Comparative Study of ECC, SSECC and NECC on basis of compression and tensile strength with different types of sand.

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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.Its main constituent is PVA fiber. ECC does not contain coarse aggregate and thus it is simply a mortar rather than concrete. So it require lot of cement and sand. Also in recent years government restricted use of natural sand. So we have to replace sand or cement to put cost in control and also to protect the nature. The aim of study is to replace the silica sand by the waste product which decreases the cost, thus making it comfortabily used in normal works. Silica sand is replaced by the slag sand which is byproduct from iron industry. Cubes and cylienders are casted and tested for compression and split tensile. Comparative graphs are plotted.

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

1. INTRODUCTION

Engineered Cementitious Composite (ECC) is 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%.

It does not contain coarse aggregate, so it consist high amount of mortar paste. Also the cost of Poly Vinyl Alcohol is high. So ECC costs about 2 to 3 times more than normal cement concrete (CC). Thus, to decrease the cost we have to use some waste material instead of cement or sand or at the place of fiber. Thus it controls the cost and does not hampered the properties of ECC.

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.

ECC is micromechanically developed by pull out test. Maximum allowable volume fraction is 2%. More than 2 % volume fraction of PVA does not vary the properties as tensile strength, ductility etc.

3. Objective

1 To study the behaviour of SSECC and NECC under the compression and split tensile.
2 Comparision of SSECC, NECC with normal ECC.

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)

- 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 Table1.

Table -1: Properties of Silica Sand

Constituent	**Properties**
Colour	Brown/Yellowish
SiO2	96.90%
Fe2O3	0.29%
K2O	0.07%
Al2O3	1.00%

Fig -1 Silica Sand

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

- 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.

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 SSECC

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

- 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. Its cost is about 2500Rs/ brass. It's cost is about 55% less than silica sand and 40% less than natural river sand.Properties of slag sand is given below in table1.

Table -2: Properties of Slag Sand

Constituent	**Properties**
Colour	Blackish
SiO2	44.25%
Fe2O3	24.10%
CaO	4.60%
Al2O3	9.10%
MgO	0.40%
Cr2O3	Nil
Total Alkali	2.80%
MnO	8.10%
P2O5	0.32%
Silt	Nil
Loss on Ignition at 9000C	5.20%

Fig -3 Slag Sand

- Super Plasticizer*:* Zentoament FBV was used as superplastisizer.

- Poly Vinyl Alcohol (PVA) fiber:. PVA fiber from China was used.
- 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 NECC

- Cement : PPC of 53 grade is used (Ultratech Cement)

- Natural Sand : Natural sand from river of Godavari is used. It should be free from silt, mud etc. Maximum allowable silt is 3% of weight. River sand properties depends on bed material of river.

Fig -4 River Sand

- Super Plasticizer*:* Zentoament FBV was used as superplastisizer.

- Poly Vinyl Alcohol (PVA) fiber:. PVA fiber from China was used.
- 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. 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 proportion of SSECC and NECC is same but with varying type of sand. Slag sand is used in SSECC and river sand is used in NECC.

Table -3: Mix Proportion of ECC, SSECC and NECC

Type	Cement	Sand	Super plastisizer (ml/bag)	PVA Fiber (%)	W/C ratio	Number of Cubes	Number of Cylinders	Type of sand
ECC	1	1	1000	1.5	0.35	6	6	Silica sand
SSECC	1	1	1000	1.5	0.35	6	6	Slag sand
NECC	1	1	1000	1.5	0.35	6	6	River Sand

4.4 Casting of ECC and CC

The mixing of both ECC , SSECC and NECC is hand mixing. Firstly dry mix of sand and cement for ECC and replacing sand for SECC and NECC is prepared. Add 50% of water and super plastisizer to dry mix. Once homogeneous mix is prepared add PVA fiber in ECC, SSECC and NECC. Water Cement ratio may be increased slightly for slag sand to get consistency.

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 -5A Dry Mix

Fig -5B Wet mix with PVA fiber

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.

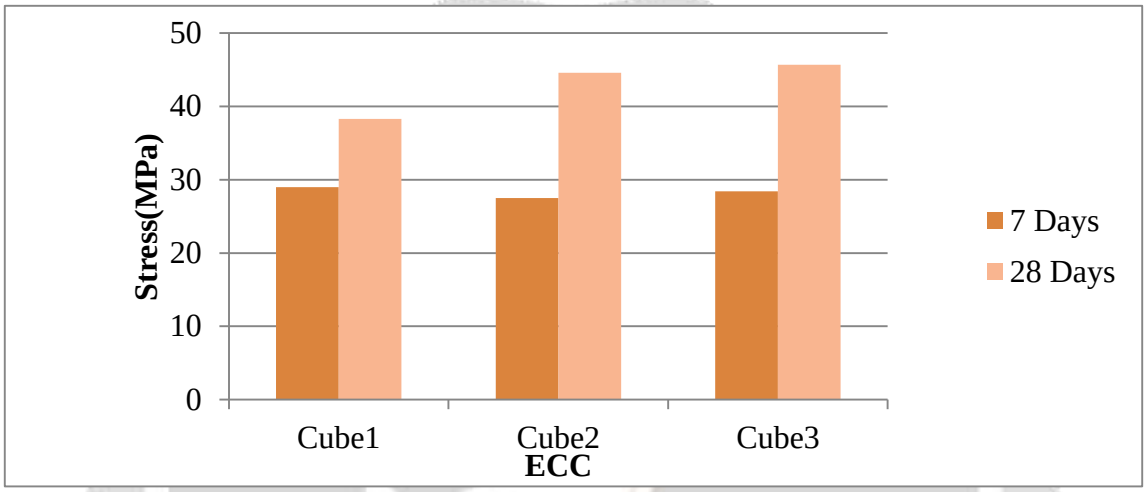

Chart -1 Compressive test of ECC after 7 days and 28 days.

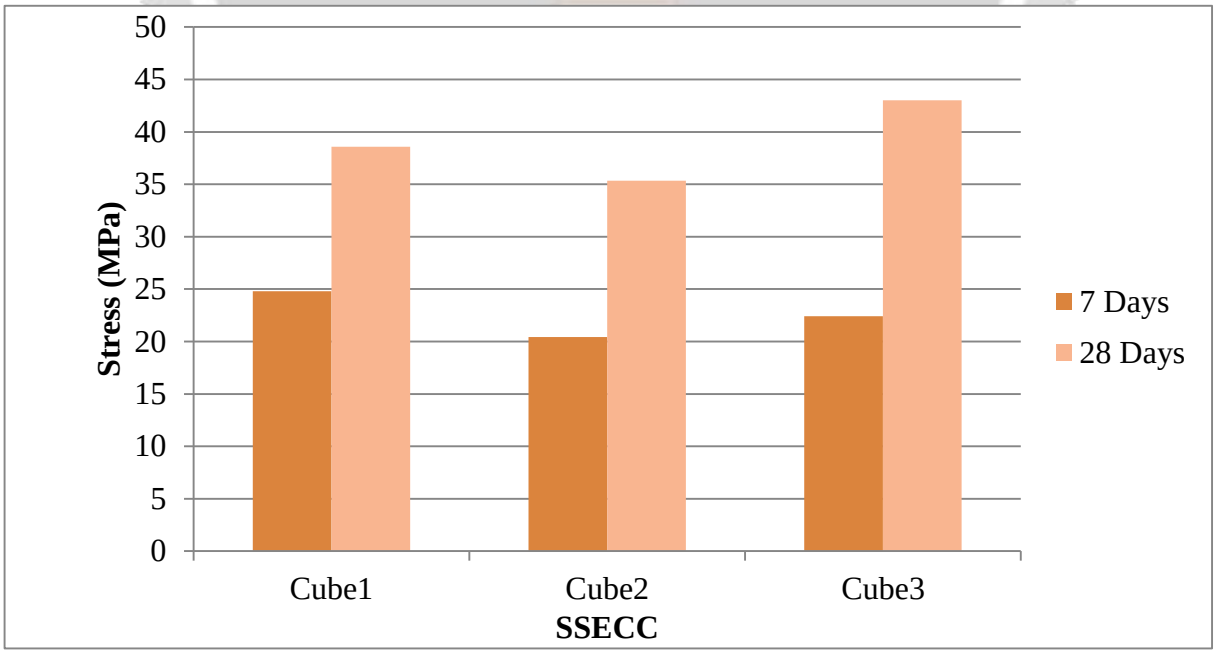

Chart -2 Compressive test of SSECC after 7 days and 28 days.

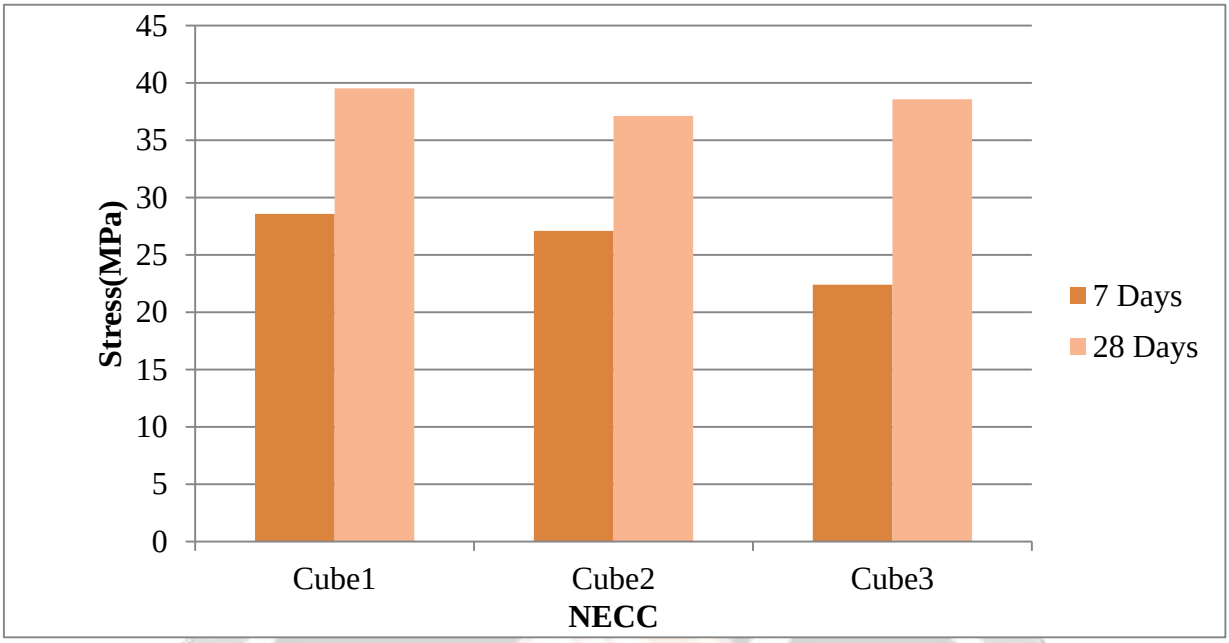

Chart -3 Compressive test of NECC and CC after 28 days.

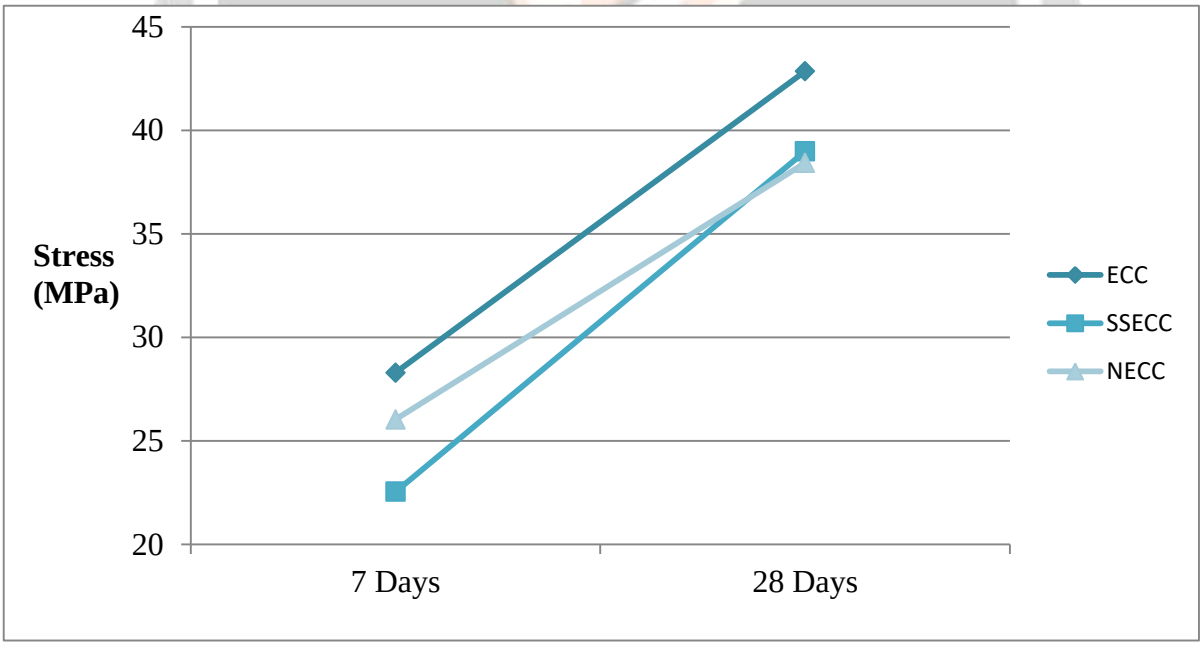

Chart -4 Comparision of Compressive strength of ECC, SSECC and NECC after 7 days and 28 days.

- 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.

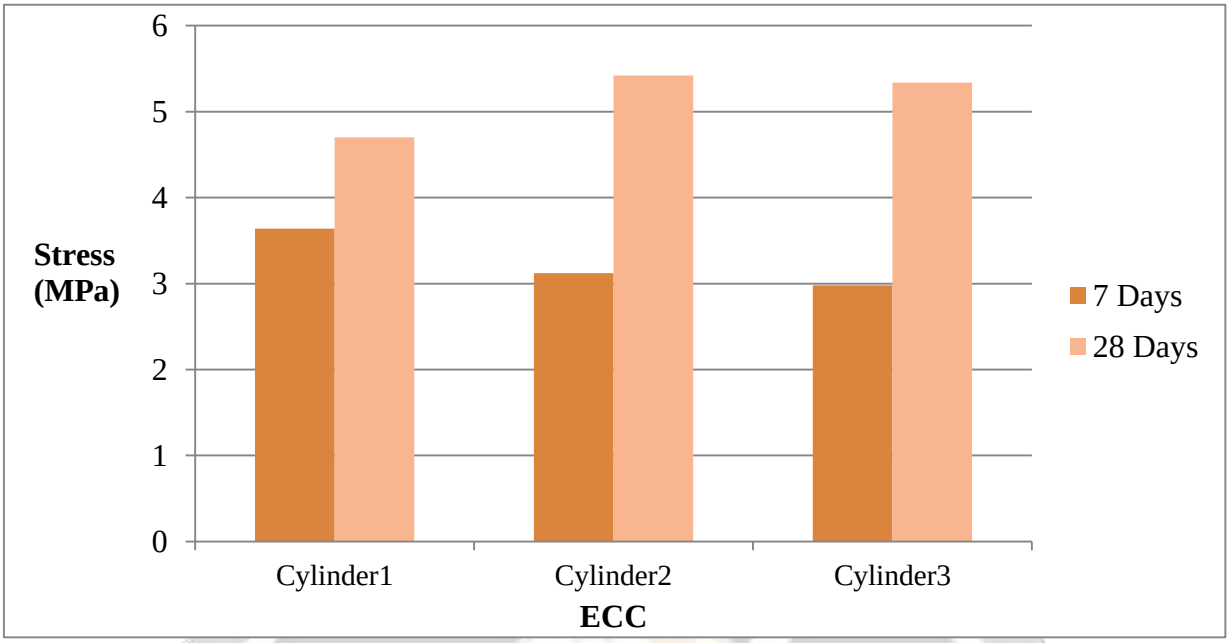

Chart -5 Split tensile strength of ECC after 7 days and 28 days.

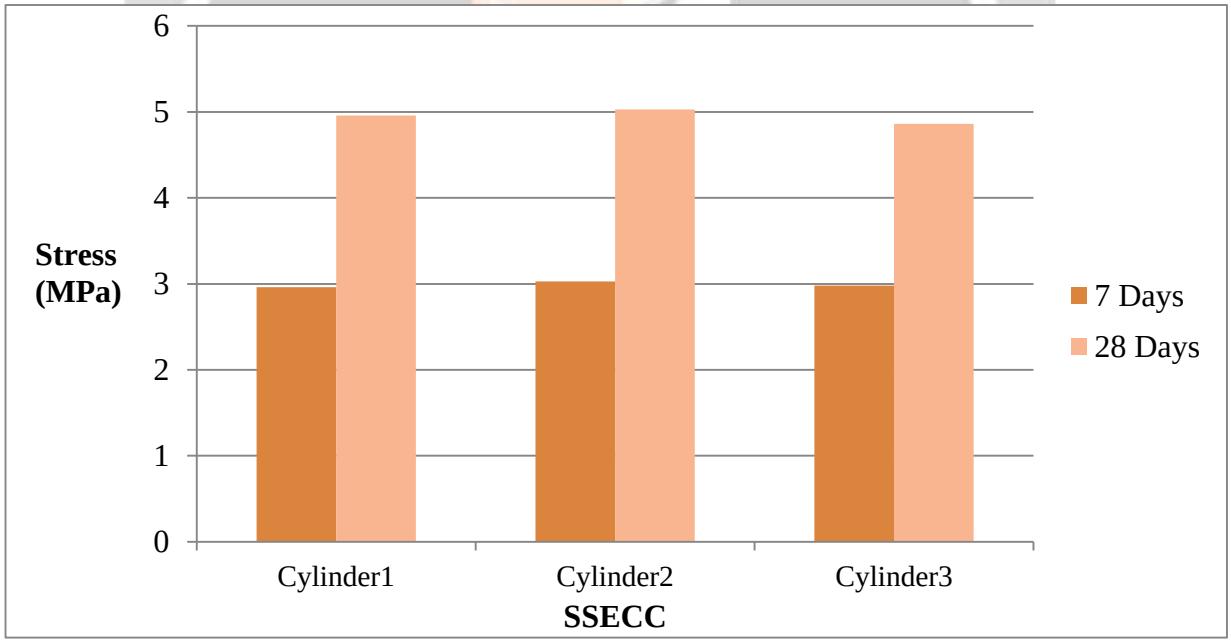

Chart -6 Split Tensile strength of SSECC after 7 days and 28 days.

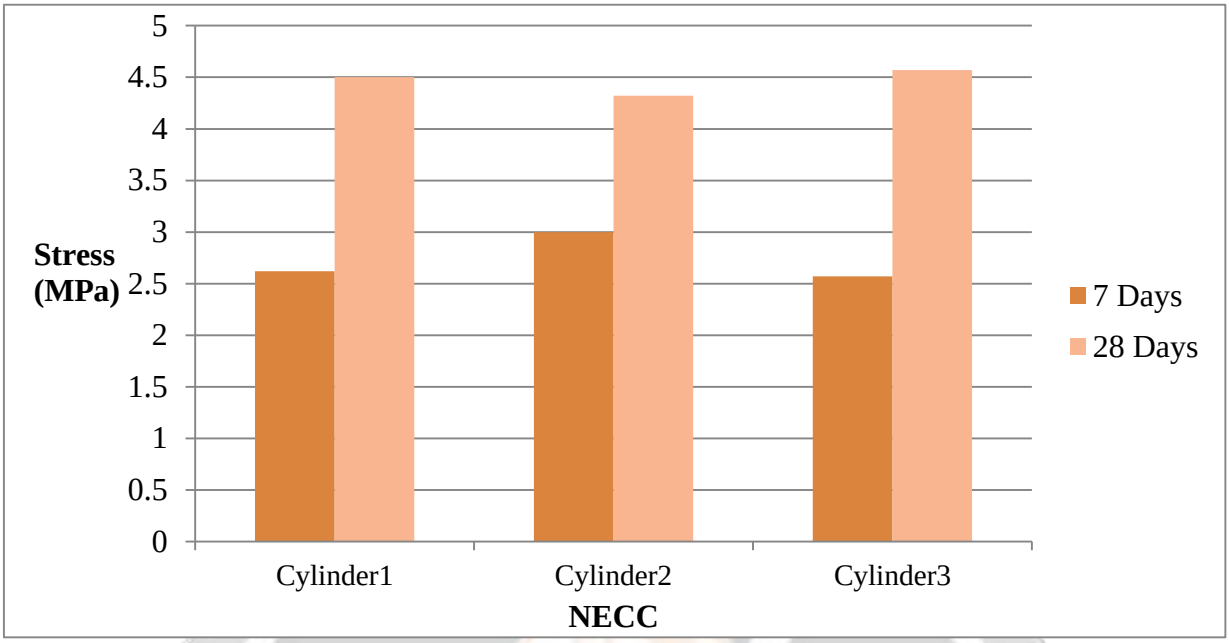

Chart -7 Split Tensile strength of NECC after 28 days.

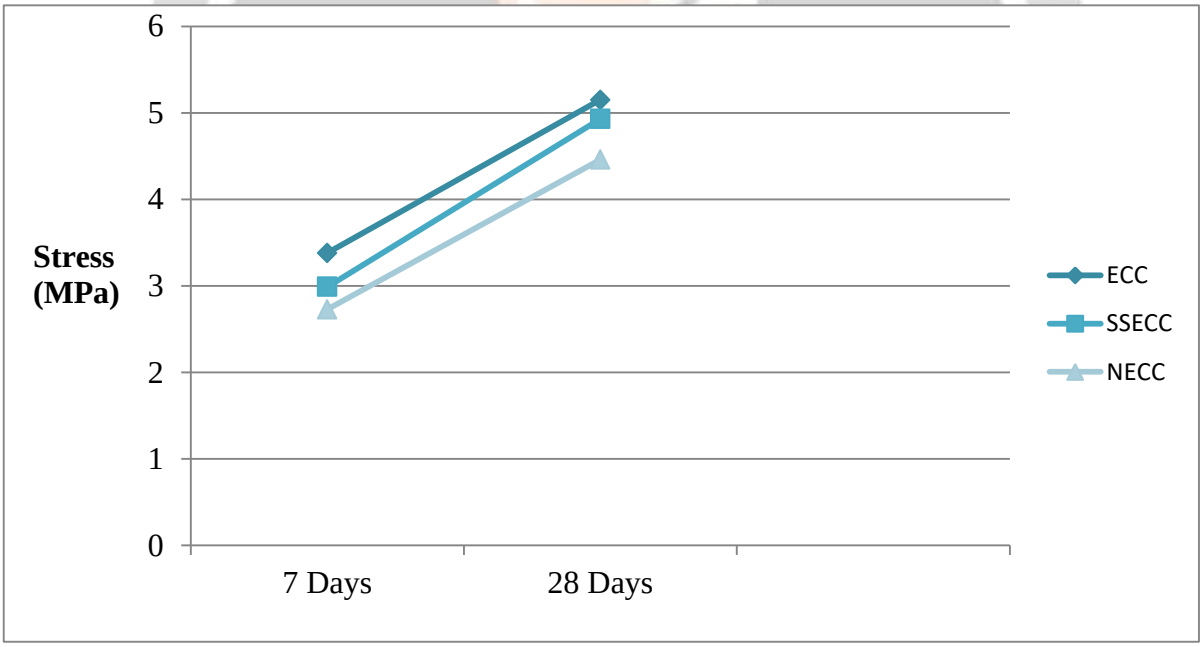

Chart -7 Comparision of Split Tensile strength of ECC , SSECC and NECC after 7 days 28 days.

4. CONCLUSIONS

- The compressive strength of SSECC is about 79.67% of ECC after 7 days and about 90.96 % after 28 days.

- The compressive strength of NECC is about 92.01% of ECC after 7 days and about 89.66 % after 28 days.
- The split tensile strength of SSECC is about 88.46% of ECC after 7 days and about 95.72 % after 28 days.
- The split tensile strength of NECC is about 80.76% of ECC after 7 days and about 86.60 % after 28 days.
- The split tensile strength of ECC is about 12.01% of compressive strength after 28 days.
- The split tensile strength of SSECC is about 12.01% of compressive strength after 28 days.
- The split tensile strength of NECC is about 11.60 % of compressive strength after 28 days.

5. ACKNOWLEDGEMENT

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