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EXPERIMENTAL STUDY ON EXTERNAL STRENGTHENING OF RC COLUMNS USING CARBON FIBER REINFORCED POLYMER (CFRP) COMPOSITES

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ABSTRACT
The use of Carbon fiber reinforced polymer (CFRP) materials for structural repair and strengthening has continuously increased in recent years, due to several advantages associated with these composites when compared to conventional materials like steel. This paper presents the results of an experiment at study on the structural behavior of reinforced concrete columns strengthened with carbon fiber sheets and strips in pre-cut grooves. The reinforced columns were strengthened before testing. The main tasks of these experiments were conducted to investigate the effects of additional strengthening of reinforced columns. Due to a number of benefits these composites have over more traditional materials like steel, the utilization of carbon fiber reinforced polymer (CFRP) materials for structural strengthening and repair has been steadily rising in recent years.
Keywords: Fibre Reinforced Polymer, FRP strengthened concrete columns, strengthening, confined concrete, buckling strength.

CHAPTER-1
INTRODUCTION

In recent decades the existing columns are undergoing retrofitting and which has become an indispensable requirement. To strengthen these existing reinforced concrete columns the application of Carbon Fiber Reinforced Polymers (CFRPs) has been done. The strength and stability were found to be increased invariably using these CFRP, of the strengthened columns. Both the experimental studies and theoretical studies on behavior of concrete confined with CFRPs showed the stress-strain behaviors for CFRP confined concrete, especially the circular columns under concentric loadings. It was evident based on the theoretical and experimental results, that, the CFRP confinement of a circular column was greater than that compared to square column. In case of square columns, the efficiency of CFRP confinement was less because, the stresses were concentrated at the corners and the active area of the confined section by CFRP was low. Hence, it was noticed that modifying a square column to a circular one will definitely increase the effectiveness of CFRP confinement.

CHAPTER-2
LITERATURE REVIEW

Muhammad N. S. HADI:
The use of steel reinforcement in concrete construction has proven to be very effective due to the excellent properties that the reinforcing steel has that complement the concrete properties, for

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example increase in tensile strength and ductility. However, one of the drawbacks of steel is its long-term behavior especially in areas where the humidity is high.

Ida BagusRaiWidiarsa:

Strengthening concrete columns with fibre-reinforced polymers (FRP) has been studied extensively, but the majority of published studies have focused on circular columns. Most concrete columns in the field have square or rectangular cross sections and resist eccentric loading as well. The objective of this study is to investigate the performance of square reinforced concrete (RC) columns wrapped with carbon FRP subjected to eccentric loading. The influence of two parameters was studied including the number of FRP layers and the magnitude of eccentricity.

CHAPTER - 3

3. PROPERTIES OF MATERIALS

- Cement
- Fine Aggregate
- Course Aggregate

CHAPTER – 4

Experimental Program

In recent decades the existing columns are undergoing retrofitting and which has become an indispensable requirement. To strengthen these existing reinforced concrete columns the application of Carbon Fiber Reinforced Polymers (CFRPs) has been done. The strength and stability were found to be increased invariably using these CFRP, of the strengthened columns.

Test Methods

CFRP were bonded to the columns after carrying out the surface preparation. All the surfaces of the Columns were made smooth using a rotary grinder. It is important to make the top and bottom surfaces of columns exactly flat to apply uniform load on both surfaces. Then the saturated CFRP layers with epoxy were pasted on to the column surfaces.

Mix proportion

The mix design has been made for M20 grade conventional concrete and light weight concrete use of code IS10262- 1982, IS 456-2000 recommended. The water cement ratio (W/C) was kept constant at approximately 0.45 for all mixes, The percentage like 10%, 25%, and 50%, incorporation was used as partial and full replacement of natural coarse aggregate and the fly ash percentage like 15%, 20%, 25% used as partial replacement for cement concrete.Mix proportion obtained for M25 Grade of conventional concrete and light weight concrete mix ratio was 1:1.5:3.

Casting of Specimen

All the columns were tested under axial in compression testing machine having a capacity of 2000 kN. The column member was placed on the supports, and care was taken to ensure that its centerline was exactly in line with the axis of the machine. The columns were instrumented to measure the axial deformation using a linear voltage displacement transducer (LVDTs), and 2000 kN load cell was used to monitor the load. Both load cell and LVDTs were connected to the 16-Channel Data Acquisition System to store the data. The load was applied to the columns using an electronic jack and they were tested to failure. The experimental observation recorded the nature of the failure, axial deformation, and ultimate load.

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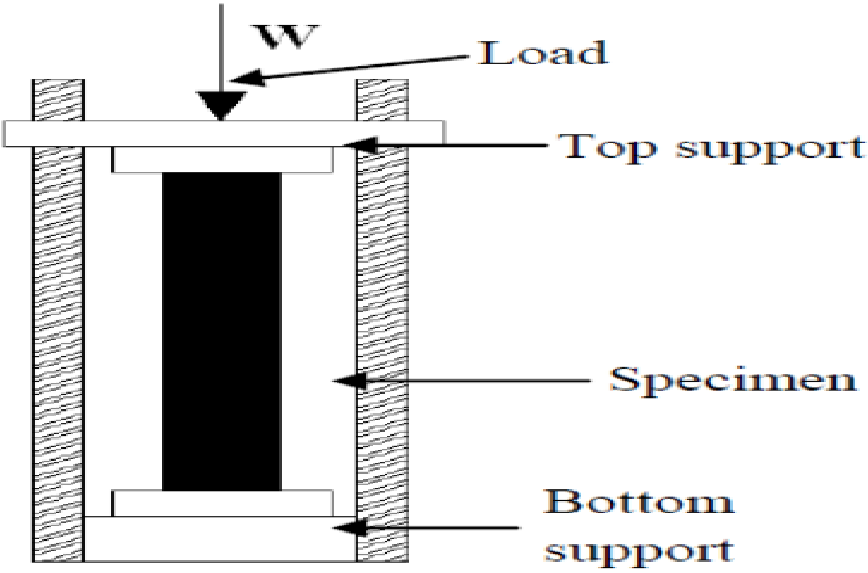
Loading arrangement



In the present experimental program the wet lay-up technique was applied in order to obtain a full CFRP confining system. The CFRP wrapping process included surface preparation and unidirectional CFRP application. At the mid-height of the column was applied a 600 mm wide CFRP and at both ends there was applied a 300 mm wide CFRP strip, resulting an overlap of 100 mm reffering to the longitudinal direction of the column. The overlap of the CFRP strips in the transversal direction of the member was equal with the side of the cross-section. At both ends of the specimens one additional 200 mm wide CFRP strip was applied in order to avoid premature failure.

Failure mode of CFRP confined column specimen

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CHAPTER – 5
RESULTS AND DISCUSSION

Load-Displacement FWB-Double Layer

Load (kN)	Displacement (mm)
0.0	2.65
0.5	7.40
1.0	14.15
1.5	26.12
2.0	40.15
2.5	60.26
3.0	93.15
3.5	134.16
4.0	154.25
4.5	178.15
5.0	206.15
5.5	229.12
6.0	249.15
6.5	265.16
7.0	289.15

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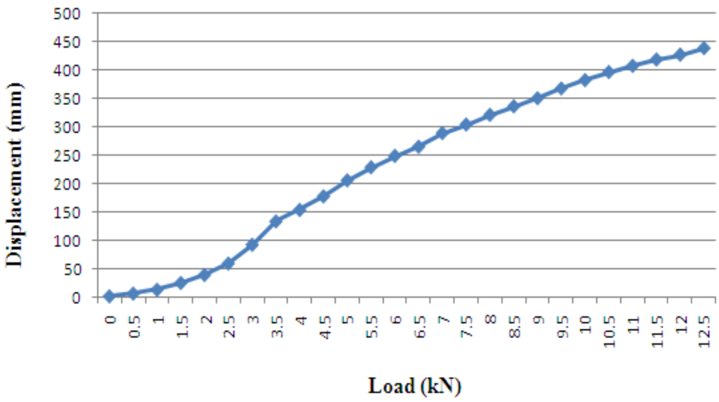
7.5	304.15
8.0	321.15
8.5	336.15
9.0	350.23
9.5	367.38
10.0	382.15
10.5	396.26
11.0	407.12
11.5	418.25
12.0	426.85
12.5	438.15



EXPERIMENTAL RESULTS AND DISCUSSION

Each group specimens were tested under axial compression concentric loading. Results were given in Table 1 and the load vs axial deflection curves were compared for each group in Fig 4.1. Some observations were made as below Specimen of group N failing by concrete spalling on the surface and buckling of the longitudinal reinforcement. Specimens of group RF and group CF failing by rupture of CFRP at mid-height of the specimen, as shown in Fig four.6.5 and Fig four.6.6. The concrete at mid-height was utterly crushed and was restrained by CFRP. Aggregates of Specimens RF and CF were utterly separated from one another, which were totally different from the concrete of Specimens N. All the Specimens of cluster N, RF and CF illustrated identical behavior throughout the primary stage of the curve, that is, the concrete wasn't crushed.

CHAPTER – 5
CONCLUSION

• CFRP has become a notable material in structural engineering applications. Studied in an academic context as to its potential benefits in construction, it has also proved itself cost-effective in a number of field applications strengthening concrete, masonry, steel, cast iron, and timber structures. Its use in industry can be either for retrofitting to strengthen an existing structure or as an alternative reinforcing (or pre-stressing) material instead of steel from the outset of a project.
• Applied to reinforced concrete structures for flexure, CFRP typically has a large impact on strength (doubling or more the strength of the section is not uncommon), but only a moderate increase in stiffness (perhaps a 10% increase).

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