IJCRT.ORG ISSN : 2320-2882
INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

BEHAVIOR OF PRISMATIC AND NON-PRISMATIC CIRCULAR TUBED STEEL REINFORCED HIGH STRENGTH CONCRETE COLUMNS UNDER AXIAL LOADING

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Abstract: Steel–concrete composite structures have been widely used because of the excellent composite action of concrete and steel. In this paper, behavior of outer prismatic inner non-prismatic and outer non-prismatic inner prismatic circular tubed steel-reinforced concrete (CTSRC) columns with high-strength concrete under axial loading were studied. A total of eight specimens considering the following parameters were modeled in ANSYS WORKBENCH 16.1 and tested: two taper ratios (0.8, 1.2) and two shapes (L, V). As a result of the project deformation along the path, the stress distribution along the path for both prismatic and non-prismatic columns were studied, ultimate stiffness for all the columns were calculated and the best taper ratio is found out.

Index Terms - **Taper ratio, High strength concrete, Ultimate Stiffness, Stress distribution, ANSYS.**

1. INTRODUCTION

Tapered columns are non-prismatic members that have better cross-section utilization, which makes them aesthetically better and more economical alternative. In architecture and structural engineering, a column or pillar is a structural element that transfers the whole weight of the above structure to the below structural elements. Steel columns have good compressive strength, but have a tendency to bend or buckle under extreme loading. Buckling is an instability that leads to structure failure. This occurs mainly due to the column length, cross-sectional area and the support conditions provided. Many practical applications of steel columns do not make use of the capacity of their cross section along the length. The most suitable application of column for this is tapered column which is more aesthetically pleasing. They are used in structures mainly due to their structural efficiency, provides more rigidity and stability to the buildings. Tapered columns are commonly seen in telephone towers, post towers, steel frames such as industrial halls, warehouses, exhibition centers etc. Now a days it is used in buildings as diagonal members. Therefore in this paper, behavior of 4 CTSRC columns with inner web tapered non-prismatic I section and 4 CTSRC columns with outer non-prismatic steel section with varying taper ratios are tested under axial loading are studied under finite element analysis using ANSYS.

1.1 Objectives of The Project

- To model outer non prismatic (L shape and V shape with taper ratios 0.8 and 1.2) inner prismatic circular tubed steel reinforced high strength concrete columns
- To model inner non prismatic (L shape and V shape with taper ratios 0.8 and 1.2) outer prismatic circular tubed steel reinforced high strength concrete columns
- To study the behavior of both outer prismatic inner non prismatic and inner prismatic outer non prismatic circular tubed steel reinforced high strength concrete columns under axial loading
- To find the best taper ratio of different shapes for a sectional column

2. SPECIMEN DESIGN

A total of 8 specimens having 3000mm length were designed and tested under axial load in this study. All the columns with outer prismatic inner non-prismatic CTSRC columns were cast in an outer steel tube having outer diameter of 323.3mm diameter and 6.3mm thickness and these dimensions are as per IS 1161:1998, and the inner non prismatic web tapered I section having 10mm as the thickness of web and thickness of flange, and width of the flange is 100mm and width of web at bottom is 146.6mm and width of the web at top is 180mm for 0.8 taper ratio and vice versa for 1.2 taper ratio (TR), and this web tapered I section is made using the steel plates and welded. All the columns with outer non-prismatic inner prismatic CTSRC columns were cast in an outer steel tube having top diameter of 269.9mm and bottom diameter of 323.3mm for 0.8 taper ratio and vice versa for 1.2 taper ratio and 6.3mm thickness, these were composed of steel plates by welding, and the inner prismatic web tapered I section having 10mm thickness of web and thickness of flange, and width of the flange is 100mm and width of web is 180mm. The steel plates used in the tube and profile steel were taken from the same batch of steel provided by a local manufacturer, and the mechanical properties of the steel and concrete are listed in Table 1.

3. MATERIAL PROPERTIES

Table -1: Material Properties

Concrete	Steel
Grade- M80	Yield strength- 345 MPa
Young's modulus- 447GPa	Young's modulus- 180 GPa
Poisson's ratio - 0.15	Poisson's ratio- 0.291
Multi linear property	Bi linear property

4. MODELLING OF THE COLUMN

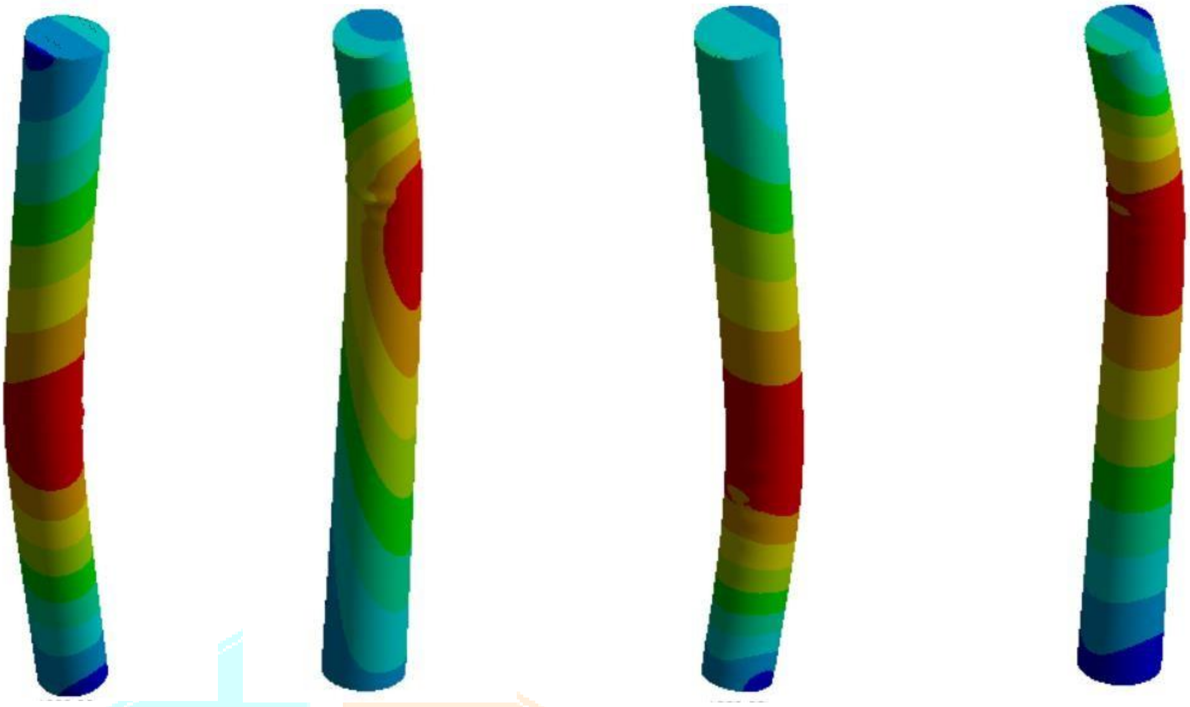
The prismatic and non-prismatic CTSRC columns are modelled according to design in specifications mentioned above. The material properties are fed into the software and applied to appropriate materials. And the supports are given as both ends pinned.

5. ANALYSIS OF THE COLUMN

The ANSYS 16.1 software was used to model all the specimens for nonlinear analysis. SOLID 186 from ANSYS library was used for 3-D finite element modeling of the column model. All the models are studied using ANSYS 16.1 under axial loading.

(a) (b) (c) (d)

Fig -1: Total deformation of outer prismatic inner non-prismatic CTSRC columns: (a) L shape, TR=1.2, (b) L shape, TR=0.8, (c) V shape, TR=1.2, (d) V shape, TR=0.8



(a) (b) (c) (d)

Fig -2: Total deformation of outer non-prismatic inner prismatic CTSRC columns: (a) L shape, TR=1.2, (b) L shape, TR=0.8, (c) V shape, TR=1.2, (d) V shape, TR=0.8

6. AXIAL LOAD VERSUS DISPLACEMENT RESPONSES

Chart -1 shows the load deflection curve for outer prismatic inner non-prismatic CTSRC columns under axial loading. The load deflection curve for L shaped column with taper ratios of 1.2 and 0.8 and V shaped column with taper ratios of 1.2 and 0.8 respectively are shown in that graph. The maximum curve obtained is for L shaped column with 1.2 taper ratio.

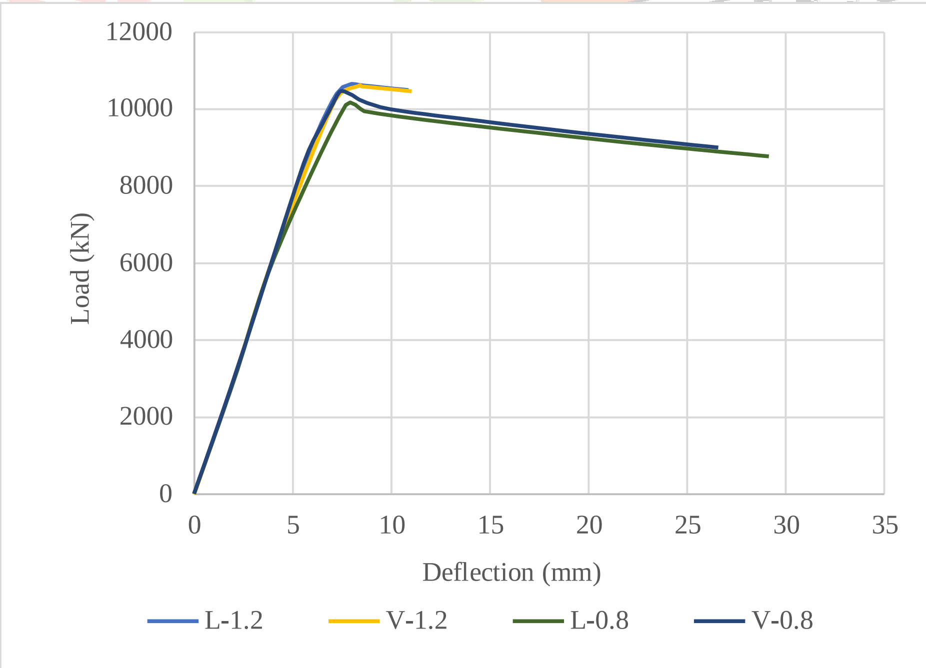


Chart-1: Load Deflection curve of outer prismatic inner non-prismatic CTSRC columns

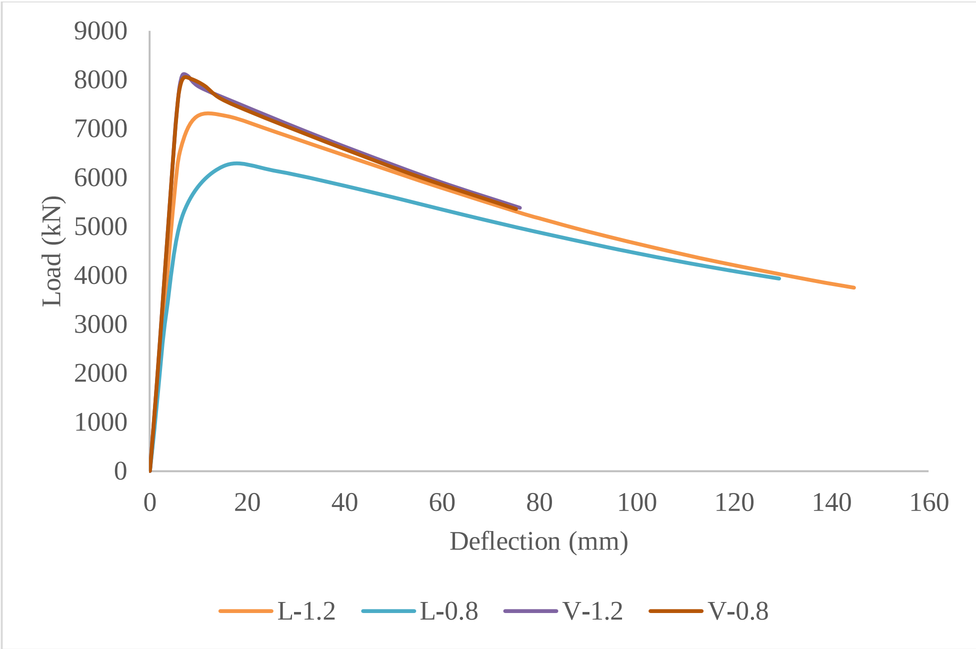


Chart-2: Load Deflection curve of outer non-prismatic inner prismatic CTSRC columns

Chart-2 shows the load deflection curve for outer non-prismatic inner prismatic CTSRC columns under axial loading. The load deflection curve for L shaped column with taper ratios of 1.2 and 0.8 and V shaped column with taper ratios of 1.2 and 0.8 respectively are shown in the graph. The maximum curve obtained is for V shaped column with 1.2 taper ratio.

7. DEFORMATION ALONG THE PATH

A path is created along the entire column with lower side of the I section as starting point and upper side of the I section as end point. Total deformation of all the best models along the path and graphical representation are shown in the figures given below.

Fig -3: Total Deformation along the path of outer prismatic inner non-prismatic CTSRC column (L shape, TR=1.2)

Fig -4: Total Deformation along the path of outer non-prismatic inner prismatic CTSRC column (V shape, TR=1.2)

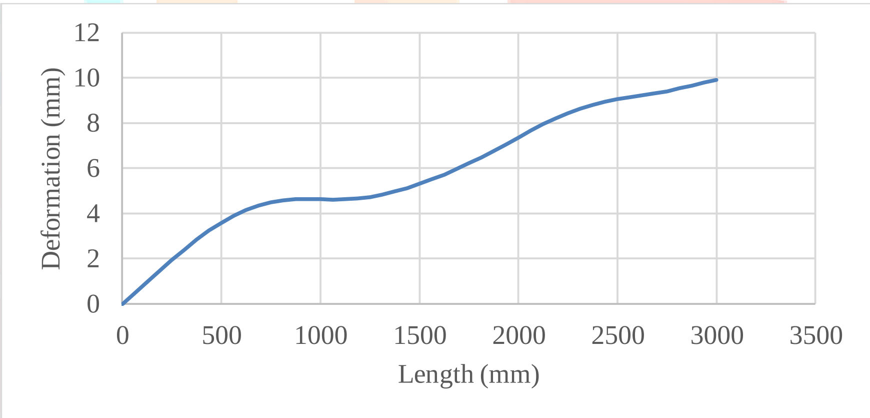


Chart-3: Total Deformation along the path of outer prismatic inner non-prismatic CTSRC column (L shape, TR=1.2)

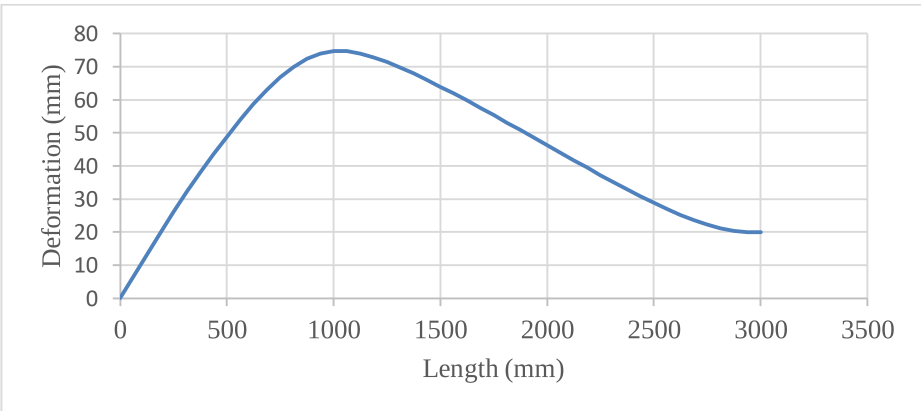


Chart-4: Total Deformation along the path of outer non-prismatic inner prismatic CTSRC column (V shape, TR=1.2)

The total deformation for all the best models obtained from outer prismatic inner non-prismatic and outer non-prismatic inner prismatic CTSRC columns are graphically represented in Chart-3 and Chart-4 respectively.

8. STRESS DISTRIBUTION ALONG THE PATH

A path is created along the entire column with lower side of the I section as starting point and upper side of the I section as end point. Stress distribution of all the best models of outer prismatic inner non-prismatic and outer non-prismatic inner prismatic CTSRC columns along the path and graphical representation of these models are shown in the figures given below.

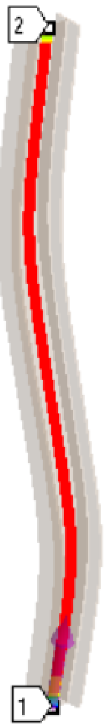


Fig -5: Stress distribution along the path of outer prismatic inner non-prismatic CTSRC column (L shape, TR=1.2)

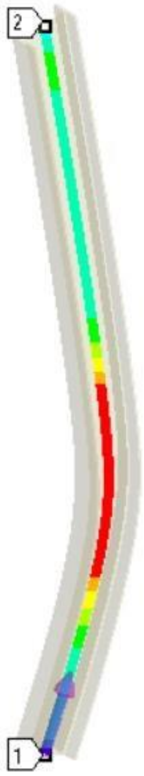


Fig -6: Stress distribution along the path of outer non-prismatic inner prismatic CTSRC column (V shape, TR=1.2)

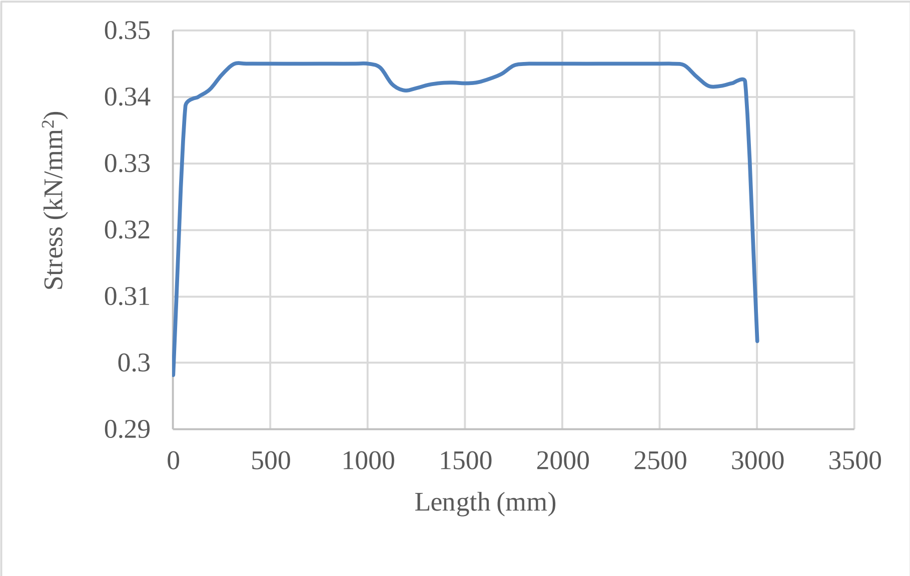


Chart-5: Stress distribution along the path of outer prismatic inner non-prismatic CTSRC column (L shape, TR=1.2)

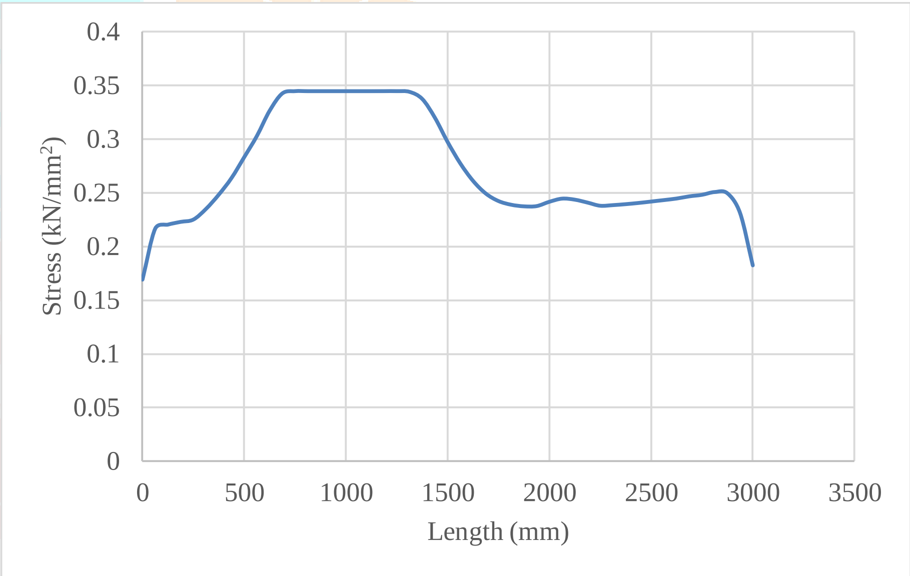


Chart -6: Stress distribution along the path of outer non-prismatic inner prismatic CTSRC column (V shape, TR=1.2)

Chart-5 shows stress distribution curve for outer prismatic inner non-prismatic CTSRC columns with L shaped specimen having 1.2 taper ratio under axial loading and Chart-6 shows stress distribution curve for outer non-prismatic inner prismatic CTSRC columns with V shaped specimen having 1.2 taper ratio under axial loading.

9. ANALYTICAL RESULTS

Comparison of specimens studied are shown in Table 2 and Table 3.
TR- Taper ratio
F- Ultimate load
D- Ultimate displacement S- Ultimate stiffness
%F- Percentage difference in ultimate load

Table -2: Test results of outer prismatic inner non prismatic CTSRC columns

Shape of the specimen	TR	F (kN)	D (mm)	S (kN//mm)	%F
L	0.8	10103	7.695	1312.93	3.46
V	0.8	10453	7.496	1394.40	
L	1.2	10631	7.817	1359.98	0.4
V	1.2	10589	8.318	1273.02	

Table -3: Test results of outer NON-prismatic inner prismatic CTSRC columns

Shape of the specimen	TR	F (kN)	D (mm)	S (kN/mm)	%F
L	0.8	6232.3	15.14	411.63	28.80
V	0.8	8032.1	6.88	1167.44	
L	1.2	7262.3	15.84	458.47	11.70
V	1.2	8113.6	6.74	1203.79	

From the nonlinear analysis done by ANSYS 16.1, for outer prismatic inner non-prismatic CTSRC columns, it is proved that, under axial loading, L shaped specimen with 1.2 taper ratio is having more load bearing capacity, and in the case of outer non-prismatic inner prismatic CTSRC columns, it is proved that, under axial loading V shaped specimen with 1.2 taper ratio is having more load bearing capacity.

10. CONCLUSIONS

1. Outer prismatic inner non-prismatic and outer non-prismatic inner prismatic CTSRC columns with L shaped and V shaped specimens having varriying taper ratios of 1.2 and 0.8 are modeled and analysed under axial loading
2. In the case of outer prismatic inner non-prismatic CTSRC columns under axial loading condition, L shaped specimen with 1.2 taper ratio is having more load carriying capacity as compared to L shaped specimen with 0.8 taper ratio and V shaped specimens with 0.8 and 1.2 taper ratios
3. In the case of outer non-prismatic inner prismatic CTSRC columns under axial loading condition, V shaped specimen with 1.2 taper ratio is having more load carriying capacity as compared to L shaped specimen with 0.8 taper ratio and V shaped specimens with 0.8 and 1.2 taper ratios
4. The total deformation and stress distribution of the best models along the path are studied
5. The best taper ratio obtained is 1.2

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