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Strengthening Of RC Beam Using Polypropylene Fiber Sheet And Rubberized Coir Fiber Sheet

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Abstract: *Retrofitting is the method of strengthening of existing structures to make structural elements more resistant to seismic activity and deterioration of members due to ageing etc. Many of the existing reinforced concrete structures throughout the world are in immediate need of rehabilitation, repair or reconstruction due to various factors like corrosion, failure of bonding between beam-column joints etc. Several techniques are available to strengthening of the structural components, wrapping is one such technique that is successively employed to repair flexural members. The objective of the present study is to determine the effect of wrapping on beams using geo-textiles and to compare the results of control beam with analytical model done by using FEM software ANSYS 16. A total 12 beams, with (150mm ×260mm) rectangular cross section and of span 1200 mm were casted and tested. Beams are wrapped in two ways:- 1) at the bottom and 2) in U-shape up to neutral axis and flexural strength of beams are compared. In the experimental method, two control beams, one beams are retrofitted by using Polypropylene Fibre sheet of 2mm at the bottom full length of the beam, two beams are retrofitted by using Polypropylene Fibre sheet of 4mm at the bottom full length of the beam, two beams are retrofitted by using Polypropylene Fibre sheet of 4mm at the bottom full length of the beam upto neutral axis, one beams are retrofitted by using Rubberized coir fiber sheet of 2mm at the bottom full length of the beam, two beams are retrofitted by using Rubberized coir fiber sheet of 4mm at the bottom full length of the beam, two beams are retrofitted by using Rubberized coir fiber sheet of 4mm at the bottom full length of the beam up to neutral axis.. The beam specimens will be tested under two point loading and the load-deflection behavior is studied up to failure. Also the maximum load, the stress strain behavior and the complete crack patterns are studied. The flexural strength of retrofitted PF sheet beam is compared with the retrofitted RCFS beam and suitable retrofitting method is suggested.*

***Key words*: Reinforced Concrete Beam, Retrofit, Polypropylene fiber sheet, Rubberized coir sheet, Ansys**

1. Introduction

In the earlier period it is thought that concrete will be a Structure of free maintenance. Later on, this myth has proved wrong. Due to the majority of Civil Engineering structures being RCC, its requirement of maintenance and strengthening work has also increased tremendously. Many existing structures, which do not fulfill the specified requirements as per expectation. These failures are due to sudden loading like impact, earthquake, rebar corrosion and fatigue etc. A structural members in general subjected to torsion, shear axial thrust or tension and flexure. Concrete is a rigid material which has high compressive strength and it is weak in tensile strength. To improve the tensile strength reinforcing bars are used. In addition to that fiber sheets are used to improve the tensile response, particularly the ductility. The most commonly used FRP types are CFRP, GFRP. The present experimental research work is based on retrofitting method for strengthening of RC beams using polypropylene fibre sheet and rubberized coir fibre sheet. And the results of conventional RC beams are compared with analytical results.

2. Literature Survey

i. **Anumol Raj et al (2013),** experimentally studied R.C.C. beams strengthened with various types of fibres externally. They casted total 30 beams with cross section of 150 mm × 150 mm × 1000 mm. They applied different types of fiber sheets i.e. Carbon, Glass, Steel, Polypropylene and Coir. The full wrapping technique around all the sides of the beams is used as the method of strengthening. They concluded that the ultimate strength increment in carbon, glass, steel and coir fiber sheet strengthened beam by 125%, 89.6%, 45.02% and 37.9% respectively. But considering cost effectiveness and strength increment, they recommended Glass FRP sheets for use.

ii. **Subramani.T et. al (2015),** An analytical and experimental study has been carried out to investigate the behavior of concrete beams bonded with strengthened Glass Fiber- Reinforced Polymer (GFRP) sheets on all sides with

different thickness of the plate under loading. The finite element program ANSYS has been used to study the Strengthened behavior of a beam. The analysis has been carried out for the comparison and the study of effect of GFRP. The beams modeled in ANSYS for the various conditions

iii. **M.N.S.Hadi (2016),** showed that there are several parameters that affect the strength of the beams. The results also show that the use of FRP composites for shear strengthening provides significant static capacity increase. With the help of above studies, In this paper, Rubberized coir fibre sheets were used for retrofitting the beams in flexure and also in shear. Also, different types of Retrofitting techniques were employed for improving the flexural and shear behavior and to increase the stiffness.

iv. **Saranyadevi M (2016)**, This paper reviews that using of Geotextile Fabric in concrete beam. The beam failure within short period because of their Shear and Flexural strength of beam was considerably reduced. Flexural test are conducted up to failure of concrete beams. An experimental investigation is compare with analytical solution to predict the Flexural strength of concrete beam reinforced with Geotextile Fabric wrapped externally. A total 6 beams, with (150mm ×100mm) rectangular cross section and of span 1200 mm were casted and tested. A Finite Element (FEM) model has been developed using ANSYS 14.5 to analysis beams.

3. Objective of Study

Retrofitting and repairing existing damaged structural elements is a basic necessity, as well as preserving the building structures for longer period. Several techniques are available to strengthening of the structural components, wrapping is one such technique that is successively employed to repair flexural members. The objective of the present study is to determine the effect of wrapping on beams using PP sheets and RCF sheet and to compare the results of conventional beam with analytical model done by using FEM software ANSYS16.

3.1 Necessity

- To increase flexural strength of the beam
- To increase the life time and repair without dismantling.
- To study about structural behavior of beam.
- It increases the tensile strength of the concrete.
- To examine the properties of externally wrapped concrete structures under static loading.

4. Materials used

i. **Cement**
ordinary Portland cement of 53 grade is used. The basic properties of cement are normal consistency of cement is 29%, initial setting time is 120 minutes, final setting time is 270 minutes and specific gravity of cement is 3.1.

ii. **Fine aggregate**
Normally river sand is used and it is passing through 4.75mm sieve. The specific gravity of fine aggregate is 2.54, water absorption is about 1.11% and Conforming to grading zone I.

iii. **Coarse aggregate**
Coarse aggregate of 20mm down size is used. The specific gravity of coarse aggregate is 2.63 and water absorption is 0.33%.

iv. **Water**
Clean portable water is used for the preparation of concrete mix and for the curing purpose.

v. **Super plasticizer**
High range water reducing admixture. The type of super plasticizer used is Conplast SP-430, which is brown in color Specific gravity of S.P is 1.22.

vi. Polypropylene sheet

Polypropylene is a monofilament fiber, used to any retrofitting technique in the field of repair and strengthening of concrete elements. The bond between the sheet and concrete has to good. These sheet have good modulus of elasticity, tensile strength, good temperature, corrosion resistance, improved fatigue & impact resistance

vii. Rubberized coir fibre sheet

A natural laminate which is brown in color. Also used in improving the, structural responses like strength and maximum deflection. It is preferable for repairing or retrofitting purpose.

viii. EPOXY RESIN is binding agents with high tensile strength the higher viscosity epoxy resin can be used for surface coating or filling larger cracks or holes. Epoxy resin and hardener is used for bonding of the polypropylene fibre reinforced polymer sheet and rubberized coir fibre sheet. The strengthening was done by wrapping above fiber mat.

Fig 1:- Polypropylene sheet

Fig 2 :-Rubberized coir sheet

Fig 3:- Epoxy Resin

5. Methodology

a. Concrete mix design according IS 10262-2009

Table 1: Concrete Mix Design

Sl.No	Concrete Mix Design Quantities	
1	Grade of concrete	M25
2	Specific gravity of cement	3.1
3	Specific gravity of FA	2.54
4	Specific gravity of CA	2.63
5	Maximum water cement ratio	0.40
6	Type of exposure	Mild

Table 2 :Final Mix Proportion

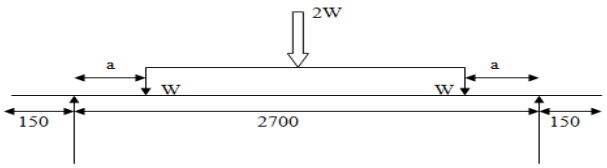
Ingredients	Quantity
Cement	394 kg/m^3
Fine aggregate	795.73 kg/m^3
Coarse aggregate	1048.63 kg/m^3
Water	157.6 kg/m^3
Mix Proportion Ratio C:F.A:C.A:W	1 : 2.02 : 2.66 : 0.4

6. Design of beam with shear reinforcement as IS 456-2000

Table 3: Details of control beam and retrofitted beam cured at 28days

Beam no.	Size of the Beam (b*D)mm	Strengthening by polypropylene and rubberized coir sheet
B1	150*260	Control beam
B2	150*260	Control beam
B3	150*260	A strip of 4mm polypropylene sheet at the bottom of the beam
B4	150*260	A strip of 4mm polypropylene sheet at the bottom of the beam
B5	150*260	A strip of 4mm polypropylene sheet at the bottom of the beam upto neutral axis
B6	150*260	A strip of 4mm polypropylene sheet at the bottom of the beam upto neutral axis
B7	150*260	A strip of 4mm rubberized coir fibre sheet at the bottom of the beam
B8	150*260	A strip of 4mm rubberized coir fibre sheet at the bottom of the beam.
B9	150*260	A strip of 4mm rubberized coir fibre sheet at the bottom of the beam upto neutral axis
B10	150*260	A strip of 4mm rubberized coir fibre sheet at the bottom of the beam upto neutral axis
B11	150*260	A strip of 2mm polypropylene sheet at the bottom of the beam
B12	150*260	A strip of 2mm rubberized coir fibre sheet at the bottom of the beam.

7. Two point loading system of beam



Loading pattern of test beam

8. Reinforcement details.

Tension reinforcement =3 No's of 12mm diameter.
2 no's of hanger bars of 12mm diameter.
Stirrups = 10mm diameter, 4 stirrups are placed at 150mm c/c, 3 stirrups are placed at 250mm c/c, 4 stirrups are placed at 150mm c/c

9. Experimental work

Three wooden plywood moulds are used for casting the beam as shown in figure. The inside surface of the mould is oiled to facilitate easy removing of the beam from the moulds. Beams were reinforced with 3 bars of 12mm diameter in tension zone and 2 hanger bars of 12mm diameter in compression zone as to support illustrated in figure. To facilitate binding of the longitudinal steel and to maintain the clear cover, 10mm vertical stirrups at equal spacing and two 12mm mild steel bars for hanger were used.

Fig 4 :- Reinforcement

Fig 5:- Placing of reinforcement

Fig 6:- Concrete surface is smoothened

Fig 7:- After de-moulding of mould

Fig 8:- Curing of beams

10. Retrofitting Of Beams

Hand layup method is used for retrofitting of beams. The surface of the beam after curing is made rough and then cleaned with water to remove all dirt's for the proper bonding with fibre sheets. Then the beam is allowed to dry for 24 hours. A layer of epoxy is applied at an appropriate thickness of about 1 mm with brush. The PFRP sheets and RCF sheets were measured and cut to the desired shape and dimensions. The strips were placed on the concrete surface and gently pressed onto the coated epoxy resin.
The retrofitting of beam is made in three ways:-

- Wrapping of sheet of 2mm at the bottom length of the beam (2000X150).
- Wrapping of sheet of 4mm at the bottom length of the beam (2000X150).
- U-shape wrapping at the bottom length of the beam up to neutral axis (2000X150X260).

Fig 9:- Beams are wrapped with PP sheets

Fig10:- Beams wrapped with RCF sheets

11. Test setup of beam

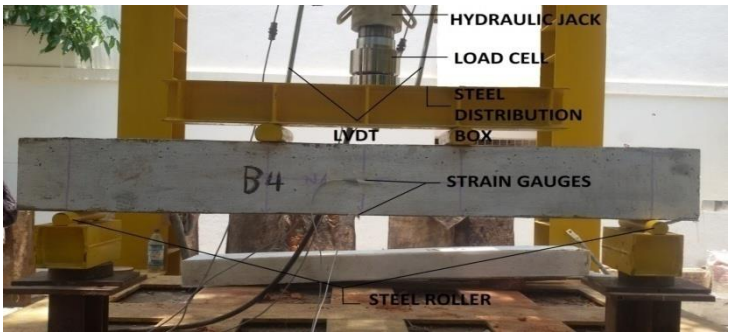


Fig 11:- Test setup of beam

Above figure shows the test setup of beam. It consist of hydraulic jack through which load is applied on beam, load cell, with the help of steel distribution box the concentrated load is divided into two point loads, steel rollers are used to support the beam over it, strain gauges used to know the amount of deflection and strains occurs in beam.

The table below shows the deflection and load at which the first crack appeared and load at final cracking load is noted.

Table 4 load at initial cracking

Beam no	Load at first crack in KN	Defection in mm	
		LVDT1	LVDT2
B1(CB)	26	3.72	5.79
B2(CB)	20	0.33	15.9
B3	33	3.79	4.84
B4	23	2.86	2.86
B5	25	2.99	3.73
B6	17	2.39	3.72
B7	25	4.76	5.54
B8	23	5.31	6.48
B9	25	3.53	3.51
B10	41	5.93	5.61
B11	26	3.03	1.89
B12	23	5.83	3.55

Table 5 load at final cracking

Beam no	Load at ultimate crack in KN	Defection in mm	
		LVDT1	LVDT2
B1(CB)	45	7.79	12.2
B2(CB)	47	7.2	22.9
B3	60	9.6	9.3
B4	53	7.22	7.33
B5	60	10.5	11.12
B6	53	9.14	11.89
B7	59	12.12	13.22
B8	57	13.22	11.98
B9	55	8.94	5.24
B10	60	5.96	7.69
B11	60	8.88	5.3
B12	60	10.66	6.26

12. Results

Below figures shows the cracking pattern of control beam

Graph of load v/s deflection

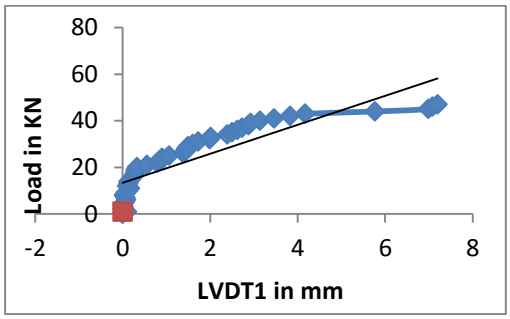


Fig 12:- cracked pattern of beam

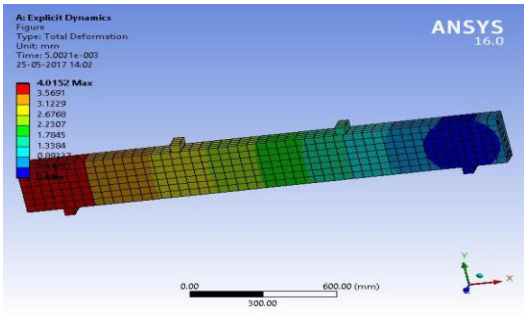
The graph of Load v/s deflection is plotted of control beam. The deflection is increasing suddenly at a load of 20kN and the deflection is increasing gradually upto a load of 40kN. Finally the beam get failed at a load of 47kN

13. Analysis of conventional RC beam using ANSYS16

13.1 Modelling Of Beam

A 3D model of the specimen is generated using ANSYS16 . RC beam of cross-section (150mmX260mm) and span of 2000mm, reinforced with 3 structural steel rod of diameter 12mm each and stirrups of 10mm is modeled. The two conventional RC beams i.e., (B1 & B2) considered for the studies.

At 28 Days Result



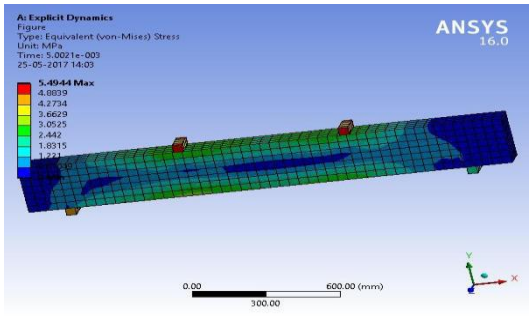


Fig 13:- Deflection of Plain RC beam

Fig 14:- Von Misses Stress of Plain RC beam

14. Conclusion

- Due to several advantages of PP sheet and RCF sheet materials used for structural repair and strengthening.
- This paper makes a comparative study between the load carrying capacity of an RCC beam and other beams with Retrofitted beams.
- An experiment study is carried out to study the change in the structural behavior of R.C.C. beams Reinforced with PP sheet and RCF sheet, to enhance the Flexural capacity of the beams
- The flexural strength of RC beam using PP sheet and RCF sheet materials given better results compared to the conventional beam.
- The strengthening with PP sheet and RCF sheet of 2mm, 4mm at the bottom of the beam and upto neutral axis of the beam found improving the ultimate load carrying capacity of beam.

- The strengthening of beam with 2mm of PP and RCF sheet at the bottom of the beam and with 4mm of PP and RCF sheet at the bottom of the beam and upto neutral axis has given the same results. So instead of using 4mm PP and RCF sheets, use 2mm PP and RCF sheet at the bottom of the beam.
- ANSYS is time saving and cost efficient tool that helps in simulation and gives satisfactory results using discrete approach. In the comparison case both experimental and analytical results varies less, due to the improper curing or compaction of conventional beam

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