STRENGTHENING OF BEAM USING ENGINEERED CEMENTITIOUS COMPOSITES

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Abstract - : *In this study, the use of Engineered Cementitious Composites (ECC) for the flexural strengthening of reinforced concrete beams was observed. ECC was prepared using Recron 3S Polyester fibres and Ground-granulated blast -furnace slag (GGBS). As in the case of RC, beams are subjected to uniform and continuous loading which increases with the increase in no. of the storey and may lead to partially damage or even total failure of the beam. In order to overcome the total failure of RC beams a layer of ECC is provided to distribute the cracks uniformly and make the beam even more ductile. Five beam specimens of M20 grade concrete of cross sectional dimensions 150mm X 200mm and length 500mm were made. One of the five beams was taken as the control specimen. The other specimens were tested after strengthening using ECC. Two specimens were Strengthened by embedding a layer of ECC as the cover in the tension zone of the beam, by plastering the tension face of the beam with ECC with GGBS and other two specimens were Strengthened by ECC without GGBS. The strength characteristics of the ECC layer for different strengthening methods were also observed by three point flexural strength test and the results are compared with that of control specimen.*

Keywords: Recron 3s fiber, GGBS, compressive strength, flexural strength, Engineered cementitious composites(ECC).

1. INTRODUCTION

1.1 GENERAL

The strength of any reinforced cement concrete (RCC) flexural member is dependent on the quality of the materials used, construction practices and age of the concrete. Because of aging the structural beam elements may become degraded. The degradation can be visible in the form of cracks and excess deformations. Strengthening using any superior material will help to overcome this degradation. In this study the superior material is recron 3s fiber and GGBS.

1.1 OBJECTIVE

- To increase the shear strength of Beam
- To increase the flexural strength, compressive strength of the beam, the recron 3s fibre concrete layer reduces the cracks.
- However the basic attributes of RFRC are reduction in shrinkage cracks and improvement in elastic properties of concrete.

1.2 METHODOLOGY

- Study of materials
- Collection of material
- Test on materials
- Casting of beam and curing
- Flexural test and compression test
- Report submission

2. MATERIALS

2.1 Recron 3s fiber

Recron 3S is a modified polyester fibre. It is generally used as secondary reinforcing material in concrete and soil to increase their performance. Recron 3s is a triangular polyester fiber in cross section with cut length of 6mm & 12mm which is being widely used in the Indian construction industry market. Use of Recron-3S as a reinforcing material is to increase the strength in various applications like cement based precast products, filtration fabrics etc.

Fig. 1. Recron 3s fiber

2.1.1 Role of recron 3s fiber

- Controls cracking.
- Reduces water permeability.
- Reduces rebound in concrete- brings direct saving and gain.
- Increases flexibility.
- Safe and easy to use.

2.2 Ground granulated blast furnace slag

GGBS (Ground Granulated Blast-furnace Slag) is a cementitious material whose main use is in concrete and is a by-product from the blast- furnaces used to make iron. The iron ore is reduced to iron and the remaining materials form a slag that floats on top of the iron.

Fig. 2. GGBS

3. PREPARATION OF CONCRETE

Ordinary Portland Cement (OPC) of grade 33 was used for both concrete and ECC mix. The Manufactured sand was used as fine aggregate (FA) for concrete and ECC. The fineness modulus for the fine aggregate was 2.7. A mixture of locally available 20mm and 10mm (60% and 40% respectively) size crushed granite stones were used as coarse aggregate (CA). The fineness modulus for coarse aggregate was 7.91. Normal potable water was used for hydrating the cementing medium. For the preparation of ECC, GGBS was used as a supplementary cementitious material. Polyester fibres named Recron produced by Reliance Industries Limited were used in ECC mix. Conplast SP430, which is a sulphonated naphthalene based super plasticizer (SP), was used for the mix. The targeted strength for the concrete was 20N/mm2. The ECC mix for this study was prepared with reference to the same.

Fig. 3.ECC mix

3.1 Mix proportion

- Concrete is made in the (1:1.5:3)ratio of M20 grade
- Recon 3s fiber is used in very small amount in mix of about 0.2% to 0.4% of cement used.
- Ground granulated blast furnace slag(GGBS) is added 50% as partial replacement of cement in ECC mix for beam B3.For beam B2 no GGBS is added with ECC mix.
- The normal dosage range of conplast sp430 is from 1.00 to 3.00 litres for 100 kg of cementitious material in mix. For high workability concrete the normal dosage range is from 0.70 to 2.00 litres/100 kg of cementitious material.

BEAM B1: A conventional beam made of normal M20 concrete.
BEAM B2: Beam with a layer of ECC without GGBS in tension zone for 25mm and 30mm as cover is provided.
BEAM B3: Beam with a layer of ECC with GGBS in tension zone for 25mm and 30mm as cover is provided.

3.2 Moulding

Moulding is the process of shaping the liquid or flexible raw material using a rigid frame called a mould. The mould size of Beam is 150mm x 200mm x 500mm is used for the moulding.

Fig. 4. Moulding of beam.

3.3. Demoulding

Demoulding is the process of removing the shaped material from the mould. Usually the demoulding is done after the initial setting time of the concrete. The initial setting time of concrete is about 24 hours.

Fig. 5. Demoulding of beam

4.TEST PROCEDURE

4.1. Flexural strength

To find out the flexural strength of the beam(modulus of rupture) we need to find the load at which the beam fails i.e. at which load cracks starts to appear in the beam while testing. Test procedure done in UNIVERSAL TESTING MACHINE(UTM) .Our beam of size 150mmx200mmx500mm is placed in the UTM machine for three point flexural test. The beam is placed on two supporting pins at set distance apart and it is subjected to a concentrated point load at center of the beam.

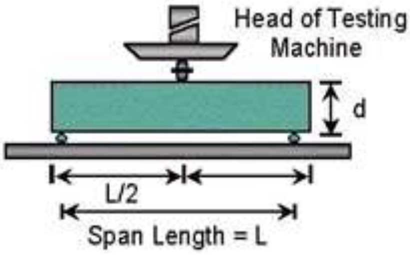

Fig. 6. Three point flexural test

The beam is placed as the tension zone of the beam is in the bottom side and the compression zone of the beam is in top side. Then the load is applied on the beam gradually until the crakes appear on the beam and the maximum load can be allowed by the beam is noted. This is the failure load of the concrete beam. The test is conducted for all the five beams and their respective failure load is noted.

The equation for calculation of flexural strength.

FLEXURAL STRENGTH $(\boldsymbol{\sigma}) = \frac{PL}{bd^2}$

where,

P=Maximum load applied on beam in kilo Newton(KN).
b=width of beam in mm.
d=depth of beam in mm.
L=supported length in mm.

4.1.1 Test result

Table 4.1.1 : show the flexural strength of beam

SPECIMEN TYPE	**FAILURE LOAD (KN)**		**FLEXURAL STRENGTH (N/mm²)**	
	14 DAYS	28 DAYS	14 Days	28 Days
SPECIMEN 1(B1)	54	61	3.86	4.28
SPECIMEN 2(B2) (with cover 25 mm)	62.1	69	4.4	4.85
SPECIMEN 3(B2) (with cover 30 mm)	65.7	73	4.6	5.11
SPECIMEN 4(B3) (with cover 25 mm)	69.3	77	4.9	5.39
SPECIMEN 5(B3) (with cover 30 mm)	70.2	78	2.77	5.49

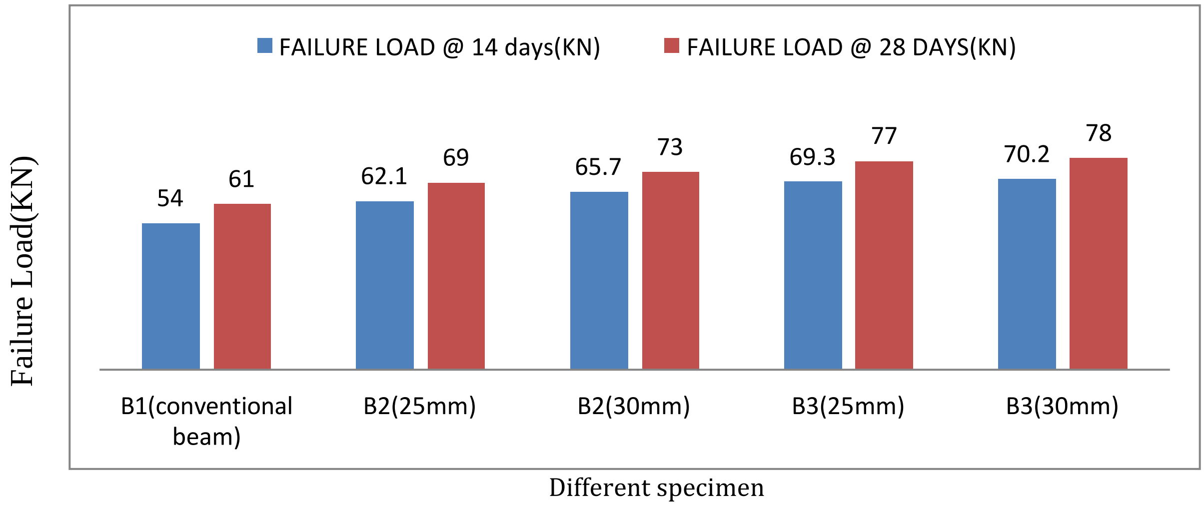

Fig 6. Comparison of failure loads of different specimen at 14 and 28 days

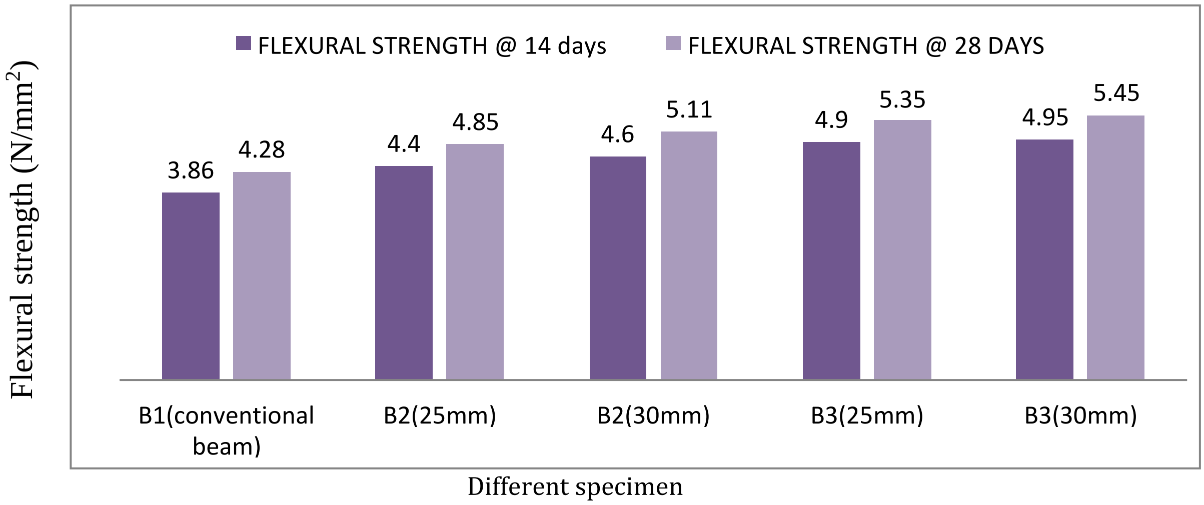

Fig 7. Comparison of Flexural strength of different specimen at 14 and 28 days

4.1. COMPRESSIVE STRENGTH TEST

The compression strength of concrete is the ability of the concrete to resist the compression loads which acts upon it. It is measured by crushing cubical concrete specimens in compression testing machine. The following procedure is used to find out the compressive strength of the hardened concrete. Calculate the mix proportion of concrete and mix the raw materials as per the mix design.

Apply the oil on the sides of the mould and pour the fresh concrete into the mould. Fill the mould with the concrete in three layers and compacted. Remove the concrete from the mould after the initial setting time of 24 hours the concrete is cured.

Place the concrete in the compression testing machine. The load is gradually increased until the specimen fails.

Note down the value of failure load. Repeat the procedure for various proportion of concrete and compare their results with conventional concrete.

Fig 8: compression test machine

4.2.2. TEST RESULTS

Table 4.1.1: show the compressive strength of beam.

SPECIMEN TYPE	FAILURE LOAD (KN)		COMPRESSIVE STRENGTH (Mpa)	
	14 days	28 days	14 days	28 days
Conventional concrete	392	438	17.4	19.5
ECC	399	445	17.8	19.8
ECC with 50% GGBS	409	454	18.2	20.2

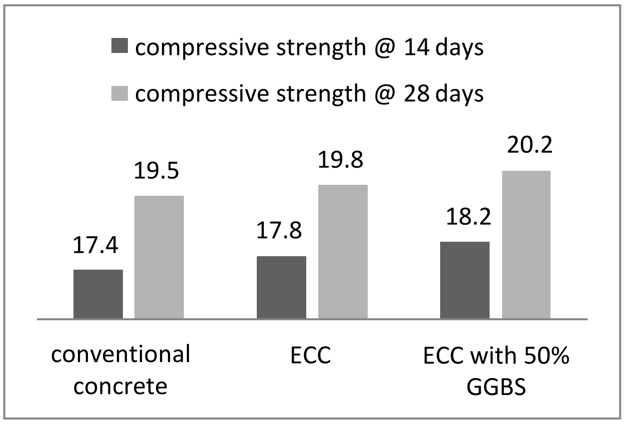

Fig.9.comparison of compressive strength at 14 and 28 days

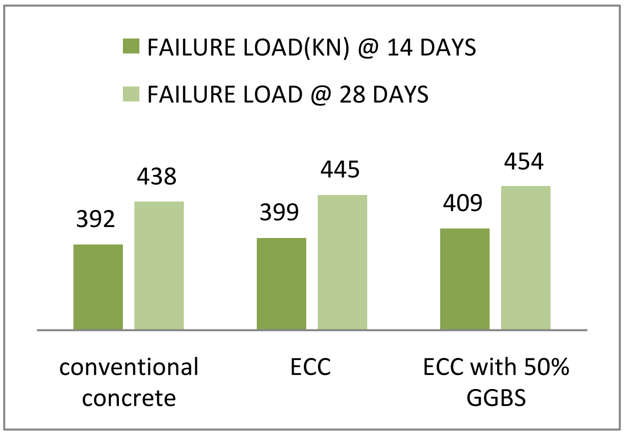

Fig.10.comparison of failure load at 14 and 28 days.

4.3. RESULTS AND DISCUSSIONS

[1] Three point bending test was conducted after 28 days of curing for the comparison of flexural capacity of strengthened specimens (B2 and B3) with that of the control specimen (B1). The load values were acquired using an electronic load cell and the mid span deformations were measured with help of UTM. A graph was plotted to present the load deformation characteristics of the beam specimens.

[2] It is clear that all the strengthened beams showed better load deformation behavior compared to the conventional beam.

[3] The ultimate load at failure for B1 was 65kN. The load at failure for B2(25mm), B2(30mm), B3(25mm)andB3(30mm) were 69kN, 73kN, 77kN and 79KN respectively. From the results it is clear that B3(30mm) showed the maximum load at failure. The deflection at failure was less than that of B1. The superior results of B3 may be due to the effect of confinement made by the ECC layer.

5. CONCLUSIONS

[1] Embedding a layer of ECC at the tension zone did not make any considerable difference in the strength characteristics of beam.

[2] Specimen plastered with ECC on the tension face showed better strength characteristics compared to the other specimens. This may be due to the confinement provided by ECC which will assist the tension face concrete to arrest tension cracks as well as the side faces to arrest shear cracks.

[3] The specimen confined with ECC on tension faces showed better deformation characteristics. This shows the betterment in deformability. The energy absorbing capacity of beams with ECC provided only at the tension face was slightly more compared to control specimen.

[4] The addition of GGBS in the ECC provides more strength to the beam and carry little more load than B2 and conventional beam.

REFERENCES

[1] S. Prem Kumar, A. J. Jeyaarthi, "Experimental Investigation of Reinforced Concrete Using Recron 3s", International Journal of Latest Engineering and Management Research, pp.45-52, 2017.

[2] Korrapati Anil Kumar, Dr. Shaik Yajdani, "Study on Properties of Concrete using Recron 3s Fibre", International Journal of Science Technology & Engineering, pp.54-62, 2017.

[3] Rakesh Kumar Gupta, Mohd Ziaulhaq, "Study of Properties of Polypropylene- Natural fiber composite", International Research Journal of Engineering and Technology, pp.3507-3511, 2017.

[4] V.Prahatheswaran ,Dr.P.Chandrasekaran, "Study On Structural Behaviour Of Fiber Reinforced Concrete With Recron 3s Fibres", SSRG International Journal of Civil Engineering Special Issue, 2017.

[5] Ridha Nehvi, Prashant Kumar and Umar Zahoor Nahvi, "Effect of Different Percentages of Polypropylene fiber (Recron 3s) on the Compressive, Tensile and Flexural Strength of Concrete", International Journal of Engineering Research & Technology, pp.124- 130, 2016.

[6] U. Bhavitha, Mohammed Safiuddin, "Study of Strength Properties of Polyester Fibre Reinforced Concrete", Journal for Research, Vol.2, pp.12-16, 2016.

[7] Huang, L., Yang, X., Yan, L., He, K., Li, H., & Du, Y. "Experimental study of polyester fiber-reinforced polymer confined concrete cylinders" Textile Research Journal, pp.1606–1615, 2016.

[8] Dr. Vagheesha S. Mathda , Ms. Hemali ,K. Khaire, "Study of Effects of Polyester Fibers on Compressive Strength of Concrete", International Journal for Research in Applied Science & Engineering Technology, pp.53-56, 2016.

[9] Saman KhanP Roohul Abad Khan, Amadur Rahman Khan, Misbahul Islam, Saman "Mechanical Properties of Polypropylene Fibre Reinforced Concrete for M25 and M30 mixes: A Comparative study", International Journal of Scientific Engineering and Applied Science, pp.327-340, 2015.

[10] A.P. Sathe, A. V. Patil, "Experimental Investigation on Polypropylene Fiber Reinforced Concrete with Artificial Sand", International Journal of Science and Research, pp.1209-1213, 2015.

[11] Damyanti G Badagha, C D Modhera, "Studies on Harden Properties of Mortar Using Polyester Fibre", International Journal of Advances in Engineering & Technology, pp-42-46, 2013