Experimental Study on Concrete Columns Confined with External FRP

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Abstract : In this paper present a various kinds of confining material like welded wire mesh, FRP, Fiber glass fly mesh , Ferrocement, welded spot stirrups. This project is high lighting the study of FRP effective confining material on RC rectangular and circular column by improving the confining quality. the dearth of confinement offered by ties was the motivation for using materials like Expanded Metal Mesh(EMM), Welded Wire Mesh (WMM) and fiber Reinforced Polymer (FRP) to confine the concrete core.

Key Words - Confining by fiber reinforced polymer.

1.INTRODUCTION

Sometimes column may damage thanks to earthquake, disasters, excess loading and fire also, reason behind it have limited strength & ductility of the concrete. Sometimes failure of column can winds up in collapse of this structure. lateral and longitudinal reinforcement are gives extra strength to column and also increase performance of RC column. transverse reinforcement in column like spirals , hoops, links are plays more significant role for increasing its strength and also provides safety, specially after they're subjected to earthquake forces & lateral loads .RC columns are load bearing element of all structures . The tendency of concrete to dilate after cracking and thus the radial stiffness of the confining jacket to restrain the concrete dilation, are considered to be two important factors affecting the concrete confinement. By wrapping the concrete by an external continuous FRP jacket, the fibers within the ring direction resist the transverse expansion of the concrete providing a confining pressure.

2.AIM

Properly design and detailed confining transverse reinforcements prevent buckling of longitudinal bars,avoid shear failure and supply sufficient Ductility.

3. OBJECTIVE

1.To achieve compressive strength of column.
2.To column confined with various confinement and increasing its strengths
3.To increase load carrying capacity (axial load and bending moment)
4.Experimental analysis of the load carrying capacity of the column
5.To study the efficiency of confinement utilized within the oblong cross section of column.

4.CONFINED CONCRETE

In current years high rise concrete buildings quite 20 story's high have started be constructed using strength concrete and transverse reinforcement with high strength steel. When columns with high strength concrete are subjected to simple seismic loading with high axial load, ductility demand for columns at yield zones is satisfied only by providing the core concrete with intensive confinement achieved by using high strength transverse reinforcement. Thus, the importance of profound knowledge about the characteristics of confined concrete is increasing with increase of cloth strength used. Confinement of Concrete is to quandary the concrete or to avoid the concrete from spilling. due to this ductility is informed to the column so on resist the axial load, buckling of column, vibrations due to the Earthquake induced inertial forces, also creation of plastic hinges due to excess loading etc. If the realm of the confined core is increased the correspondingly the ductility of the column growths.

5. AXIAL STRENGTHENING BY COLUMN CONFINEMENT

5.1 Mechanics of confinement:

Under low level of longitudinal strain, the concrete is known to behave elastically and thus the crosswise strain is claimed proportionally to the longitudinal strain by the Poisson's ratio. because the load increases, cracks twitch to system leading to an outsized increase within the transverse strain. Assuming deformation compatibility, the lateral strain of the confined specimens is up to the strain within the FRP jacket. The tendency of concrete to dilate after cracking and thus the radial stiffness of the confining jacket to restrain the concrete dilation, are considered to be two important factors affecting the concrete confinement. By wrapping the concrete by an external continuous FRP jacket, the fibers within the ring direction resist the transverse expansion of the concrete providing a confining pressure. At low levels of longitudinal stress; however, the transverse strains are so low that the FRP jacket induces little confinement, if any. At higher longitudinal stress levels, the dramatic increase in transverse tensile strains activates the FRP jacket then the confining pressure becomes more significant.

5.2 Effect of confinement strength of FRP:

The confinement strength of FRP, which relies on of and also the last word enduringness of FRP, features an instantaneous impact on the axial stress and thus the axial deformation at failure. the increase in confinement strength can cause an improvement in strength and make the prisms more ductile. Furthermore, it's going to change the stress-strain curve of FRP-confined prisms from a strain-softening response to a strain hardening response.

5.3 Effect of cross section of shape:

It was observed that the presence of FRP reinforcement increases the strength of plain concrete, but this phenomenon is strongly influenced by the shape of the cross-section. Rectangular columns might have different confinement effect in two orthogonal directions and have different levels of confinement pressure between the long and short sides of the cross-section. Confinement pressure along the long side plays a dominant role on concrete strength. As a consequence of this, so on get in columns having a square cross-section analogous performance in terms of strength as in columns having a circular transverse cross-section and reinforced with FRP, an increase within the volumetric ratio of FRP is required and/or a metamorphosis of the square section into one with rounded corners.

5.4 Effect of corner radius:

The sharpness of the section corner might be a big influence parameter to the stress–strain curve of FRP-confined prisms. The sharpness of the section corner is expressed by the ratio of the radius corner (r) to the longer side length of the section (h). thanks to stress concentration at sharp edges, round corners are necessary to avoid kink damage to the FRP jacket.

5.5 Effect of unconfined compressive strength:

The lower-strength concrete has larger deformability than higher-strength concrete. Also, the peak compressive strain of lower-strength concrete is lower compared therewith of higher-strength concrete. it's believed that the confinement efficiency to lower-strength concrete prisms is higher, and also the influence of unconfined concrete strength on the transitional stress & strain

5.6.Lateral Confining Pressure of Circular Specimens:

When an FRP confined circular column is subjected to axial compression, the concrete expands and this expansion is resisted by the FRP. As the FRP is subjected to tension in the hoop direction, eventual failure occurs when its hoop tensile strength is reached. This failure mechanism dictates that the fibers, or the main fibers if there are secondary fibers in other directions, are oriented in the hoop direction. FRP tensile rupture due to hoop tension is almost the only possible failure mode in FRP confined circular columns.

5.7 Lateral confining pressure of rectangular specimens:

The effectiveness of FRP reinforcement is less in the case of a rectangular section compared to a circular cross section and this is due to the concentration of stresses at the corner of the square section and also to the smaller effectively confined concrete core in a rectangular section with respect to a circular cross-section. In a rectangular cross section the stress is not uniform along the perimeter because of stress concentration near the corners of the section. The material round the corners and across the diagonals between opposite corners is more or less confined by the FRP wraps while the fabric alongside the flat portions of the rectangular section is less or not at all confined, depending on the curvature and extent of the corners

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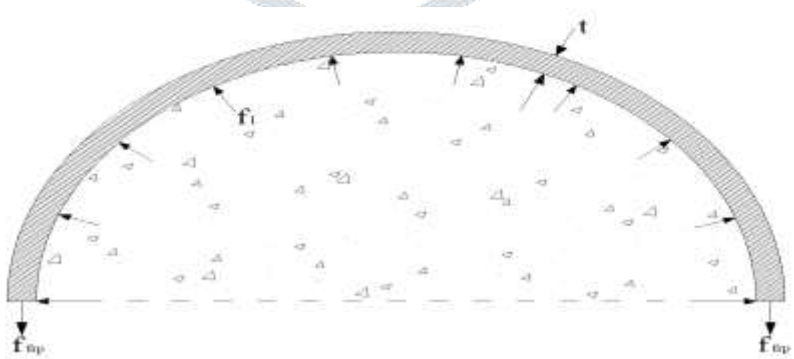

Figure 5.7. 1 : Confining Action of FRP

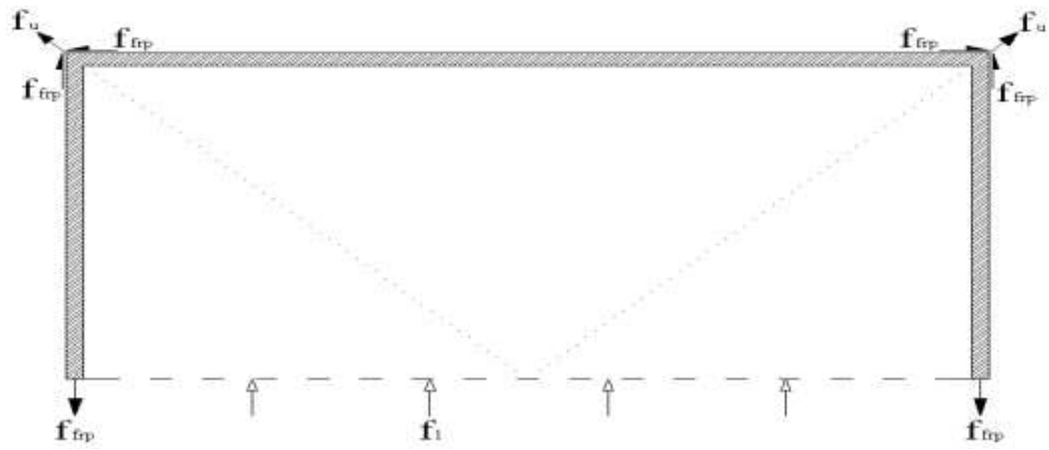

Figure 5.7.2: Stress Distribution in Confined Rectangular Columns in Case of Sharp Corners

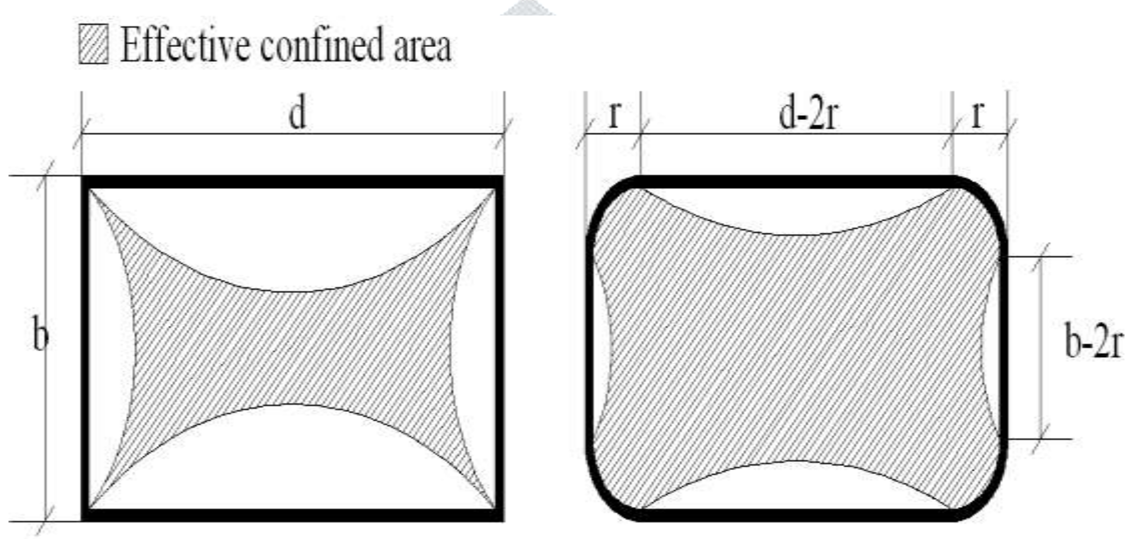

Figure 5.7.3: Effect of Corner Radius on Effective Confined Area of Rectangular Columns

5.8. Confining Material

FRP (Fiber Reinforced Polymers)

The use of Fiber Reinforced Polymers (FRP) to wrap concrete columns has been generally investigated and has become a really successful method to boost their structural performances. It's been recognize that
FRPs, thanks to the presence of an organic resin. the chance of reinforcing concrete elements by
externally applying fiber reinforced polymer (FRP).

Advantages Of CFRP Wrap Strengthening:

1. Easy Installation
2. Corrosion resistance
3. Short Construction period
4. No maintenance required
5. Light Weight, no influence to original structure
6. Low cost, cost effective compared with other structure

Table 5.8: Mechanical Properties of Carbon Fiber Reinforced Polymers (CFRP) Wrap:

Weight	200g/sqm
Thickness	0.111mm
Density	1.8g/cm3
Direction	unidirectional
Packing	100 meters/roll
Width	100mm, 200mm, 300mm,500mm

Figure 5.8 : Column strengthening

6.DESIGN PROCEDURE OF RC COLUMN

Various column specimen sizes :taking 3 different column sizes for casting .

Table 6: Column sizes

Sr. no	Sizes of column(mm)	Height(mm)
1	200*200	700
2	230*200	700
3	175	700

6.1EXPERIMENTAL WORK

To investigate the enhancement of strength due to FRP wrap on various shaped RCC columns confined with CFRP sheets, total 6 numbers of RC columns of different cross-section and different length. In which 3 specimens are control specimens and remaining 3 are confined with one layer of CFRP sheet. All the specimens will be subjected to axial compression in a 100 ton capacity compression testing machine (CTM). Data acquisition (DAQ) system will be used to measure the readings from the instrumentation.

6.1.1Fabrication of moulds :

Figure 6.1.1: Rectangular Mould Having 200 X 230X700 mm ,Square-200X200mm

6.1.2. Casting and curing of specimens :

a) Process of casting specimens are as following :
b) Fabrication of Moulds and Reinforcement
c) Oiling to the inner surface to the moulds
d) Preparing concrete mixture as per concrete mix design
e) Insertion of Reinforcement in to the moulds
f) Filling up moulds by concrete mix
g) Removal of moulds and curing

Figure 6.1.2: Ready Specimens

6.1.3.CFRP wrapping

Figure 6.1.3: Applying Epoxy Resin and Wrapping CFRP on Specimens

6.1.4. Test setup :

Figure 6.1.4: Universal Testing Machine Having 100 Ton Capacity

Figure 6.1.4.2: Mode of Failure of CFRP Wrapped Columns

6.2 Field Applications

1. The strength and ductility of concrete are often improved by adding confinement, which helps RC structures to face up to extreme loads during a ductile manner.
2. confinement with FRP (fiber reinforced polymer) jackets may be a useful reinforcement technique to enhance the strength and ductility of concrete columns subjected to axial compression loads, especially in those that have a circular cross section. This strengthening method is a smaller amount effective for elements with square or rectangular sections during which , unlike the circular ones, the FRP confinement isn't uniform.
3. It improves the properties of concrete by confining it.
4. confinement materials which are chosen are improve strength and durability

6.3 Ductility of column

- Ductility are the ability of reinforced concrete member to undergo deflection prior to failure.it provides sign of failure and prevents total collapse structure. Measures used for ductility performance of ferroconcrete elements are discussed.
- Measures to extend Ductility of ferroconcrete Structural Members
    - Generally use for improve ductility is the prevention of foundation failure.
    - brittle failures like failures thanks to shear, anchorage, bond, and concrete compression failure shall be avoided.
    - Use under ferroconcrete sections so as to be ready to rotate significantly before failure.
    - It is mostly provide for lateral confinement at critical locations of columns so as to make concrete experience greater deformations.

7. LAYOUT OF EXPERIMENT & TEST RESULT

7.1Test Specimen

The main experimental program includes 6 RC Column externally confined with FRP sheet. The tested column have total height 'H' mm and rectangular cross section (bxd mm), circular (d mm) of different slenderness ration (l/d)

Table 7.1: Data of tested columns

Column No.	Concrete Grade (Mpa)	Column dimensions			Internal Reinforcement		CFRP Wrapped Columns
		H (mm)	Bxd (mm2) Or D (mm)	l/b	Ast %	S(Ast)	
1	M20	700	200 X 200	3.5	4Ø 12mm (1.13%)	150 mm (0.6%)	Unwrapped
2	M20	700	175	4	6Ø 12mm (2.82%)	150 mm (0.6%)	Unwrapped
3	M20	700	230 X 200	3.04	4Ø 12mm (0.98%)	150 mm (0.6%)	Unwrapped

4	M20	700	200 X 200	3.5	4Ø 12mm (1.13%)	150 mm (0.6%)	Wrapped
5	M20	700	175	4	6Ø 12mm (2.82%)	150 mm (0.6%)	Wrapped
6	M20	700	230 X 200	3.04	4Ø 12mm (0.98%)	150 mm (0.6%)	Wrapped

7.2Axial Load

Ultimate failure load of all column and percentage increment failure load over unconfined columns are presented in table no.

Table 7.2: Experimental results for columns

Column no.	Notation	Ultimate Failure Load (KN)	Average ultimate failure load (KN)	% Increase of average ultimate failure load over unwrapped columns
1	C1	610	676.67	-
2	C2	750		
3	C3	670		
4	C4	650	713.33	5.42%
5	C5	790		
6	C6	700		

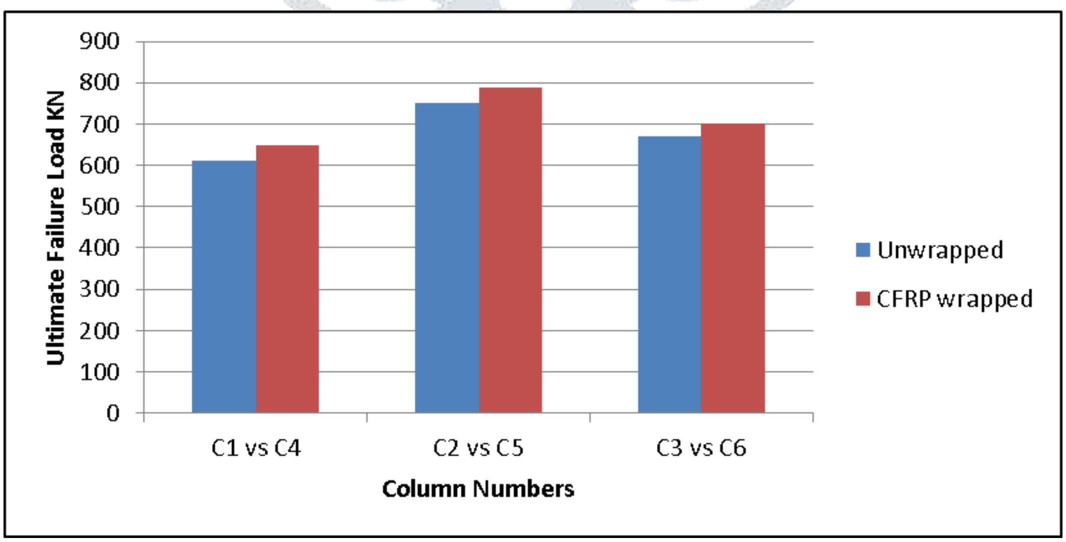

Figure 7.2: Comparison of ultimate failure load for unwrapped and wrapped column

7.3Strain Measurements

7.3.1 Axial Loading Stress-Strain

$\Sigma = \frac{F}{A}$, $\varepsilon = \frac{\sigma}{E}$ …… $E=5000\sqrt{Fck}$

Table 7.3: Stress Strain for Columns

Column No.	Axial stress N/mm2	Axial strain
C1	15	0.0244
C2	31.18	0.03
C3	14.56	0.0268
C4	16.25	0.026
C5	32.84	0.0316
C6	15.21	0.028

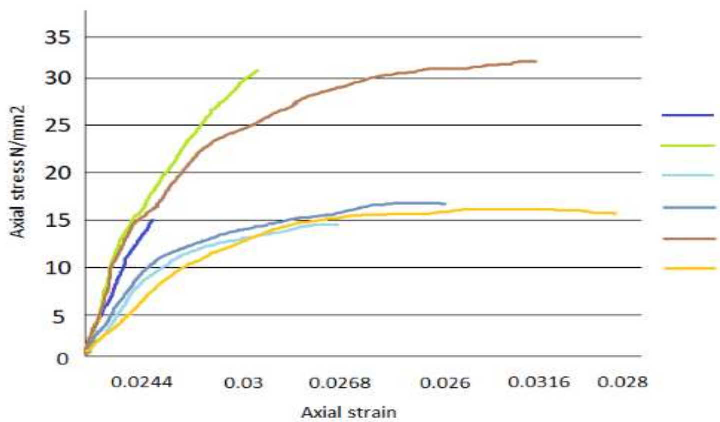

Figure 7.3.1: Ultimate failure load of all specimens

8.CONCLUSION

Based on the experimental results, the subsequent conclusion are drawn:

1. In this project rectangular column is consider having different type of confinement as reinforcement.
2. The experimental results clearly demonstrate that CFRP wrapping can enhance the structural performance of RC column under axial loading, in term of maximum strength and strain.
3. Percentage increment in ultimate failure load is 5.42% for all confined column as compared to that a unconfined column.
4. Increasing the number of CFRP layers increases the axial compressive strengths of the columns. However, the strength increase is not in linear proportion with the number of CFRP layers.
5. Higher ultimate failure load capacity is achieved for the columns having C1,C2,C3 of compared to the columns C4, C5, C6
6. Increase in axial stress and axial strain of column is observed with increase in number of CFRP layers.

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