ISSN: 0976-3031

*Available Online at http://www.recentscientific.com*

**CODEN: IJRSFP (USA)**

*International Journal of Recent Scientific Research*
*Vol. 9, Issue, 6(D), pp. 27489-27492, June, 2018*

**International Journal of Recent Scientific Research**

**DOI: 10.24327/IJRSR**

**Research Article**

# EXPERIMENTAL STUDY ON ECC CONCRETE

**Balaji R***

Department of Civil Engineering, Prist University, Puducherry Campus

**DOI: http://dx.doi.org/10.24327/ijrsr.2018.0906.2270**

## ARTICLE INFO

***Article History:***

Received 11th March, 2018
Received in revised form 6th April, 2018
Accepted 26th May, 2018
Published online 28th June, 2018

***Key Words:***

ECC (Engineered Cementitious Composites) or Bendable concrete, Recron fibre, Poly Vinyl Alcohol fibre, Super plasticizer.

## ABSTRACT

The conventional concrete commonly used is very low in flexural properties. The strain capacity of conventional concrete is just about 0.01 %. Traditional concrete gets sudden great damage when the strain exceeds due to an earthquake or when over loaded. Therefore the need of some specially designed fibre reinforced concrete materials with good flexural properties are developed and termed as Engineered cementitious composites (ECC). ECC remains safe to use at tensile strains from 3% to 5%. It is also called as bendable concrete reinforced with micromechanically designed polymer fibres. The Recron fibres, Poly Vinyl Alcohol Fibres, fly ash are partially incorporated with cement as supplementary materials to increase the flexibility of concrete in different percentages and it shows different values of strength in each mix.

**Copyright © Balaji R, 2018**, this is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

## INTRODUCTION

### *Recron Fiber*

While selecting fibres for ECC, it was found that Recron 3s fibre was of cost effective and high performance. It increases resistance to water penetration, abrasion and impact and arrests shrinkage cracks. The hydrophilic nature of Recron fibre is a great challenge in the composite design, as the fibres are susceptible to rupture instead of being pulled out because of the tendency for the fibre to bond strongly to cementitious matrix. It makes concrete homogenous and also improves the compressive strength, ductility and flexural strength. Recron fibres have some structural strength and can also be used for shrinkage control. While they cannot replace reinforcing steel, they improve the mechanical properties of cured concrete, boosting its strength. Use of uniformly dispersed recron 3s fibres reduces segregation and bleeding, resulting in a more homogeneous mix, which possesses alkali and weather resistance due to its unique molecular structure, taking on good affinity to cement, effectively prevent and suppress the crack formation and development, improved bending strength, impact strength and crack strength, improve permeability, impact and seismic resistance of concrete, making the structure/plaster/component inherently stronger. Addition of Recron 3s to concrete and plaster arrests cracking caused by volume change expansion and contraction This product can be widely used in Domesetic and Industrial buildings, Roads, Bridges, Tunnels, Reinforcement for embankment slopes.

### *Bendable Conrete*

Engineered Cementitious Composites abbreviated as ECC also known as bendable concrete. 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 yielding. Conventional concretes are almost unbendable and have a strain capacity of only 0.1% making them highly brittle and rigid. This lack of bend ability is a major cause of failure under strain and has been a pushing factor in the development of an elegant material namely, bendable concrete. This material is capable to exhibit considerably enhanced flexibility. The tensile strain capacity of ECC can reach 3-5%, compared to 0.01% for normal concrete. A bendable concrete is reinforced with micromechanically designed polymer fibres. ECC is made from the same basic ingredients as conventional concrete but with the addition of High-Range Water Reducing (HRWR) agent is required to impart good workability.

However, coarse aggregates are not used in ECCs, the powder content of ECC is relatively high. Cementitious materials, such as fly ash, silica fume, etc., may be used in addition to cement

**Corresponding author:* **Balaji R**
Department of Civil Engineering, Prist University, Puducherry Campus

to increase the paste content. Additionally, ECC uses low amounts, typically 2% by volume, of short, discontinuous fibres. This surface coating allows the fibre to begin slipping when they are over loaded so they are not fracturing. It prevents the fibre from rupturing which would lead to large cracking. Thus an ECC deforms much more than a normal concrete but without fracturing. The ECC are subjected to flexural loading and it can be seen that the beam can deform sufficiently without sudden direct failure. ECC has proved to be more flexible than traditional concrete, and lighter in weight, which could even influence design choices in skyscrapers. The excellent energy absorbing properties of ECC make it especially suitable for critical elements in seismic zones.

Decreasing the density while maintaining strength and without adversely affecting cost is a challenge in making a lightweight concrete. Invention of new aggregates into the mix design is a common way to lower density of concrete. Normal concrete contains four components, cement, crushed stone, river sand and water. The crushed stone and sand are the components that are usually replaced with lightweight aggregates.

***Ingredients of ECC Concrete***

ECC (Engineered cementitious composite) is composed of

- Ordinary Portland Cement (53 grade)
- Fine Aggregate (Sand)
- Water
- Super plasticizer (Conmix SP 1030)
- Recron fibre

Here coarse aggregates are not used because property of ECC Concrete is formation of micro cracks with large deflection. Coarse aggregates tends to increase the crack width which contradicts the property of ECC Concrete.

***Procedure for Making ECC Concrete***

***Nominal Mix Design***

We are not using coarse aggregate in the ECC Concrete, there is no separate mix design. For this research we have to estimate the different mixes having different constituents which are Fibers and Fine aggregate Super Plasticizer.

**Fig 1** Mixing of mortar for ECC Concrete

The initial mix proportion was Recron fibre at 2% and super plasticizer dose was 30ml per slab mould (700x150x60 mm), (700x150x30 mm) and 10ml per cube mould(70.6x70.6x70.6 mm), then water to cement ratio of 0.5. By using this proportion workability was achieved. The ratio of concrete mix is 1:2 (cement: sand) and w/c=0.5 Figure 1, 2, 3 shows the mixing of ECC concrete.

**Fig 2** Recron Fibre

**Fig 3** ECC Concrete

***Casting Procedure of ECC- Concrete***

ECC Concrete's performance was influenced by the mixing. This means that a proper and good practice of mixing can lead to better performance and workability of the ECC Concrete. The quality of the concrete is also influenced by the homogeneity of the mix material. Flexural Test was carried out on the slab during the mixing and after the placement of fresh concrete. A proper mixing of concrete is encouraged to obtain the strength of concrete & better bonding of cement with the Recron fibres. Once the concrete mix design was finalized from various trials, the mixing was carried out. The mixing of ECC Concrete was carried out by using hand mixing. It is different from normal concrete the mixing should be done in proper order to get a good workable mix. The procedure of hand mixing was as follows:- Add sand, cement, add the Recron fibres slowly then add 50% of water and super plasticizer. Add slowly remaining quantity of water, super plasticizer and mix for 2-3 minutes till the homogenous mixture is formed. Figure 4 and 5 represents the casting of cubes and slabs.

**Fig 4** Casting of ECC Concrete Cube

**Fig 5** Casting of ECC Concrete Slab

### *Placing and Compacting of Concrete Specimen*

The concrete mould should be oiled for the ease of concrete specimens stripping before placing of concrete,. Once the workability test of ECC concrete was done, the fresh concrete must be placed into the concrete moulds for flexure and compression tests. During the placing of fresh concrete into the moulds, tamping was done using tamping rod in order to reduce the honeycombing. It allows full compaction of the fresh concrete to release any entrained air voids contained in the concrete. After this operation, the levelling of concrete was done on the surface of the concrete. Levelling is the initial operation carried out after the concrete has been placed & compacted. After the levelling of the fresh concrete was done, the concrete in the mould was left over night to allow the fresh concrete to set.

### *Curing of Concrete Specimen*

The concrete specimens which are left in the moulds for 24 hours are removed from the moulds. All the concrete specimens were placed into the curing tank with a controlled temperature of $25^{o}$ C for a period of 28 days to attain the hardening property of concrete. Curing is an important process to prevent the concrete specimens from losing of moisture while it is gaining its required strength. Lack of curing will lead to improper gain in the strength. After 7, 14 and 28 days of curing, the concrete specimens were removed from the curing tank to conduct hardened properties test of ECC Concrete.

### *Testing on Concrete*

After curing process, the specimens are to be tested. Results are obtained by testing cubes and slabs for 7, 14, 28 days. Cubes were tested on Compression testing equipment and slabs of (two different thickness) were tested on flexural testing machine and during this flexural testing the bendable characteristics of slab also been determined.

### *Flexural Strength*

Flexural strength is the maximum stress at the extreme fibers in bending. It is calculated by flexure formula. After removal of the slab specimen from the curing tank, they are tested on the load frame in accordance with IS 9399:1679. The load frame is provided with two rollers at a distance of 400mm apart at the base. The load is applied through two similar rollers mounted at the third point of the supporting span spaced 133mm apart and centrally with the respect to the base rollers. The axis of the specimen is carefully aligned with the axis of the loading frame as shown in the figure 4. The load is applied gradually without shock increasing continuously such that the extreme fiber stresses increase at a rate of 7kg/ sq.cm/min. i.e., application of load it at the rate of 4000N/min. the load is divided equally between the two roller points and it increased until the specimen fails. The load is measured by a load gauge (proven ring) mounted on top of the loading rollers the modulus of rupture is calculated for the maximum load taken by the member.

**Fig 4** Flexure test on Slab

$fb = P \times l / bd^2$

$fb = 3 \times P \times a / bd^2$

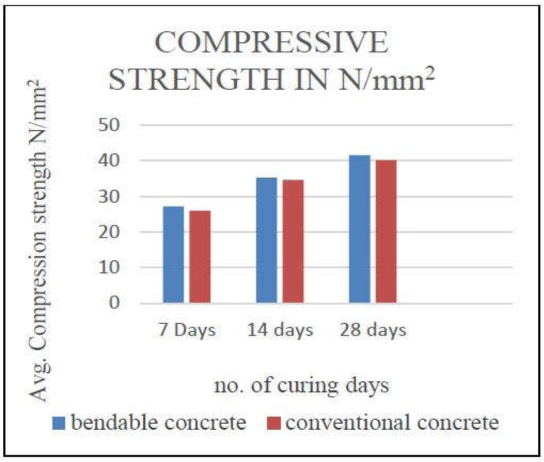
The results are given below:

**Table 1** Comparison of Results between bendable concrete and conventional cubes and slabs.

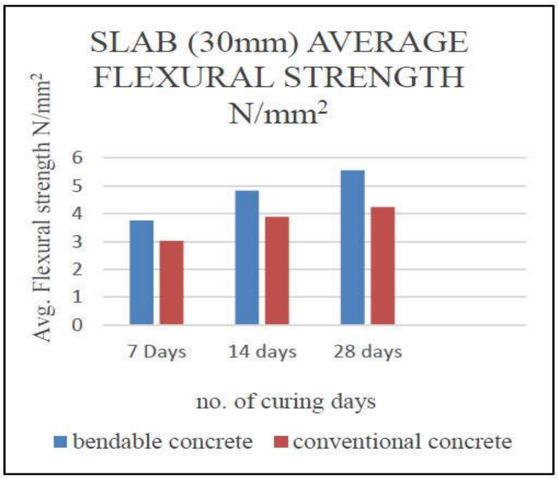
| Properties | Bendable Concrete | Conventional Concrete |
|---|---|---|
| Compressive Strength in N/mm$^2$ in | | |
| 7 days | 28.1 | 26.8 |
| 14 days | 35.5 | 34.6 |
| 28 days | 41.9 | 40.7 |
| Flexural strength in N/mm² at | | |
| 7 days | 3.82 | 3.05 |
| 14 days | 4.78 | 3.87 |
| 28 days | 5.59 | 4.21 |
| Flexural strength in N/mm² at | | |
| 7 days | 3.84 | 3.24 |
| 14 days | 5.10 | 4.55 |
| 28 days | 5.96 | 5.19 |

### *Comparision*

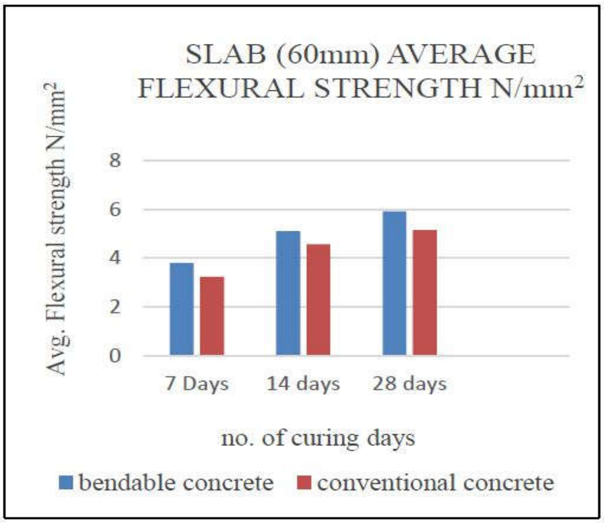
The comparison of results of the properties based on the tests between the bendable concrete and conventional concrete.




**Graph 1** Comparison of bendable and conventional Concrete cubes.




**Graph 2** Comparison of bendable and conventional slabs (30 mm)




**Graph 3** Comparison of bendable and conventional slabs (60 mm).

## DISCUSSION

By viewing the results the compression strength and flexural strength of the ECC or Bendable concrete is comparatively higher than the conventional cubes and slabs. This higher strength shows that the presence of Recron fiber in bendable concrete has increased its efficiency and strength. The strength of conventional cubes and slabs is comparatively low since it is not reinforced.

## CONCLUSION

The compression and flexural strength of bendable concrete is done the values are compared with conventional cubes and slabs. From the investigations, it is concluded that the Bendable Concrete is having best results and stated as best when compared with conventional concrete. Therefore it is proved that the ECC Concrete or bendable concrete is more strength than the conventional concrete and in workability aspect of Recron fibre reinforced ECC is appreciable and satisfactory. It is more flexible so that it resists cracks and acts as more efficiency in seismic regions.

## References


1. Sagar Gadhiya, Patel T N and Dinesh Shah(2015) “Parametric study on flexural strength on ECC 2015 ijscer vol:4 no:5
2. Beeldens, A., and Vandewalle, L. (2005). "Engineered Cementitious Composites (ECC) - First Application in the U.S ECC link slab.” *ACI Materials Journal*., 123(8), 69-76.
3. S.Z. Qian, J. Zhou, E. Schlangen“Influence of curing condition and pre cracking time on the self healing behaviour of Engineered Cementitious Composites” *Journal of Cement & Concrete Composites* 32 (2010) pp. 686-693.
4. Lepech, Michel, D. and Victor, C. Li. (2004). “Large scale processing of ECC.”*ACI Materials Journal*., 13(4), 162-167.
5. Jian Zhou, Shunzhi Qian, Guang Ye, Oguzhan Copuroglu, Klaas van Breugel , Victor C. Li,” Improved fibre distribution and mechanical properties of engineered cementitious composites by adjusting the mixing sequence,”*Jounal of Cement & Concrete Composites*” 34(2012)pp.342-348. 4) Seminar report on on “Bendable concrete “presented by Chitari Nagesh Babasahebi m.tech. in structural engineering Basaveshwar Engineering College Bagalkot
6. Peng, Z., Qingfu Li. and Li, J. (2013). “Fracture Properties of Polypropylene Fiber Reinforced Concrete Containing Fly Ash and Silica Fume.” *Research Journal of Applied Sciences*., 5(2), 665-670.
7. Li VC, Kanda T. “Engineered cementitious composites for structural applications”. *ASCE J Mater Civil Eng* 1998.
8. Sasikala, K. (2012). “Compararison of Polypropylene, Recron Fiber Bendable Concrete.” *International Journal of Engineering Research & Technology (IJERT).*, 6(1), 29-36.
9. Bensaid Boulekbache, Mostefa Hamrat, Mohamed Chemrouk, Sofiane Amziane, “Influence of yield stress and compressive strength on direct shear behaviour of steel fibre- reinforced concrete”, *Journal of Construction and Building Materials* 27 (2012) pp. 6-14.


*******