Axial Performance Investigation on Green Columns with Demolished Concrete Lumps Core

Archana Prashanth[1], Varsha Susan Thomas[2]

[1]PG Student, Dept. of Civil Engineering, MGM College of Engineering & Technology, Kerala, India
[2]Assistant Professor, Dept. of Civil Engineering, MGM College of Engineering & Technology, Kerala, India

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Abstract - *The structural members made of two or more different materials are called composite members. The properties of different materials can be combined to form a single unit in such construction. The steel-concrete construction is one of the types of composite construction which utilizes the properties of both steel and concrete. Green columns, proposed in this paper, are composite columns comprising of steel, concrete and Demolished Concrete Lumps (DCL) core which act as a single unit to give better performance than in its individual form. The main aspect of green column concept is to make a high strength column economically and to reduce the amount of virgin aggregates. Thus, to improve the performance of composite column, demolished concrete lumps are placed in the middle portion. In this paper three types of green columns are considered. Axial loading condition is mainly used to analyze the column. ANSYS software is used for analyzing the column with core confinement.*

***Key Words*: Green Column, ANSYS Workbench, Demolished Concrete Lumps, Recycled Aggregates, Composite Columns**

1. INTRODUCTION

Green columns are composite columns comprising of steel, concrete and demolished concrete lumps (DCL) core, which gives better performance than in its individual form. DCL cores are made of large pieces of coarsely broken concrete, obtained from construction and demolition wastes. It is made from large pieces of coarsely broken concrete. The usage of recycled concrete waste gives a new direction to economical concrete waste management. The lumps sizes ranges vary from 60-250 mm, but in the case of recycled aggregate the size will be less. Due the large sizes of lumps debris pieces can be avoided. Mainly lumps size depends on the cross-sectional dimensions of the members to be cast. Recycling process also simplified by the avoidance of crushing concrete waste to smaller pieces and sieving; Bo Wu et.al [1]. In the concepts of demolished concrete lumps in columns will reduce amounts of cement and water, thus reducing the emission of carbon dioxide which makes it 'green'. So, usage of DCL will reduce the problems related to waste disposal. Studies says that recycling process of recycled aggregates is difficult because it takes lots of time to complete the crushing process which takes more of amount of energy consumption.

In this paper, three types of composite green columns were analyzed under axial loading with same cross section but varying the core of the column using DCL. The analytical study is carried out by using ANSYS Workbench software.

1.1 Scope and Objectives of the Study

Various types of green columns with same lumps size and different types of core are selected for the study.

Work is restricted to analysis of square composite columns under axial loading conditions. The work is limited to modelling and analysis of columns by using ANSYS.

The main objectives of the study are follows;

- Develop and analyze different types of composite columns with demolished concrete lumps core such as;
    1. Double skin concrete filled steel composite column
    2. Fibre Reinforced Polymer (FRP) encased column
    3. Demolished concrete lumps core as segmental blocks in composite column.
- To determine axial performance by non-linear static analysis.

2. FINITE ELEMENT MODELLING

2.1 Geometry

In this study model various types of columns which is then incorporated with demolished concrete lumps. A square is considered for the study which is 400x400mm in cross section and 2000mm in length. Once the modelling is done columns are analyzed under axially that is load is applying in the axis of the column. Circular, square, segmental block sections are provided as core. The column is provided with top end free and bottom end fixed. Three-dimensional models were developed to study the performance of column.

2.2 Material Properties

In this study the compressive strength of DCL is 43.7 MPa, corresponding Poisson's ratio is 0.15 and Young's modulus is around 3.305×10^4. The Poisson's ratio of steel is 0.3 and tensile strength of the same is selected as 371MPa. The material properties of FRP tube is shown in table1 Peng Feng et.al [3].

Table -1: Properties of Fibre Reinforced Polymer

Properties	Values
Young's Modulus in X direction	8000MPa
Young's Modulus in Y direction	45300MPa
Young's Modulus in Z direction	8000MPa
Poisson's Ratio in XY	0.3
Poisson's Ratio in YZ	0.3
Poisson's Ratio in XZ	0.3
Shear Modulus in XY	8000MPa
Shear Modulus in YZ	8000MPa
Shear Modulus in XZ	8000MPa
Yield Strength	657MPa

2.3 Modelling and Analysis

The columns are modelled using ANSYS Workbench software. First the engineering properties were assigned and then the support condition and loading were provided. In this mainly four types of model were considered. In first case double skin concrete filled steel composite column were modelled which contain two types of cross section that is circular and square section. The steel tube is provided inside and filled with DCL and concrete outside. The circular section is provided with a thickness of 5mm and inner radius is 200mm; Huang Yuan et.al [2]. The face surface of the tube is around 3063mm^2, the circular section is replaced by using a square section having area of cross section 158mmx158mm. For concrete and tube frictional connection is provided. After this meshing is carried out automatically by ANSYS. The axial loading is applied in displacement-controlled method. In order to model an FRP tube encased column the best model from previous column is selected. That is in the previous case square shaped section gives more load carrying capacity so that model was considered, the thickness of FRP tube is 5mm and same area of cross section of the previous case. The fourth model consists of segmental blocks as core, the precast segmental blocks are used here, the model is from double skin square CFST column, the square blocks are modelled, based on the volume of the DCL. Total four numbers of blocks were created. The total volume of square DCL tube is around 4.3808x10^7mm^3, the cross section of the block is 186mmx186mm, gap between the blocks is 75mm, and the leg bar is provided with 12.5mm radius. Every model was meshed using a 3D-20 noded quadratic element solid 186 in order to improve accuracy in analysis. The isometric view of each model is shown below, the fig 5 showing example of meshing of column in ANSYS.

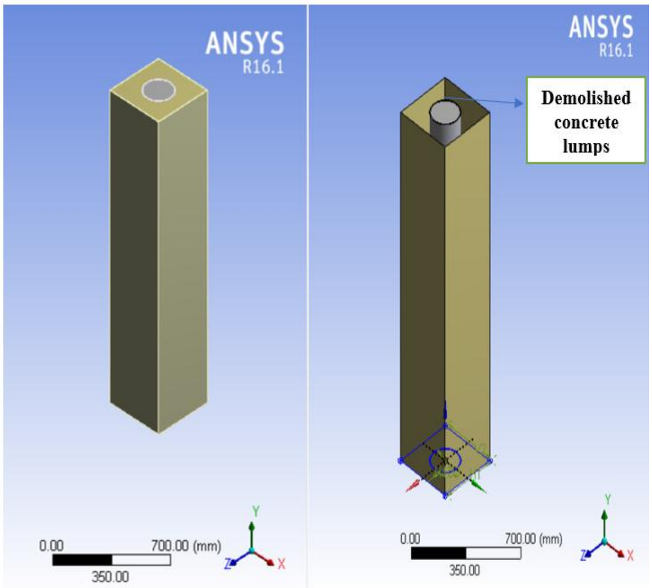

Fig -1: Model of Circular Section from ANSYS

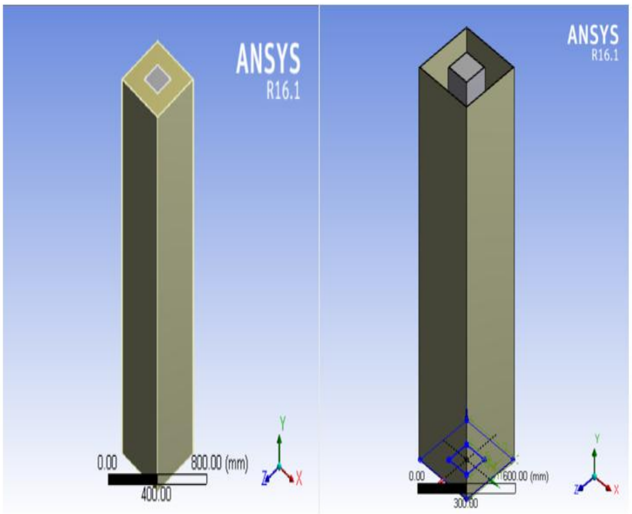

Fig -2: Model of square section from ANSYS

Once the modelling was done next part is to apply the connections in different materials, here mainly connections with concrete and steel and steel with demolished concrete lumps core. The applied connections are frictional and bonded, steel and concrete provided with frictional connection and other type is bonded connection.

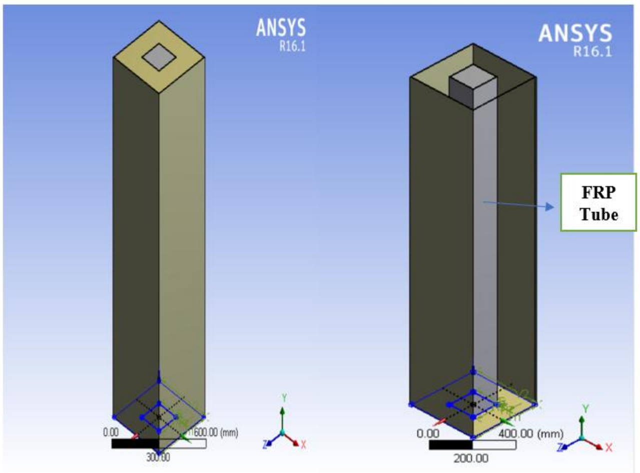

Fig -3: Model of FRP tube section from ANSYS

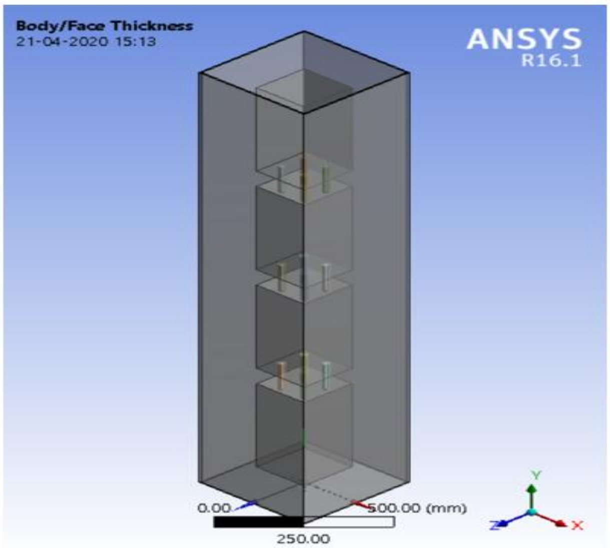

Fig -4: Model of segmental blocks from ANSYS

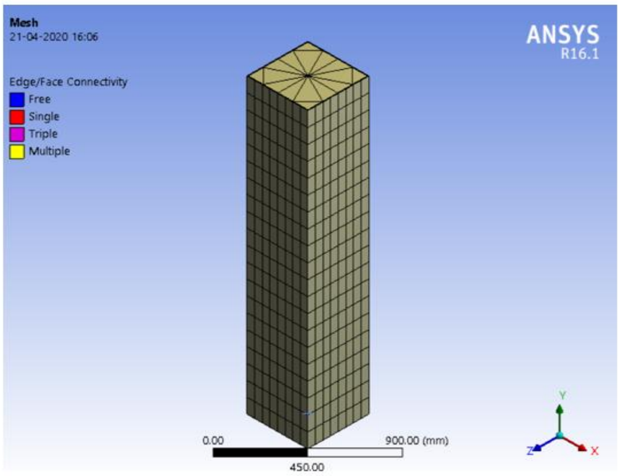

Fig -5: Meshing of segmental blocks in Column

3. RESULT AND DISCUSSIONS

The four types of models were analyzed axially by non-linear static analysis in ANSYS Workbench. Axial loading is applying load at the center of gravity of the column. Different types of green columns are axially analyzed. All columns are with same cross section, length and having same property of demolished concrete lumps. The maximum axial load carrying capacity shows by double skin CFST with core shape square. The load is about 11524kN corresponding to the total deformation of 9.9002mm. The load obtained for circular section is about 11445kN. FRP tube section shows load around 11224kN, and for segmental blocks the axial load carrying capacity obtained as 11218kN.From the values of deflection, maximum load carrying capacity gives less value of deflection in axial loading. The least axial load carrying capacity is given by FRP tube and segmental block section. In FRP it is due to the reduction in elastic modulus. As discussed above, the double skin CFST with square core gave the best performance. The axial performance of circular core of double skin CFST is less than that of Square core by 0.68%. the axial performance showed a reduction of 2.60% in FRP tube and 2.72% in segmental column, when compared with the double skin CFST with square core. The figures below show the total deformation after the analysis of column.

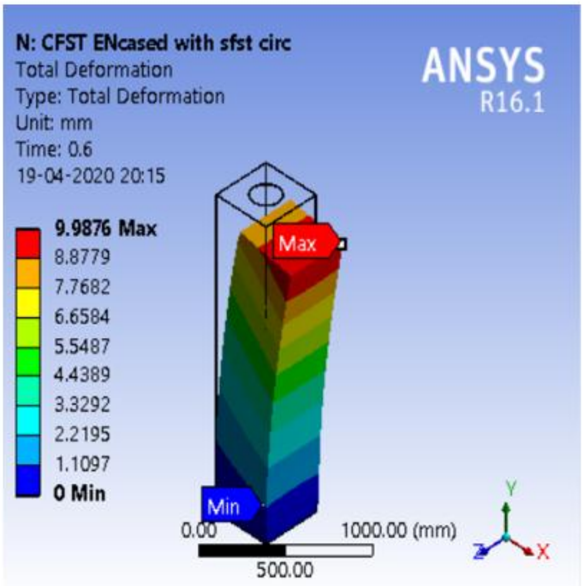

Fig -6: Total deformation of circular section under axial load

The variation load with deflection is shown in table 2.and the percentage reduction load carrying capacity is given by chart 2. The comparison of axial loading curve is shown in chart 1.

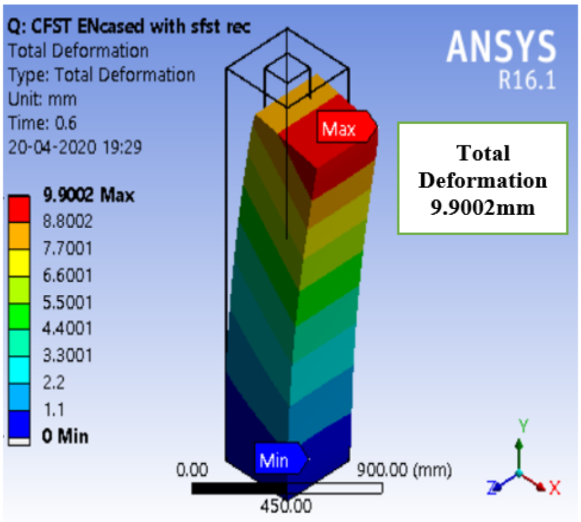

Fig -7: Total deformation of square section under axial load

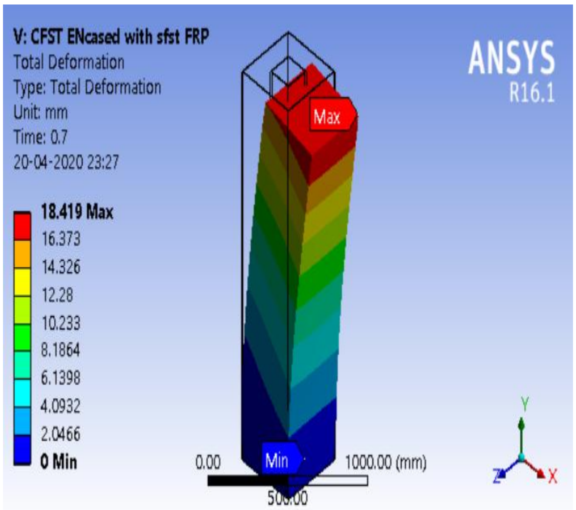

Fig -8: Total deformation of FRP tube under axial load

Table -1: Axial loading on columns

Model	Axial Load (kN)	Deflection(mm)
Circular Section	11445	9.9876
Square Section	11524	9.9002
FRP Square Tube	11224	18.419
Block Section	11218	12.648

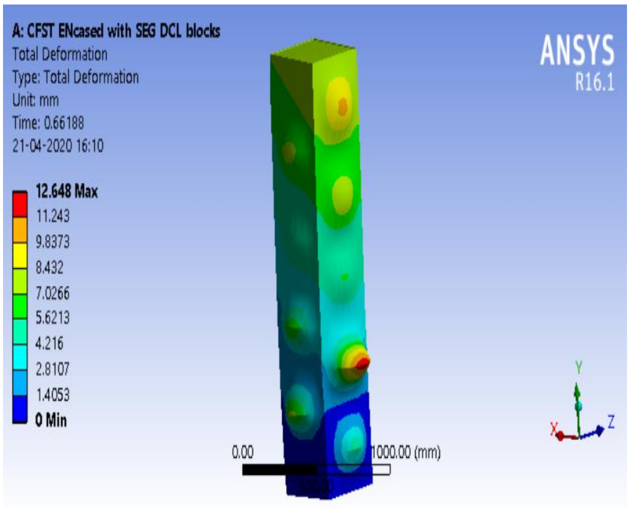

Fig -9: Total deformation of segmental blocks under axial load

For each of the model load-deflection curves were plotted. Load- deflection curve gives the maximum allowable limit of the column can sustain, that means with increase in axial load there may be variation in deflection which is completely based on the type of column. Hence from this curve the point of maximum load or ultimate load can be found, breaking point of the specimen with maximum deflection is obtained. The main usage of this curve is to design a column completely with safety, so once the load carrying capacity is found design a column by using that value and preventing it from early collapse. The composite column with same cross section is used in this analysis, from different types of curves the range of load and deflection can be found, that means if the curve gives an idea about the collapse and behavior of columns. The curve first starts with zero and corresponding to each deflection the load gets increased, and once it reaches the maximum and starts to decrease and move to breaking point.

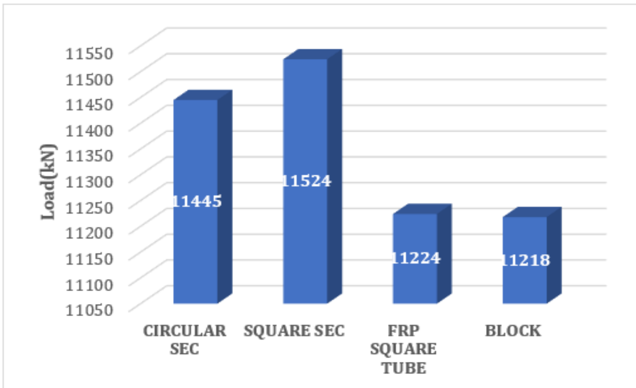

Chart- 1: Axial load comparison on columns

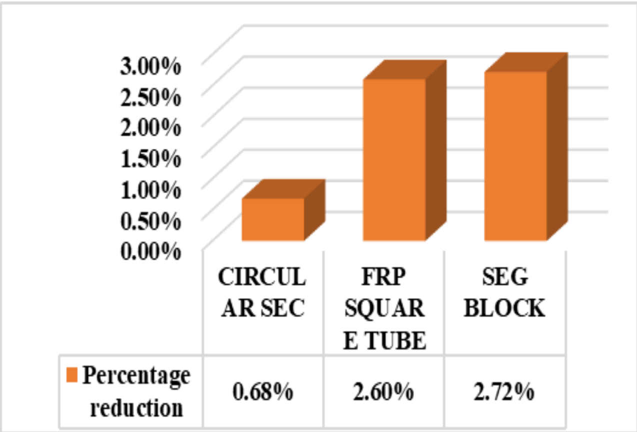

Chart- 2: Percentage reduction in axial load capacity

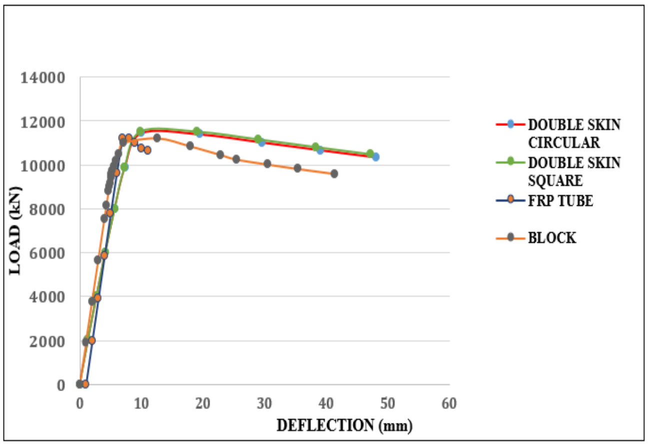

Chart- 3: Load-deflection comparison on axial loading

4. CONCLUSION

In this study, investigation on performance of demolished concrete lumps in various types of composite green columns was done. Demolished concrete lumps is a waste product obtained from construction and demolition wastes. Thus, to improve the performance of composite column, demolished concrete lumps are placed in the middle portion. Different types of green columns are considered and study the performance by varying the types of core. Mainly three major types of columns were considered, which include four models, the maximum load carrying capacity in axial case is obtained for double skin CFST square section is about 11524kN corresponding to the deflection 9.9002mm. Other types such as FRP tube, CFST with RCC, segmental blocks column also gives higher loads. The least performance was given by segmental block section, which showed a reduction of 2.72% in axial performance as compared to CFST square section. As compared to double skin CFST there is a slight decrease in load capacity in FRP tube column, it may be due to the less modulus of elasticity of FRP tube. Segmental blocks types also give better performance with DCL core and reduce time of construction. Thus, inclusion of these types of waste product gives new direction to economical as well as concrete waste management. Overall performance of column also increased.

ACKNOWLEDGEMENT

I wish to thank the Principal and Head of Civil Engineering Department of MGM College of Engineering and Technology, affiliated by Kerala Technological University for their support. This paper is based on the work carried out by me (Archana Prashanth), as part of my PG course, under the guidance of Ms. Varsha Susan Thomas (Assistant Professor, MGM College of Engineering and Technology, Kerala). I express my gratitude towards her for her valuable guidance.

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