Structural Performance of Tubed Steel Reinforced Short column with Crumbed Rubberised Concrete

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Abstract - *Concrete-steel composite structure is defined as a construction in which both steel and concrete materials are combined to maximize the structural and economic advantages of each material. Composite column enhances the rigidity of the structure and provide significant axial load carrying capacity. Composite columns are generally classified as Concrete Filled Steel Tubular columns and encased columns. Tubed steel reinforced concrete column is special type of composite column which have reinforcing bars in the form of steel tube on the perimeter and steel shape at core of the column. When Concrete Filled Steel Tube is used, the strength of concrete is increased due to the confining effect provided by the steel tube, and the strength reduction is not very severe, since the tube prevents the spalling of concrete. In this paper three types of Steel Encased RCC column with Crumbed Rubber Concrete cores under axial loading are analysed using ANSYS, seems to be a practicable alternative means for tire rubber waste management.*

Key Words: **Concrete Filled Steel Tube, Crumbed Rubber Concrete, Steel Encased RCC column, Composite column, Encased column**

1. INTRODUCTION

Tubed steel reinforced concrete (SRC) columns are special SRC columns where reinforcement cage is in the form of an outer thin steel tube. Thus steel tube prevents the concrete cover from spalling off. At the same time, the strength and ductility of the concrete core is increases owing to the confinement of the steel. The Concrete-Filled Steel Tubular (CFST) columns have been widely used owing to their excellent composite action. Generally, the CFST core utilizes high strength concrete to provide enough axial compressive strength, while the peripheral RC encasement utilizes normal or high strength concrete to resist most of the lateral load. Compared with conventional RC columns, the Steel Tube Reinforced Concrete (ST-RC) columns have higher compressive strength, ductility and deformation capacity due to the presence of inner CFST. Apart from those advantages, faster construction speed is expected since the inner CFST column can be erected first to bear the construction load.

The use of rubber product is increasing every year in worldwide. Waste tires are major environmental problem for many metropolitan areas in the India. The concrete mixed with waste rubber added in different volume proportions is called Crumbed Rubber Concrete (CRC). Partially replacing the coarse or fine aggregate of concrete with some quantity of small waste tire in the form of crumb and chipped can improve qualities such as low unit weight, high resistance to abrasion, absorbing the shocks and vibrations, high ductility and brittleness and so on to the concrete. This crumb and chipped waste tires are different to other wastes materials with a potential for re-use because their production method is now well developed, the reuse of this material in concrete could have both environmental advantage and at the same time ensure economic viability with improvement the characteristic design properties of concrete mix.

1.1 Objectives of the Present Study

- To investigate the structural behaviour of steel encased RCC column with CRC core under axial loading.
- To evaluate the performance of axial load carrying capacity of steel encased RCC column with CRC core and comparing with conventional RCC column.

1.2 Methodology

- Collecting various literature reviews on tubed steel reinforced columns and crumbed rubber concrete.
- Validation of FE model of tubed steel reinforced concrete short column with concrete using ANSYS.
- Modelling & analysis of steel encased RCC column with three different types of sections with CRC core using ANSYS workbench 19.0.
- Comparing the results of various models with conventional RCC column under axial loading to find the best one.
- Concluding from the results.

2. FINITE ELEMENT MODELLING

Modelling of steel encased RCC column with CRC core using ANSYS Workbench 19.0.For analysis, three different sections of TSRC columns with CRC were used.Infilled Tubular section (IF-TS), Partially encased Channel Back to Back section (PE-B2B) and Partially encased Channel Face to Face section (PE-F2F). These columns were analysed and compared with the conventional RCC column. Column size of 400x400x1200mm, stirrups of 8mm diameter 11 numbers at 100mm center-to-center with 16mm diameter 4 numbers of longitudinal reinforcement were used for all the four models. The mix proportion used for CRC is mentioned in the Table 1.The material properties of concrete, rubberized concrete and steel used in ANSYS are shown in Table 2, 3 and 4 respectively. Details of various models are given in Table 5.

Table -1: Mix Proportion (kg/m^3)

W/C	0.50
C/Total aggregates	0.17
% of rubber[a]	05.33
Cement	388
Water	194.0
Coarse aggregate	10mm-465.6
	14mm-737.2
Fine aggregate	663.48
Rubber	14.73
Admixture	0

[a] By volume of fine aggregates

Table -2: Material Properties of Concrete

Property	Value
Compressive strength	40MPa
Flexural strength	4.427MPa
Modulus of elasticity	31623MPa
Poisson’s ratio	0.12

Table -3: Material Properties of Rubberised Concrete

Property	Value
Compressive strength	47.2MPa
Flexural strength	4.36MPa
Modulus of elasticity	31500MPa
Poisson’s ratio	0.12

Table -4: Material Properties of Steel

Property	Value
Yield strength of steel tube	250MPa
Yield strength of longitudinal bar	415MPa
Yield strength of transverse bar	293MPa
Modulus of elasticity	200000MPa
Poisson’s ratio	0.30

Table -5: Properties of Column

Property	Size of column
IF-TS column	Diameter of tube-219mm Thickness of tube-4.8mm
PE-B2B column	Depth of tube-150mm Breadth-75mm Thickness of web-4.8mm Thickness of flange-7.8mm
PE-F2F column	Depth of tube-150mm Breadth-75mm Thickness of web-4.8mm Thickness of flange-7.8mm
RCC column	400x400x1200mm

Here axial type of loading was given to all the four specimens of steel encased RCC column with CRC core. The bottom part of the columns is having fixed supports and the top end is set to free. Axial loading was applied on the top of the column of all the four specimens. Figure 1 to 4 shows the axial loading applied to steel encased RCC columns with CRC core.

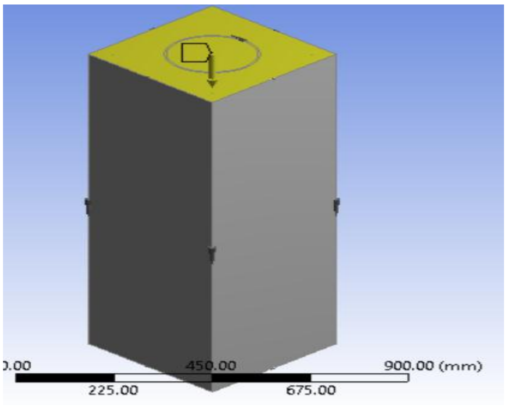

Fig -1: ANSYS model of CRC-IF-TS column

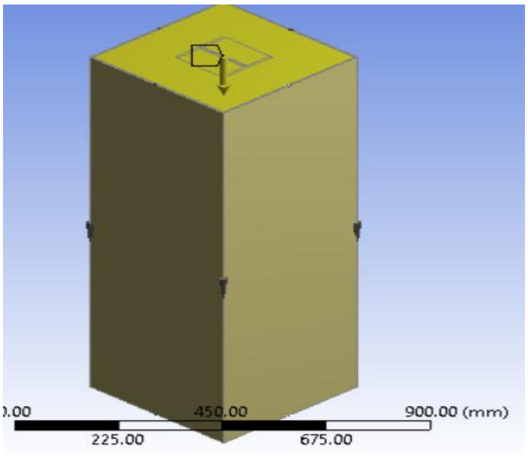

Fig -2: ANSYS model of CRC-PE-B2B column

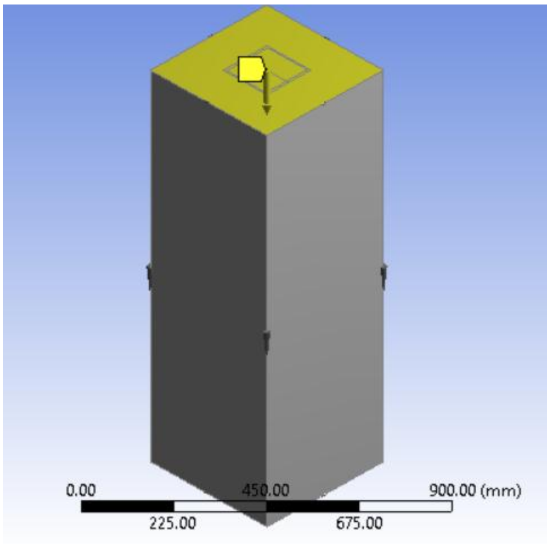

Fig -3: ANSYS model of CRC-PE-F2F column

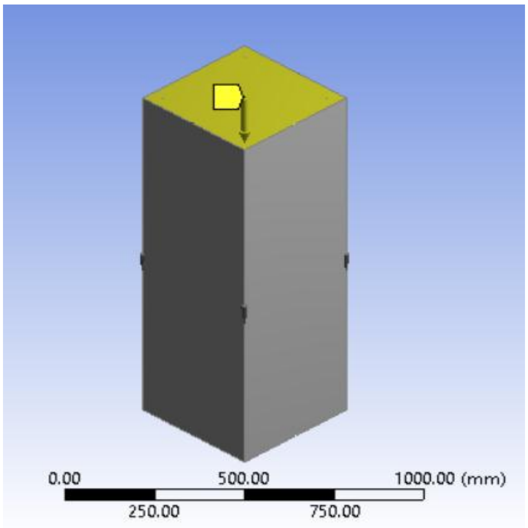

Fig -4: ANSYS model of RCC column

3. RESULTS AND DISCUSSIONS

The load-deformation is a key parameter for determining the load carrying capacity of CFST columns with CRC and RCC column. Chart.1 shows the load-deformation graph obtained for all the four models under axial loading. Also each of the three above mentioned CFST columns with CRC's percentage of axial load carrying capacity were compared with the conventional RCC column. Table 6 shows the percentage of axial load carrying capacity of columns.

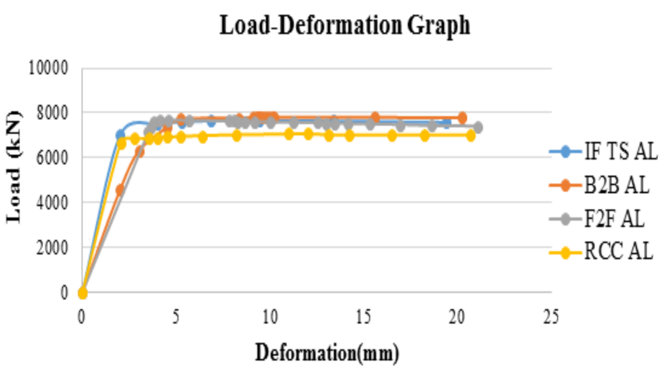

Chart -1: Load-Deformation graphs of all the geometry

From the above analysis, it is clear that Partially encased Channel Back to back section with Crumbed Rubberised Concrete core has the maximum percentage of axial load carrying capacity with 10.41% with maximum axial load of 7807kN at 10.22mm deformation when compared to the conventional RCC column with an axial load of 7070.7kN at 12.03mm deformation.Fig.5 shows the deformed shape of PE-B2B-CRC column under axial loading.

Table -6: Maximum Loads and Corresponding Deformation

Model	Deformation(mm)	Load(kN)	% of load carrying capacity
IF-TS column	9.4	7655	8.26
PE-B2B column	10.22	7807	10.41
PE-F2F column	4.09	7693.5	8.80
RCC column	12.03	7070.7	-

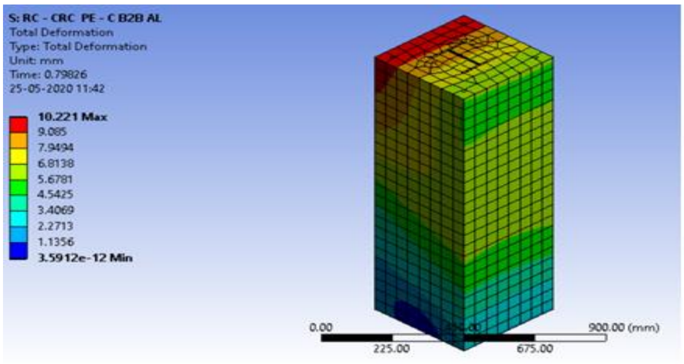

Fig -5: Deformed shape of CRC-PE-B2B column under axial loading

4. CONCLUSIONS

- Under axial loading of Steel Encased RCC column with CRC core, the cross-sectional area, longitudinal reinforcement and spacing of ties is maintained constant for all the four models.

- Compared with the conventional RCC column, PE-B2B with CRC core has the highest axial load carrying capacity of 7807kN.

- PE-B2B-CRC has 10.41%, PE-F2F-CRC has 8.80% and IF-TS-CRC has 8.26% of axial load carrying capacity compared to RCC column.

- Since PE-B2B-CRC is similar to an I section, they have the ability to resist axial forces and bending forces. However due to deeper lever arm between flanges, they have better moment capacities.

- Hence they would be excellent for use in columns of unbraced frames.

- It has high moment of inertia and can bear higher loads and deflections.

- They have good support to structure over it.

- It reduces the load intensity on below structure.

- For PE-B2B-CRC, along the web, the strength is more and across the web, strength is less.

- Thus we can say that Composite columns have a good ductility than RCC columns.

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