Journal of Advances and Scholarly Researches in Allied Education
Vol. 18, Issue No. 4, July-2021, ISSN 2230-7540

Behavior of Square Concrete Column Confined with CFRP Sheets

Milind V. Tondase[1]* Munkund M. Pawar[2] Manik G. Deshmukh[3] Sonali P. Patil[4]

[1] PG Student-Civil Engineering Department, SVERI'S College of Engineering, Pandharpur, Maharashtra

[2,3] Associate Professor, Civil Engineering Department, SVERI'S College of Engineering, Pandharpur, Maharashtra

[4] Assistant Professor, Civil Engineering Department, SVERI'S College of Engineering, Pandharpur, Maharashtra

Abstract – In this research, a study was conducted to determine the axial shortening and axial loading for a total of 30 columns specimens. It consists of six plain control columns, six reinforced columns with a minimum steel content of 0.8 percent of cross section, and eight plain strengthen columns with varying layers of CFRP one, two, and three in the transverse direction for different concrete grades M 20, M 30, and M 40. For the repair and retrofitting of concrete structures, externally bonded fibre reinforced polymer (FRP) composites have become increasingly common. FRP composites are popular because of their well-known benefits, which include a high strength-to-weight ratio and superior corrosion resistance. The use of FRP composites as a confining material for retrofitting existing reinforced concrete (RC) columns with FRP jackets is a common application. The carbon fibre utilised in this investigation is known as "Nitowrap" and is widely accessible on the market. With the use of epoxy adhesive, the fibres are wrapped around the column. The experimental results reveal that rounded sharp increases load carrying capacity up to two layers of CFRP wrapping in the transverse direction, while ductility rises up to three layers of wrapping as compared to the control. The toughness index of the reinforced column rises as the concrete grade rises, and as the number of CFRP sheet layers rises.

Keywords – CFRP, FRP, RC Columns.

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I. INTRODUCTION:

Concrete is one of the most important materials for infrastructure development because of its wide range of applications; globally, it is second only to water in terms of utilisation. Concrete is one of the most common building materials. Concrete has evolved as a material and technology since its inception. There has been a constant search for improving the qualities of concrete due to the increased demands for performance and durability. Concrete is the most adaptable building material, and it is utilised in a wide range of civil engineering projects and structural parts all over the world. For a variety of reasons, concrete is the most extensively utilised engineering material. For starters, concrete is extremely water resistant. Concrete's resistance to some abrasive waters is to blame for the fact that it has been used in a variety of harsh industrial and natural conditions. The ability of structural concrete elements to be moulded into a range of shapes and sizes is the second reason for its extensive use. This is due to the fact that freshly mixed concrete has a plastic consistency, allowing it to flow into prefabricated formwork. Concrete's appeal among engineers is due to the fact that it is usually the cheapest and most easily available material on the job. Portland cement and aggregates are the main elements in concrete, both of which are very inexpensive and widely available in most parts of the world.

II. MATERIAL PROPERTIES:

A. Cement:

Ordinary Portland 43grade cement was used in the experiment. Hydraulic cement was tested according to IS: 40311988 guidelines. Table 1 summarises the findings.

B. Fine Aggregate:

Fine aggregate is defined as material that can pass through a 4.75 mm IS sieve, as defined by IS: 383—1970. Sand size aggregate is another name for it. Fine aggregate was made from locally accessible river sand. In Table-1, the qualities of fine aggregate are listed.

C. Coarse Aggregate:

In this project, crushed granite aggregates with a size of 20 mm are employed. To determine the specific gravity and fineness modulus of coarse aggregates, tests are carried out. The results of the tests are listed in Table-1.

Table 1: Physical Properties of Materials

S. NO.	Description	Results	As per code
1	**TEST ON CEMENT** Normal consistency of cement	31%	28-33%
	Setting time of cement Initial Time Final Time Fineness of cement Specific gravity of cement	 90minutes 270 minutes 226 Sq. m/kg 3.05	 Min.30 Max.700 226 Sq. m/kg 2.9-3.15
2	**TEST ON FINE AGGREGATE** Fineness modulus of fine aggregate Water absorption of fine aggregate Specific gravity of fine aggregate	 2.64 % 1.15 % 2.6	2-4
3	**TEST ON COARSE AGGREGATE** Fineness modulus of coarse aggregate Water absorption of coarse aggregate Specific gravity of coarse aggregate	 2.56 % 0.5 % 2.7	

D. Water:

Concrete must be made with water that is free of sewage, oil, acid, strong alkalis, or vegetable matter, as well as clay and loam. The water utilised is safe to drink and can be used in concrete. Casting and curing of concrete specimens utilised in the experimental work are done with tap water provided by Sri Sunflower College of Engineering and Technology.

E. Reinforcing Steel:

In the case of reinforced columns, mild steel bars with a yield stress of 415MPa were used for longitudinal and transverse reinforcement.

F. Carbon Fibers and Epoxy Adhesive:

The carbon fibre utilised in this investigation is known as "Nitowrap" and is widely accessible on the market.

Table 2: Properties of Nitowrap Carbon Fiber

S. NO.	PROPERTY	VALUE
1	Fiber orientation	Unidirectional
2	Weight of fiber	200 g/m2
3	Fiber thickness	0.11mm
4	Ultimate elongation	1.5%
5	Tensile strength	4900 N/mm2
6	Tensile modulus	285x103N/mm2

G. Super Plasticizer:

Super plasticizers are a type of water reducer that is chemically distinct from regular water reducers and capable of lowering water content by 30-40%. Glenium B233 is a sort of super plasticizer given by BASF Bangalore, which we employed in our research.

III. EXPERIMENTAL PROGRAMME

MIX DESIGN:

The current study used concrete mixes with specific characteristic strengths of M 20, M 30, and M 40 MPa made with locally available ordinary Portland Cement (OPC), crushed granite jelly (20 mm down), river sand, and Glenium B233. The mix designs for these three concrete classes are based on IS 102622009 guidelines. The compressive strength of the concrete was measured using standard cubes (150mmX150mmX150mm). The mix proportions are decided based on the test results from a number of trial mixes.

Table 3: Details of Concrete Mix Proportions

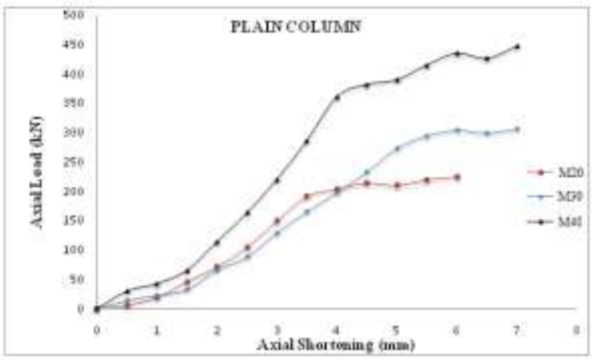
S NO	Mix Designation	Proportion	W/B Ratio	Super-Plasticizer % by wt of cement	Comp. strenth @28 days (N/mm²)	Slump (mm)
1	M20	1:1.82: 3.36	0.5	0.2	28.66	75
2	M30	1:1.66: 3.06	0.45	0.2	38.25	70
3	M40	1:1.48: 2.75	0.4	0.2	46.69	68

IV. TESTS AND RESULTS

The effect of wrapping CFRP sheets to the concrete column to increase axial load carrying capability for different grades of concrete is described in this research.

Axial Load and Axial Shortening Curve of Column:

Axial Load and Axial Shortening for Plain Column



Graph 1: Axial Load v/s Axial Shortening for Unconfined Column

Figure 1: Failure Pattern of Unconfined Different Grades of Concrete Columns

Axial Load and Axial Shortening for Reinforced Column

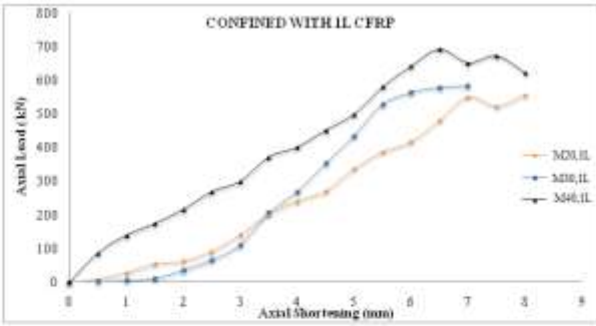
M20RC

M30RC

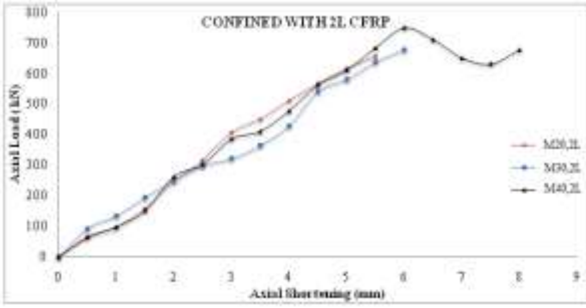
M40RC

Figure 2: Failure Pattern of RC Column with Different Grade

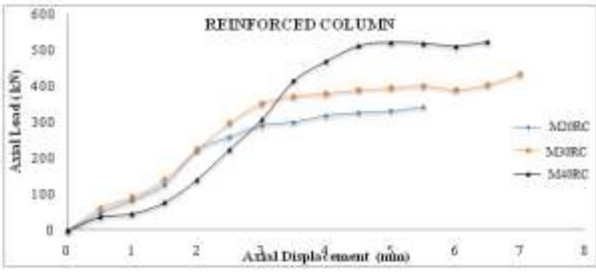
Axial Load and Axial Shortening for Single Layer Strengthened Column



Graph 2: Axial Load v/s Axial Shortening for One Layer CFRP Confined Column

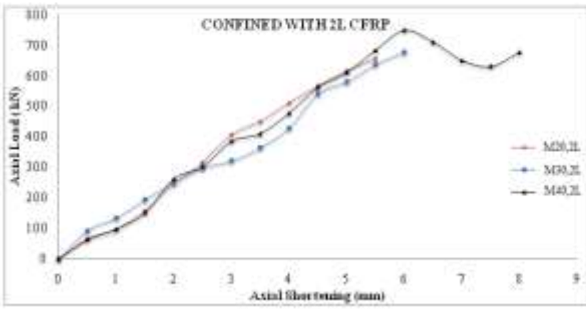


Axial Load and Axial Shortening for Two Layers CFRP Strengthened Column

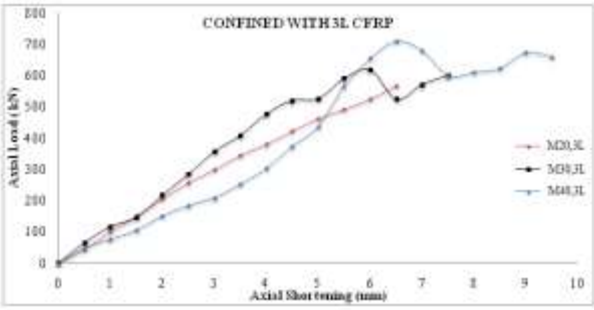


Graph 3: Axial Load v/s Axial Shortening for Reinforced Column

Axial Load and Axial Shortening for Two Layers CFRP Strengthened Column



Graph 4: Axial load v/s axial Shortening for Two Layers CFRP Strengthened Column



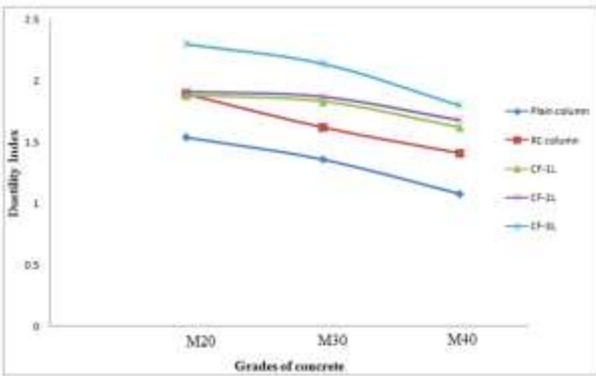
Graph 5: Axial Load v/s Axial Shortening for Three Layers CFRP Confined Column

Figure 3: Failure Pattern of CFRP Strengthened Column with Different Layers

Axial Load Carrying Capacity of Column

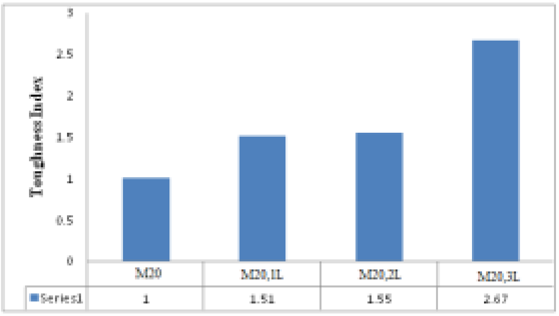
Specimen	Ultimate Axial Load (kN)			Axial Shortening at Ultimate Axial load (mm)		
	M20	M30	M40	M20	M30	M40
PCC	225.60	307.80	447.80	6.0	7.0	7.0
RCC	341.2	434.60	522.50	5.5	7.0	6.5
CF-1 Lyr.	556.20	582.40	690.40	8.0	7.0	6.5
CF-2 Lyr.	655.30	678.20	749.08	5.5	6.0	6.0
CF-3 Lyr.	566.75	617.62	710.20	6.5	6.0	6.5

Ductility Index

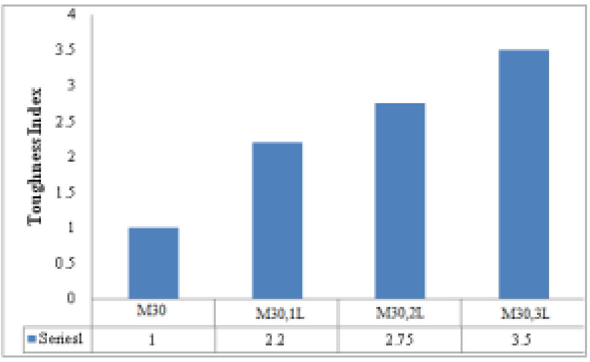


Graph 6: Ductility Indices of Column for Different Grades of Concrete and Layers of Wrapping

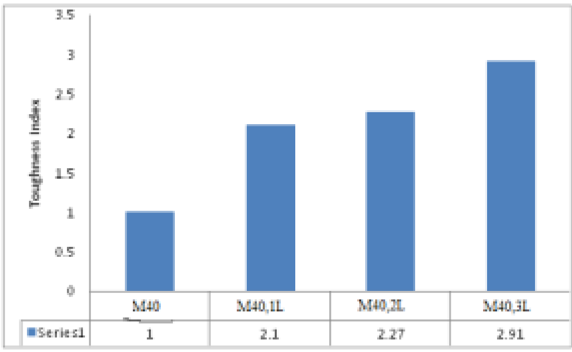
Toughness Index



Graph 7: Toughness Index of M20 column

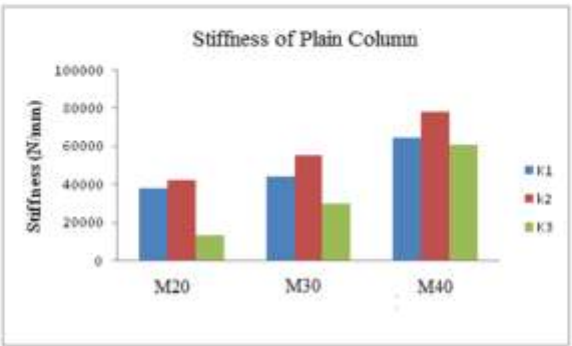


Graph 8: Toughness Index of M30 column

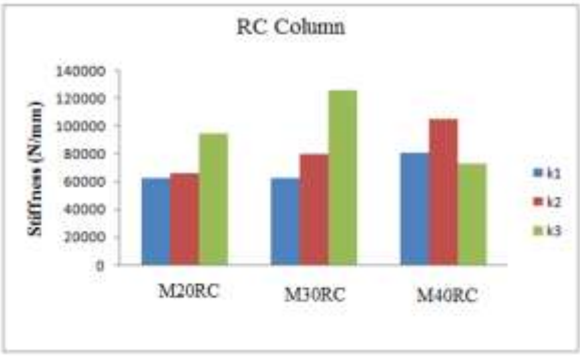


Graph 9: Toughness Index of M40 column

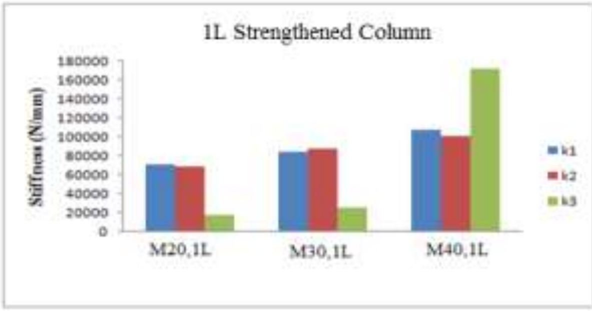
Stiffness



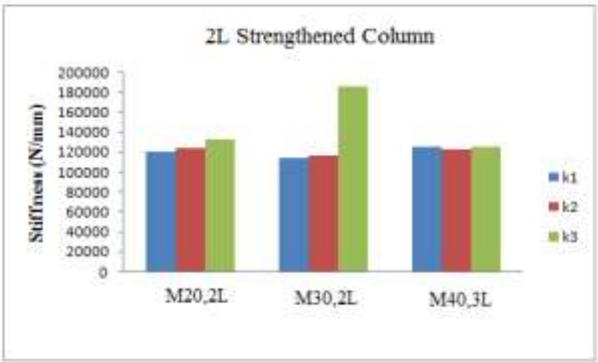
Graph 10 Stiffness of plain column



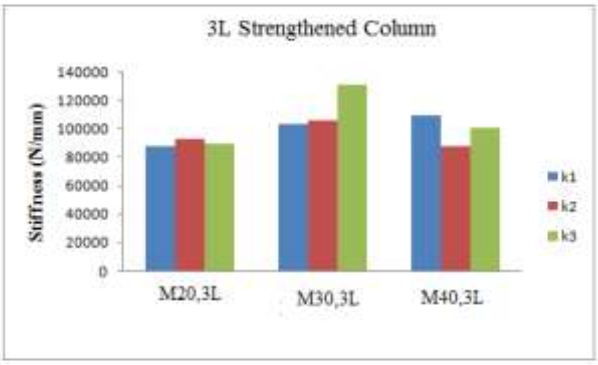
Graph 11: Stiffness of RC column



Graph 12: Stiffness of 1L strengthened column



Graph 13: Stiffness of 2L strengthened column



Graph 14: Stiffness of 3L strengthened column

V. CONCLUSION& SCOPE OF FURTHER WORK

CONCLUSIONS:

- The CFRP-strengthened column with up to two layers is effective in boosting the column's axial load carrying capability; nevertheless, the CFRP layers deemed ineffectual.
- Column ductility is increasing as a result of the use of reinforcement and carbon fibre wrapping; ductility increases as the number of layers increases.
- Tensile rupture of the CFRP jacket failed one-layer strengthened columns, while delamination and rupture of the CFRP jacket failed two-layer stronger columns, and simply delamination of the CFRP jacket failed three-layer strengthened columns.
- When compared to a plain column, the RC column has a 36.37 percent improvement in load carrying capacity.
- When compared to plain columns, one, two, and three layers strengthened columns enhance load carrying capacity by 96.64 percent, 126.02 percent, and 103.49 percent, respectively.
- When compared to RC columns, one, two, and three layers reinforced columns enhance load carrying capacity by 43.04 percent, 63.82 percent, and 48.04 percent, respectively.
- The toughness index of carbon fibre wrapped columns rises as the concrete grade rises and the number of CFRP sheet layers rises.
- Proposed analytical models (Theriult and Neale, 2005) indicate reasonable wrapped column axial load capacities.
- A plain column covered in one layer carbon fibres has 43.04 percent greater axial capacity than a R.C column. As a result, R.CC column can be replaced with a wrapped plain column.
- When comparing the stiffness of two and three layer wrapping specimens to one layer wrapping specimens, RC, and plain column, the stiffness of two and three layer wrapping specimens is found to be the highest.
- A two-layer plain column made of M40 grade concrete performs better in every way.

SCOPE OF FURTHER WORK:

The current experiment looks at the axial compressive strength of concrete columns of various grades that have been strengthened in the transverse direction with one, two, and three layers of CFRP.

VI. REFERENCES

Y.Xio, H. Wu (2000), "Compressive behavior of concrete confined by carbon fiber composite jackets", journal of material in civil Engineering, Vol 12, pp. 139-146.

King Hwee Tan (2002). "Strength enhancement of rectangular reinforced concrete columns using fiber reinforced polymer", journal of composite for construction, Vol 6, pp. 175-183.

M. Reza Esfahani, M. Reza Kianoush(2005)., "Axial compressive strength of reinforced concrete columns wrapped with fibre reinforced polymers", Vol. 18, No. 1-11.

Lei Ming Wang, Yu Fei Wu (2007)., "Effect of corner radius on the performance of CFRP confined square concrete columns", Engineering structures, Vol. 30, pp. 493-505.

Hegde, R. R Dahiya, Kamath, M.G.(2004)., "Carbon fibers."

N. Chikh, M. Gahmous, R. Benzaid (2012)., "Structural Performance of High Strength Concrete Columns Confined with CFRP Sheets", Proceedings of the World Congress on Engineering, Vol. 3.

Manuel A.G. Silva (2011). "Behavior of square and circular columns strengthened with aramidic or carbon fibers", Construction and building materials, Vol. 25, pp. 3222-3228.

A. R. Rahai, P. Sadeghian, M.R. Ehsani (2008)., "Experimental behavior of concrete cylinders confined with CFRP composites", 14th world conference on earthquake Engineering.

IS: 10262-2009 recommended guidelines for concrete mix design.

IS: 456-2000 Plain concrete and reinforced concrete code of practice.

Corresponding Author

Milind V. Tondase*

PG Student-Civil Engineering Department, SVERI'S College of Engineering, Pandharpur, Maharashtra