 1980's , Fiber Reinforced Concrete (FRC) material with tensile ductility has developed. FRC is with use of discontinuous fibers at high dosage (4-20%) give response of tension softening. Next to the FRC , separate class with different degree of ductility are achieved accompanied with strain hardening property is High Performance Fiber Reinforced Cementitious Composite (HPFRCC). HPFRCC class has most of the material without coarse aggregate, thus regarded as Fiber Reinforced Cement Paste or mortar.

Recently two new class are developed of HPFRCC namely DUCTAL and ECC. Ductal with high tensile strength 12 MPa and a ductility 0.02- 0.06 % and ECC with moderate tensile strength of 4-6 MPa and higher ductility of 3-5 %.

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

## 2. Scope and Background

ECC is class of ultra high ductile concrete, thus acts more than metal than glass i.e flexible instead of brittle. Cement concrete is totally brittle in nature and suffer catastrophic failure when strained during earthquake. ECC thus safe in place of normal CC with high tensile strain and low volume fraction.

Also CC shows behaviour of Griffith crack, thus widening crack which is ease to entry of water detoriates the steel in it, lowering the strength. ECC is having steady state cracking give large number of multiple crack which not allow drop of water to pass through it acting water tight.

## 3. Objective

1 To study the behaviour of ECC under the compression and split tensile.

2 Comparision of ECC with normal CC.

## 4. Experimental Programme

### 4.1 Materials of ECC

- Cement *:* Cement used is generally Ordinary Portland Cement with flyash or Portland Pozzolona Cement (PPC). PPC of 53 grade is used(Ultratech Cement)

- 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.

**Fig -1** Silica Sand

- Super Plasticizer*:* This is utilized to control reological properties of fresh concrete.

- 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.

**Fig -2** Poly Vinyl Alcohol Fiber

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

**4.2 Materials of CC**

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

- 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.

- Super Plasticizer*:* This is utilized to control reological properties of fresh concrete.

- Coarse aggregate: The grading of aggregate influences the mix proportion for a desired strength and workability. Coarse aggregate passing from 20mm sieve is used conforming to Indian standard.

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

**4.3 Mix Proportion of ECC and CC**

The mix design for ECC Concrete is basically based on Micromechanics which is branch of mechanics applied at the material constituent level that captures the mechanical interactions among the fiber, mortar matrix, and fiber–matrix interface. PVA fiber is order of thousands of nanometer 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 1.

The CC of M40 is design according to Indian Standard with PPc , sand and coarse aggregate of mix proportion shown below in Table 1.

**Table -1:** Mix Proprtion of ECC and CC

| Type | Cement | Sand | Coarse Aggregate | Super plastisizer (ml/bag) | PVA Fiber (%) | W/C ratio | Number of Cubes | Number of Cylinders |
|---|---|---|---|---|---|---|---|---|
| ECC | 1 | 1 | 0 | 1000 | 1.5 | 0.35 | 6 | 6 |
| CC M40 | 1 | 2.26 | 2.88 | 1000 | 0 | 0.35 | 6 | 6 |

**4.4 Casting of ECC and CC**

The mixing of both ECC and CC is hand mixing. Firstly dry mix of sand and cement for ECC and sand , cement and coarse aggregate is prepared for CC respectively. Add 50% of water and super plastisizer to both. Once homogeneous mix is prepared add PVA fiber in ECC only.
Cast cubes of size 150mm x 150mm x 150mm and cylinder of size 300mm x 150mm is casted by filling mixture in layer and tamping each layer .

**Fig -3** Mixing of ECC

**4.5 Curing**

Curing is done for 7 days for 3 specimen and for 28 days for remaining 3 specimen in curing tank.

## 3. Testing of ECC

- Compressive Test

According to cement association of India (2003), compressive strength of concrete is that value at which material fails completely under uniaxial compressive stress. At the end of 7 days (counted from time of mixing of water with cement and aggregates) three cubes are taken out. The excess water is allowed to drain off and then the cube is placed in a compression testing machine (CTM).Load is applied gradually till the failure occurs.

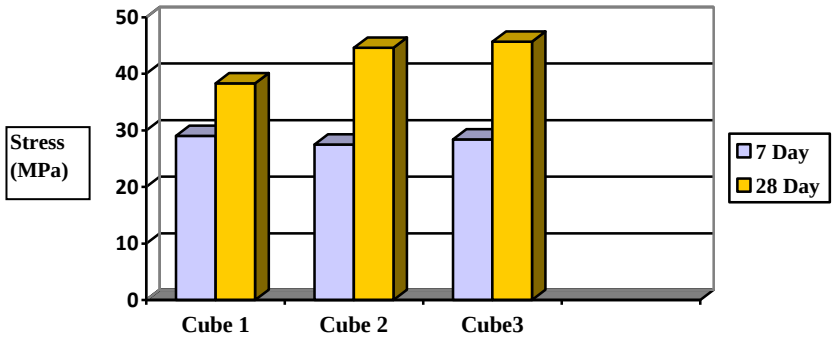


**Chart -1** Compressive test of ECC after 7 days and 28 days.

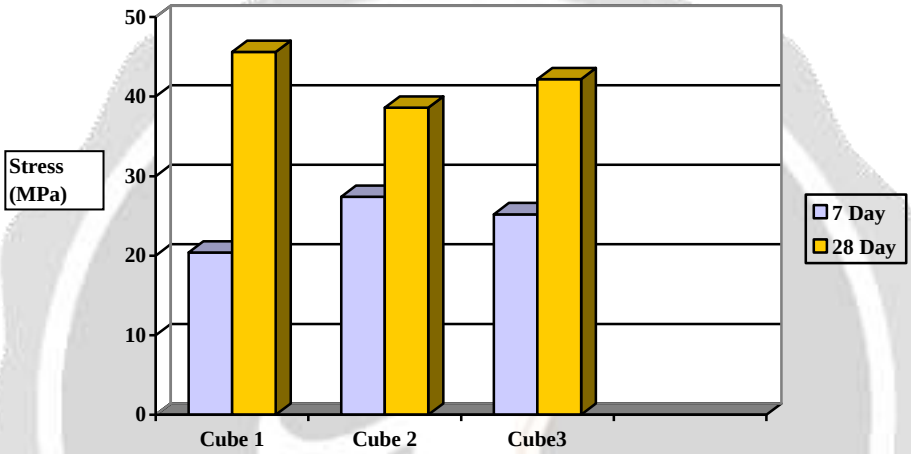


**Chart -2** Compressive test of CC after 7 days and 28 days.

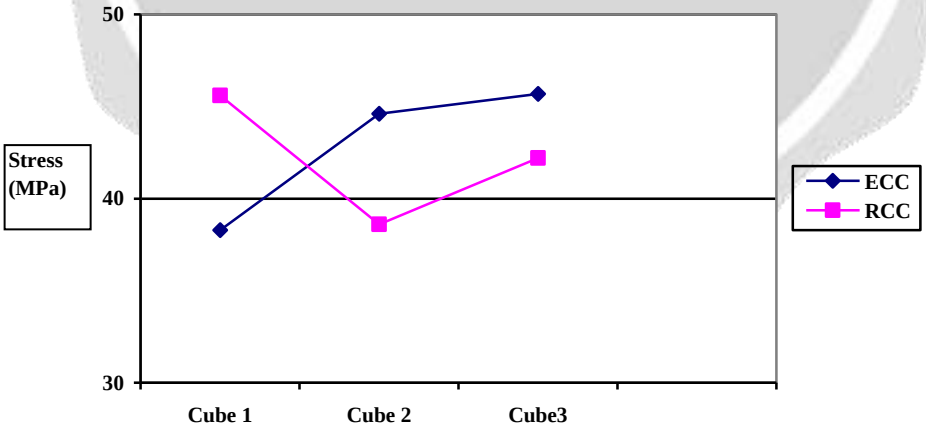


**Chart -3** Compressive test of ECC and CC after 28 days.

- Split Tensile Strength Test

Tensile strength is very low in concrete. It is very difficult to measure tensile strength directly, so split tensile strength confirming IS 5816:1999. The load is applied at gradual rate and continue it fails.

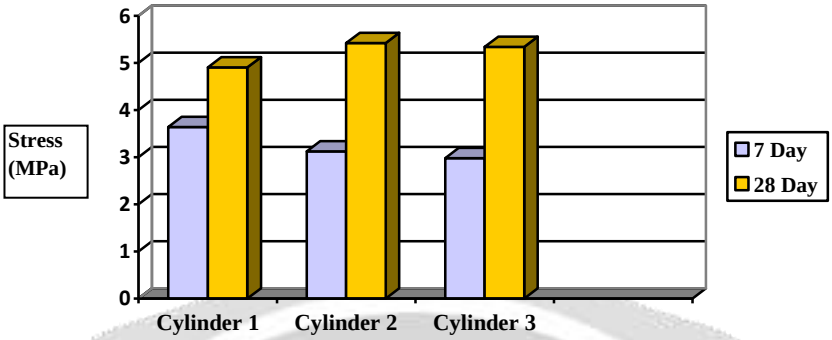


**Chart -4** Split tensile strength of ECC after 7 days and 28 days.

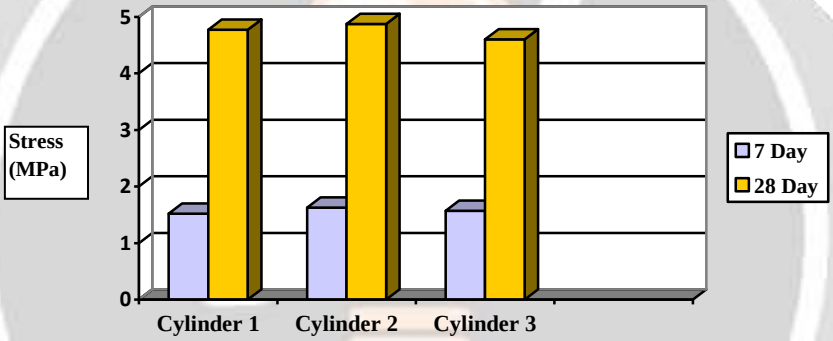


**Chart -5** Split Tensile strength of CC after 7 days and 28 days.

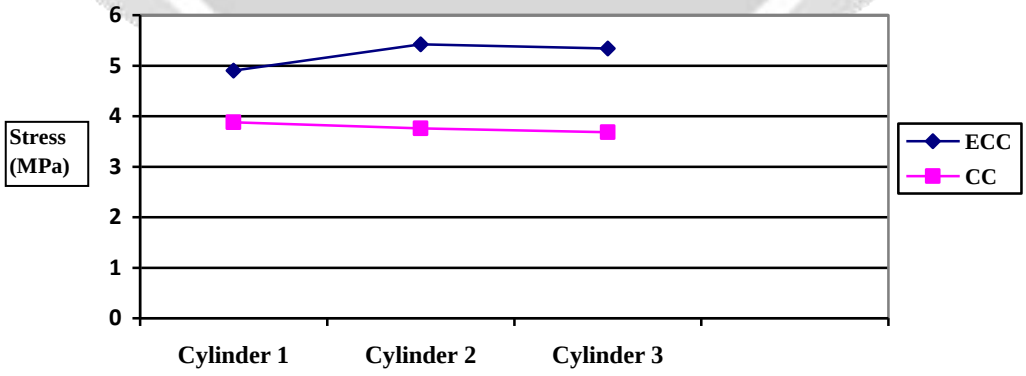


**Chart -6** Split Tensile strength of ECC and CC after 28 days.

## 4. CONCLUSIONS

According to test result of compression test the compressive strength of ECC and CC both is nearly same. Also without the coarse aggregate it is possible to gain strength with the use of PVA fiber volume fraction less than <2%. Nearly 65.70% strength is developed within 7 days for compression.

Split tensile strength shows the higher tensile strength for ECC than CC. It is about 27% more than the CC.

## 5. ACKNOWLEDGEMENT

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## 6. REFERENCES

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