Strengthening of RCC Column Using Fiber Reinforced Polymer and rPET Sheet

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Abstract:- *Now days it is common observation that structures are unable to give service as much as they are expected as per design. This is because of deterioration of the concrete and reinforcements caused by environmental factors and the widespread application of deicing salts, or due to an increase in applied loads. The Retrofitting can be used as a cost-effective alternative to the replacement of these structures and is often the only feasible solution. Fiber Reinforced Polymers (FRP) sheets or plates are well suited to this application because of their high strength to-weight ratio, good fatigue properties, and excellent resistance to corrosion. A lot of research has been done on the FRP as reinforcement in concrete column. However, the amount of research conducted on FRP as a sheet & laminate is quite less. So in the thesis, effect of FRP on RC column as a retrofitting material is studied. Also comparative effect of laminates with sheets having equivalent area is studied. The reinforced concrete columns designed and molded under axial load. It is demonstrated analytically that it is possible to strengthen the compressive strength of RCC columns with FRP. Comparative study of replacing rPET fiber with FRP for productive us.*

Key Words: strengthening, short column, cfrp, rPET

1. INTRODUCTION

An increasing number of reinforced concrete structures have reached the end of their service life, either due to deterioration of the concrete and reinforcements caused by environmental factors and the widespread application of deicing salts, or due to an increase in applied loads. These deteriorated structures may be structurally deficient or functionally obsolete, and most are now in serious need of extensive rehabilitation or replacement. Strengthening can be used as a cost-effective alternative to the replacement of these structures and is often the only feasible solution

1.1. FIBRE REINFORCED COMPOSITES (FRC)

Composite can be defined as 'two or more dissimilar materials which when combined are stronger than the individual materials.' Composites can be both natural and synthetic (or man-made) and as materials technology moves toward more sustainable solutions, the focus on the use of organic, or natural materials, especially as reinforcements, increases each year.

Wood is a good example of a natural composite which is a combination of cellulose fiber and lignin. The cellulose fiber provides strength and the lignin is the "glue" that bonds and stabilizes the fiber. Reinforced concrete is another example of composite in which concrete and steel combines to create structures that are rigid and strong. This is a classic composite material where there is a synergy between materials. In this case, synergy means that the composite (or combination) of materials is stronger and performs better than the individual materials. Concrete is rigid and has good compression strength, whilst steel has high tensile strength. The result is a structure that is strong in both tension and compression.

Composites are of two types, one is particle based & other is fiber based. Fiber based composites are used for civil engineering applications which is composed of fibers and resins. Two main types of polymer used for resins: thermosets and thermoplastics. The thermosetting polymers used in the construction industry are the polyesters and the epoxies. There are many thermoplastic resins used in composite manufacture: polyolefins, polyamides, vinylic polymers, polyacetals, polysulphones, polycarbonates, polyphenylenes and polyimides. Resin systems such as epoxies and polyesters have limited use for the manufacture of structures on their own, since their mechanical properties are not very high when compared to, for example, most metals. However, they have desirable properties, most notably their ability to be easily formed into complex shapes.

1.2. rPET FLAKES FOR FILM SHEET

Demand for rPET intended for film and sheet production is currently very high and still growing. This application is becoming increasingly important all over the world as it can assure high economic returns on the investment, similarly to Bottle-to-Bottle and thermoforms applications.

Physical and mechanical characteristics for rPET flakes for film application must meet very strict requirements as PET films are used specifically for their advantageous characteristics. In particular, these materials are often employed because of their high tensile strength, high chemical stability, transparency, and reflectivity. In addition, they constitute an efficient barrier towards gases and aromas and can act as an electrical insulation.

The PET washing line must be correctly designed and properly studied in order to obtain the highest amount of rPET flakes matching the strict requirements of the downstream film equipment's. SOREMA's long experience in this field is a guarantee of its ability of meeting such demands. Our label scrapers and washer are capable of removing great amounts of contaminants. Centrifugal spin drying takes care of the removal of excess water.

PET films may be designed and engineered for many different uses. They are adopted as substrates for several different applications, such as antimicrobial films, insulating films, photovoltaic backsheets, surface protection films, photographic films, and packaging. The main steps in their production are extrusion of a molten film, followed by quenching and drawing. Once the drawing is completed, the film is crystallized to prevent it from shrinking back to its initial shape. The orientation of polymer chains, obtained during the extrusion process, is the main factor allowing the achievement of high tensile strength.

BoPET is a particular type of PET film. Its name derives from the fact that it is biaxially-oriented (Bo). This film was originally developed by DuPont in the 1950s but is now manufactured by several industries under different commercial names. Some of its applications are widely adopted in daily life. For example, clear BoPET is used from the production of lids for ready meals which can be placed directly in the microwave due to the excellent heat resistance of the film. Metallized BoPET is instead used for the emergency blankets used to cover shock victims, to prevent them from losing body heat. Kites and high performance sails on sailboats are also produced using this particular PET film

1.3. NEED OF STUDY

The need for repair and strengthening of deteriorated, damaged and substandard infrastructures has become an important challenge worldwide. The demand for increasingly heavier truck loads is forcing bridge owners to upgrade existing structures. In response to the growing need for concrete repair and rehabilitation, an experimental program was conducted to investigate the feasibility of using different strengthening techniques as well as different types of FRP in strengthening concrete members.

Seismic retrofitting of constructions vulnerable to earthquakes is a current problem of great political and social relevance. Most of the Indian building stock is vulnerable to seismic action even if located in areas that have long been considered of high seismic hazard. During the past thirty years moderate to severe earthquakes have occurred in India. Such events have clearly shown the vulnerability of the building stock in particular and of the built environment in general. Hence it is very much essential to retrofit the vulnerable building to cope up for the next damaging earthquake.

The present study focuses on the behavior of reinforced concrete beam-columns strengthened using Glass Fiber Reinforced Polymer (GFRP) and Carbon Fiber Reinforced Polymer (CFRP) subjected to reverse cyclic loading. Reinforced concrete columns designed as per IS 456-2000 possess less necessary ductility to dissipate seismic energy during earthquake. Such beam-columns are seismically deficient and require additional confinement to improve their seismic parameters. Fiber reinforced polymer (FRP) composites are increasingly used for this purpose. Hence, experiments were conducted on Reinforced concrete beam-columns with and without FRP wrapping.

One Specimen each was tested without GFRP and CFRP wrapping, three specimens were tested with 2 layers, 4 layers and 6 layers of GFRP wrapping and other two specimens were tested with CFRP wrapping. The specimens were tested under a constant axial load and reversed cyclic lateral loading. Experimental results indicate a significant increase of ductility and increase in energy absorption capacity of RC beam-column when strengthened by both GFRP and CFRP Jacket.

2. METHTHODOLOGY AND INVISTIGATION

2.1. AIM OF THE PROJECT

- To observed that strengthening of rcc column after wrapping of CFRP and rPET.
- In case of short column applying different wrapping pattern and under the axial compression load
- To compare two different results of different material and also compare cost.
- The main objective of this experimental program is to study the behavior of under reinforced concrete column retrofitted with CFRP laminates & to make comparison of performance of laminates & sheets. To carry out the investigation three real size columns were casted.

2.2. TEST PROGRAM

The objective of test program was to find out the properties of materials and the behavior of retrofitted column. The test program involved

Determinations of basic properties of constituent materials namely cement, sand, coarse aggregates and steel bars as per relevant Indian standard specifications.

Three real size column (700 x 150 x 150mm) were casted using M 20 grade concrete. Each column was reinforced with four 12 mm diameter steel bars for longitudinal reinforcement and 8mm diameter bar for stirrups reinforcement

The column are stressed up to the level at which they stopped taking further load and then retrofitted with CFRP laminates & sheets.

2.3. MATERIALS

Cement, fine aggregates, coarse aggregates, reinforcing bars are used in casting of column, and cement slurry with bonding agent for grouting is used for retrofitting of this column. The specifications and properties of these materials are as under:

a. Cement

Portland pozzolona cement of 53 grades from a single lot was taken for the study.

b. Fine Aggregates

The sand used for the experimental works was locally procured and conformed to grading zone III. Sieve Analysis of the Fine Aggregate was carried out in the laboratory as per IS 383-1870. The sand was first sieved through 4.75mm sieve to remove any particle greater than 4.75 mm sieve and then was washed to remove the dust.

c .Coarse Aggregates

Crushed stone aggregate (locally available) of 20mm are used throughout the experimental study.

d. Water

Fresh and clean water is used for casting the specimens in the present study. The water is relatively free from organic matter, silt, oil, sugar, chloride and acidic material as per Indian standard.

e. Reinforcing Steel

HYSD steel of grade Fe-500 of 12mm and 8mm diameters were used as longitudinal steel. 12mm dia. bars are used as tension reinforcement and 8mm bars are used as compression steel. 8mm diameter bras are used as shear stirrups.

f. CFRP material

For retrofitting two types of CFRPs sheets & laminates were used. Carbon Fiber Reinforced Polymer (CFRP) Laminates - Aslan™ 400 series (appox. Cost -2700 sq meter)

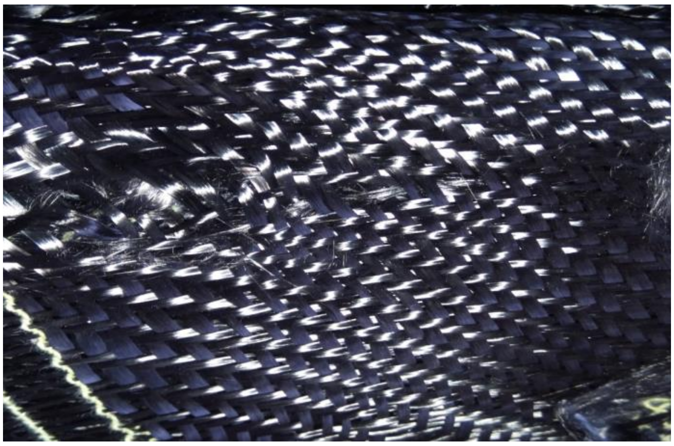

Fig1.CFRP

e.g rPET flakes for Film sheet

Demand for rPET intended for film and sheet production is currently very high and still growing. This application is becoming increasingly important all over the world as it can assure high economic returns on the investment, similarly to Bottle-to-Bottle and thermoforms application. (appox. Cost - 100 sq meter)

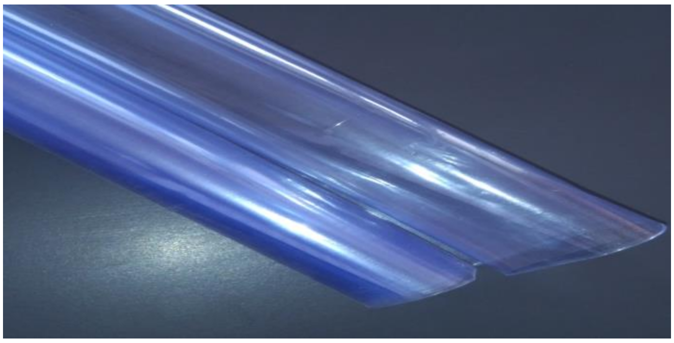

Fig2.rPET sheet

2.4. CONCRETE MIX

M20 grade concrete is considered as per standard design procedure using the properties of materials as discussed above .The mix proportion of material is 1:1.5:3.0 (cement: sand: aggregate) and compressive strength of concrete after 28 days is 20 N/mm^2.

2.5. RCC COLUMN DESIGN

In the present study the RCC column is design using M20 grade and Fe500 steel. The RCC column is design with limit state method considering it to be under-reinforced section. The stirrups used were of 8 mm diameter at 75 mm C/C. Cross sectional dimension of the column are 150 x 150 mm.

2.6. CASTING OF COLUMN

The casting of column was done in single stage. The column was cast in mould of size 700 x 150 x 150 mm. First of the entire column mould is oiled. So that the beams can be easily removed from the mould after 24 hours. Spacers of size 25mm are used to provide uniform cover to the reinforcement. When the bars have been placed in position as per design concrete mix is poured in the mould and vibrations are given with the help of needle vibrator, so that the mix gets compacted. The vibration is done until the mould is completely filled and there is no gap left. The beams are then removed from the mould after 48 hours. After demoulding the beams are cured for 28 days using jute bags. Application of deicing salts or due to an increase in applied loads.

The Retrofitting can be used as a cost-effective alternative to the replacement of these structures and is often the only feasible solution. Fiber Reinforced Polymers (FRP) sheets or plates are well suited to this application because of their high strength-to-weight ratio, good fatigue properties, and excellent resistance to corrosion.

A lot of research has been done on the FRP as reinforcement in concrete beams. However, the amount of research conducted on FRP as a sheet & laminate is quite less. So in the thesis, effect of FRP on RC beams as a retrofitting material is studied. Also comparative effect of laminates with sheets having equivalent area is studied.

2.7. Wrapping of Fiber

We have two different materials, after 28 days we wrapped column with CFRP and r pet sheet with different pattern of wrapping with help of bond (HETEX)

5 cm and 10 cm strips of both material are wrapped with same pattern

3. RESULTS & DISCUSSION

According to methodology axially compression test taken on columns with different pattern of wrapping after 28 days The following table shows results

Table -1: Sample Table format

TEST FILE CODE	PATTERN OF WRAPPING	SIZE OF STRIP (cm)	LOAD AT PEAK (kN)	ELONGATION AT PEAK (mm)	COMPRESSIVE STRENGTH (N/mm^2)
N001 N002 N003			370.800 354.900 402.300	9.25 8.80	18.54 17.745 20.11 Mean strength=18.80
CFRP 001 r PET 001	Single horizontal strip	5 cm	516.200 440.200	36.13 15.40	25.81 22.01
CFRP 002 r PET 002	Single horizontal strip	10 cm	490.270 402.920	20.11 16.51	24.53 20.14
CFRP 003 r PET 003 r PET 011	Fully wrapped		520.826 441.368 452.88	20.05 16.98 17.43	26.04 22.06 22.64
CFRP 004 r PET 004	Double X pattern	5 cm	411.800 398.729	19.17 18.53	20.59 19.93
CFRP 005 r PET 005	Single middle strip vertical	10 cm	390.180 410.908	9.9 9.44	19.50 20.09
CFRP 006 r PET 006	Single corner strip at corner	5 cm	460.812 430.15	19.58 18.27	23.04 21.50
CFRP 007 r PET 007	Full X pattern	5 cm	395.270 380.600	13.83 13.34	19.76 19.03

From above results we concluded that according to pattern of wrapping there is variation of strength.5 cm strip with vertical wrapping and also 10 cm strip achieve good strength. After axial compression test observed different cracking on column very less crack or failure on wrapping portion. In case of fully wrapped also achieved good strength. When we compare two materials CFRP is the used from many years so it is best option for strengthening but due to high cost we suggesting for new way to use productive use of rPET as a strengthening material is also possible but future work on the material is necessary

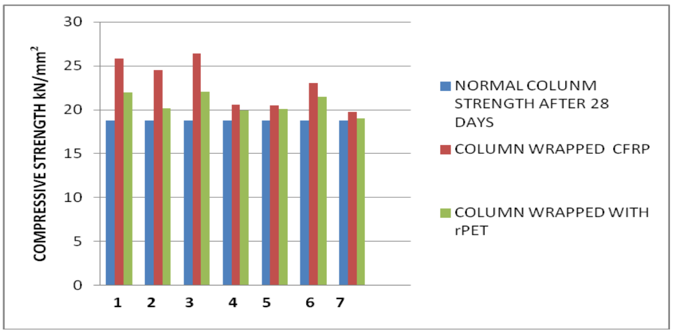

Chart -1: compressive strength comparison

REFERENCES

[1] Ascione, L., Feo, L (2000), "Modeling of composite/concrete interface of RC

[2] beams strengthened with composite laminates", Composites Part B:

[3] Benjeddou, O., Ouezdou, M. B., and Bedday, A. (2006), "Damaged RC beams repaired by bonding of CFRP laminates." Construction & Building materials, pp 1301-1310.

[4] Duthinh, D., and Starnes, M. (2004), "Strength and Ductility of Concrete Beams Reinforced with Carbon Fibre-Reinforced Polymer Plates and Steel." Journal of composites for construction, Vol 8, pp 59 – 69.

[5] Garden, H. N., and Shahidi, E. G. (2002), "The use of advance composite laminates as structural reinforcement in a historic building." ACIC 2002, Thomas Telford, London, pp 457 – 465.

[6] Head, P. R. (1999), "Advanced composites in Civil engineering- a critical review", Advanced composite materials in bridges and structures, Proceedings of second international conference, Quebec , Canada, edited by El-Badry, pp. 3-15.

[7] Heffernan, P. J., and Erki, M. A. (2004), "Fatigue Behavior of Reinforced Concrete Beams Strengthened with Carbon Fiber Reinforced Plastic Laminates." Journal Of Composites For Construction, Vol 1 , pp 132 – 140.

[8] Li, L. J., Guo, Y. C., Liu, F., and Bungey, J. H.

[9] (2005), "An experimental and numerical study of the effect of thickness and length of CFRP on performance of repaired reinforced concrete beams." Construction & Building materials, pp 901- 903.

[10] Marco, A., and Nanni, A. (1997), "Behavior of precracked RC beams strengthened with carbon FRP sheets." Journal of composites for construction, Vol 1, pp 63 – 70.

[9]Meier, U. (2002), "The development of composites and its utilization in Switzerland." ACIC 2002, Thomas Telford, London, pp 23 – 31.

[11] D. Kornack and P. Rakic, "Cell Proliferation without Neurogenesis in Adult Primate Neocortex," Science, vol. 294, Dec. 2001, pp. 2127-2130, doi:10.1126/science.1065467.

[12] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[13] R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.

[14] K. Elissa, "Title of paper if known," unpublished.