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Non Linear Behaviour of RCC Core Steel Composite Column

Dona Chacko[1]
[1]P.G Student,
Department of Civil Engineering,
Amal Jyothi College of Engineering, Kerala, India

George M Varghese[2]
[2]Assistant Professor,
Department of Civil Engineering,
Amal Jyothi College of Engineering, Kerala, India

Abstract— **In RCC core steel composite column the concrete and steel are combined in such a fashion that the advantages of both the materials are utilized effectively. The core steel composite column helps to improve the strength and ductility of column when compared to the ordinary reinforced concrete column. Core steel section is helpful in resisting column from large axial compressive force, bending moment, and shear failure. A materially nonlinear model is proposed using ANSYS software with proper boundary conditions. This paper presents nonlinear finite element analysis of concrete encased steel column subjected to reverse cyclic, buckling and monotonic loading condition and to understand maximum deformation, load it can withstand, and stress distribution. The result obtained from finite element analysis showing that the core steel composite column is a effective solution for seismic and non seismic areas. Core steel composite column shows large deformation capacity, lateral load resistance and stiffness.**

Keywords— RCC core steel composite column, RC column

1.INTRODUCTION

Composite column are structural members composed of steel and concrete joined together to act as a single unit. The composite structural members are often used for medium-rise to high-rise buildings. Two types of composite columns frequently used in the buildings which are concrete-encased steel (core steel) columns and concrete filled steel tube columns [1]. The core steel composite column can be divided into two: fully encased core steel composite column and partially encased core steel composite column (Fig. 1).

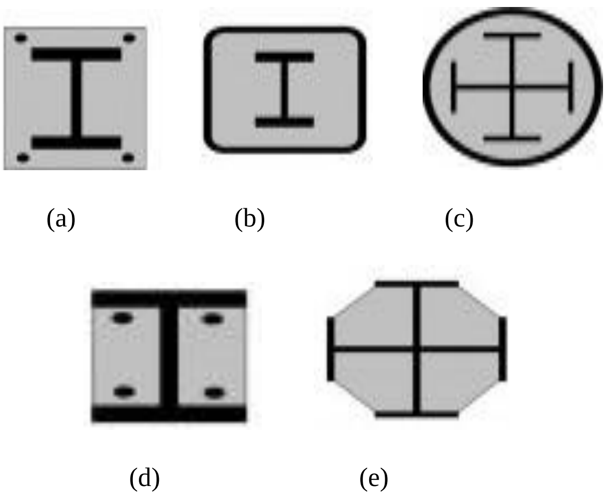

Fig. 1: Different types of RCC Core steel composite column: a, b &c-fully encased composite column, d &e-partially encased composite column

Steel and concrete are merged in such a fashion that the advantages of both the materials are utilized effectively in core steel composite column. In this type of column both the steel and concrete would resist the external loading by interacting together by bond and friction.A composite column is a combination of concrete, structural steel and reinforcing steel to provide an sufficient load carrying capacity of the member [2], increases its strength and stiffness, but also protects it from fire damages. Encased core steel makes the deformation capacity of the RC column to be large [3]. In core steel columns, the encased steel section can improve the shear resistance of the column [4].

To understand the behavior, several researches where conducted on core steel composite column. An analysis is conducted on concrete encased steel special shaped column (CESC) by providing combined axial and cyclic lateral loading and the results indicates that CESC column exhibits higher lateral bearing capacity and better seismic performances and are recommended to be widely applied to high rise buildings and in seismic prone areas[5]. To know more about core steel composite column an experimental study conducted on normal strength and high strength core steel composite column under monotonic and cyclic loading [6]. The result obtained showing that the column made with high strength concrete showed improved performance. The experimental results concrete-encased composite beam–columns with T-shaped steel section indicate that the behaviour of column under cyclic load and failure modes of the beam–columns are greatly affected by the direction of the bending moment due to the unsymmetrical cross section [7]. Pedro et al.,[8] conducted studies for concrete-encased I-shaped steel composite columns to investigate the axial load-carrying capacity, behaviour under uniaxial bending and axial compressive load, and behaviour under biaxial bending and axial compressive load. The composite structural member produced by inserting an additional steel section into the inside of the cross section takes the axial compressive force shows the best performance for the cyclic loading.

The studies reveals that there are some factors which influence the performance of core steel composite column, which are axial compressive ratio, stirrup ratio and steel shape. These factors also affect seismic behaviour of composite column. A structural steel with H, I or cross-shaped steel section is generally used in an inner column of the composite building. As it shows better performance compared to other sections [9]. The behavior of column under fire is one of the main problems to be studied. Joao Paulo et

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al. [10]presented an experimental study on column subjected to fire and the tested column shows a critical time higher than 180minutes represents column have very good fire performance.According to the results of the analytical studies and experiments conducted by Stefan et al. [11],the effects of the second order theory analyzed.

A new type of column consisting of steel, concrete and FRP was proposed and assessed through experimental testing and analytical modelling. Studies were conducted on the composite column utilizes a glass FRP (GFRP) composite tube that surrounds a steel I-section, which is then filled with concrete. Experimental results showed a 40–80% increase in the compressive strength of the concrete in the composite specimens [12]. The uses of FRP as external confinement all over the length of the column give remarkable increase in strength of the column. [13].

The beginning of frequent use of composite columns in tall building dates to about 1980.The columns are designed to resist both gravity and seismic loads either alone or in combination with other columns and shear walls. A number of buildings have been constructed with core steel composite columns worldwide. Encased composite columns are also used as bridge piers in different parts of the world. `

This paper presents an attempt to model the nonlinear behaviour of composite column under reverse cyclic, buckling and monotonic loading condition using ANSYS Workbench.

2. METHODOLOGY

The fundamental concept of finite element method is dividing the geometry of a structure into finite number of elements, connected at finite number of points called nodes. A non-linear finite element analysis was done to study the behaviour of RCC Core steel composite column. In this thesis two columns with same geometric properties are modeled with one end free and the other end is fixed. The first one is RC column and second one is the core steel composite column, (I section encased). The performances of these columns are studied under seismic, buckling and monotonic loading condition. Finite element method is widely employed to study the structural behaviour of steel concrete. Finite element model is developed using ANSYS 16.1 version. ANSYS is a general purpose finite element modelling package for numerically solving variety of problems which comprises static/dynamic structural analysis (linear and nonlinear), fluid problems, electro-magnetic problems heat transfer problems etc. In this paper, RC column is designed manually; the dimension of the column is taken as per the design. Column of M 30 grade concrete and Fe 500 grade steel is used. The dimension of the column is 0. 22mx0.22m and span is 3m. 4 number of 12mm ϕ diameter bars is provided as longitudinal reinforcement and 2 legged 8mm ϕ diameter bars is given as shear reinforcement, which is provided at a spacing of 100mm c/c critical zone and 200mm c/c at remaining length of column.

3. VALIDATION

The validation of the work is done based on, "*Behavior of fully encased steel-concrete composite columns subjected to monotonic and cyclic loading*". The authors of the journal are Cristina Campian, Zsolt Nagy, Maria Pop, (2015). Experimental analysis considered which is solved using software ANSYS. Then the values are compared with ANSYS results. The cross-sectional area of composite columns was 220 mm×170 mm and a height of 3m. The column is considered embedded on the base and free of restraints on the other side. Results obtained for maximum lateral load from experiment is 20.40kN and with help of ANSYS workbench is 20.511kN. The difference between the results lies within the range of 0. 5%. This difference is very negligible and FE results demonstrate the validity and accuracy of the proposed FE model.

3. RESULTS & DISCUSSIONS

3.1 Seismic Analysis

It can be able to find out the lateral load which a column can withstand by non linear seismic analyses. Seismic analysis can be executed to find deformation, stress distribution and maximum lateral load. A constant axial load of 342kN is applied to the model. Seismic load is given as reverse cyclic loading which is provided as deformation. Seismic load is applied cyclically in positive and negative range value. The deformation starting with 0mm, 50mm, 0mm and -50mm completes one cycle. The load is increased with respect to the number of cycles.8 cycles is provided for each model. Fig. 2(a) and fig. 2(b) shows the ANSYS model of RC column and core steel composite column provided with lateral loading.

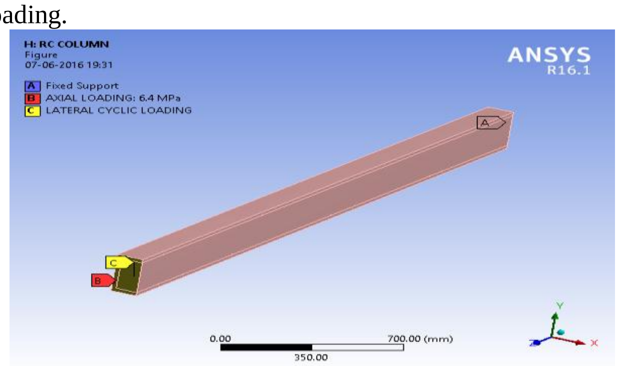

Fig. 2.(a): Lateral loading RC Column

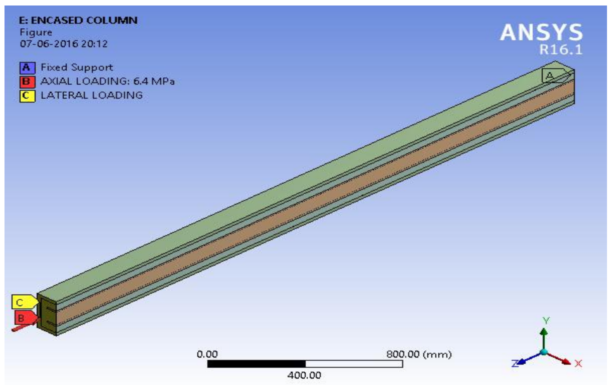

Fig. 2.(b):RCC Encased column(I Section)

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The hysterisis loop of RC column and core steel composite column are shown Fig. 3.(a) and fig. 3.(b).The RC column undergoes a maximum deformation of 280mm,which takes a lateral load of 20kN. The core steel column undergoes a maximum deformation of 240mm and it takes a lateral load of 37kN.The primary crack occures at 20-21kN for both the column.The maximum load a RC column can bear is 20-25kN.Where as in the case of core steel composite column it can take more than twice the load a RC column can carry with less deformation.

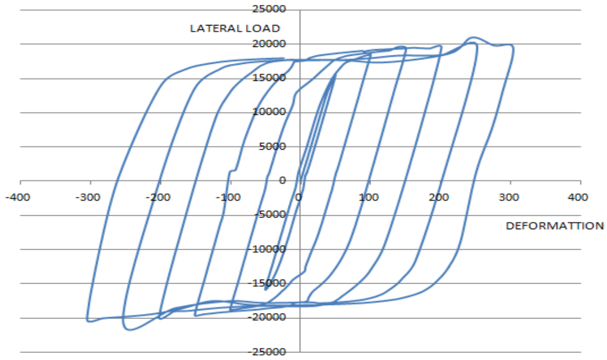

Fig. 3.(a): Hysterisis loop RC Column

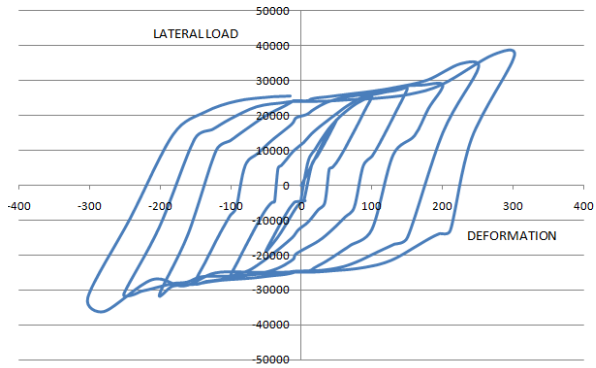

Fig. 3.(b):Hysterisis loop- RCC core steel composite column

3.2 Buckling Analysis

Buckling analysis is a method widely used to determine the buckling loads or critical loads at which a structure becomes unstable and buckled mode shapes are the characteristic shape incorporated with a structure's buckled response. There is a buckled mode shape for each load; this is the shape that the structure assumes in a buckled condition.

Fig. 4.(a) and fig. 4.(b) shows the total deformation occured in RC column and core steel composite column respectively. Fig. 5.(a) and fig. 5.(b) shows thebuckling load v/s deformation curve of RC column and core steel composite column respectively.

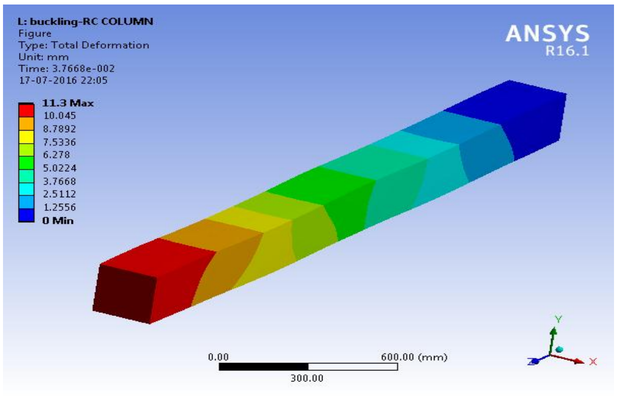

Fig. 4.(a): Total deformation of RC Column

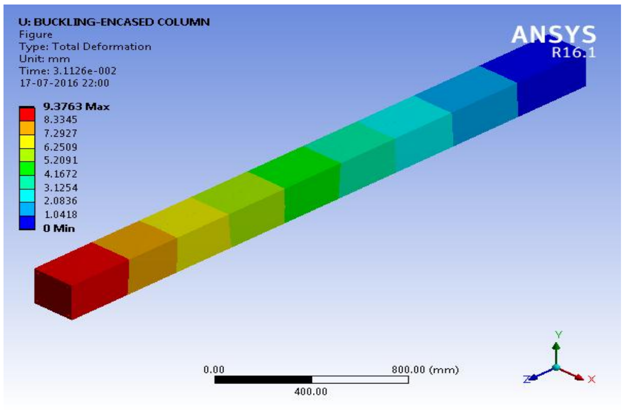

Fig. 4.(b): Total deformation of RCC core steel column

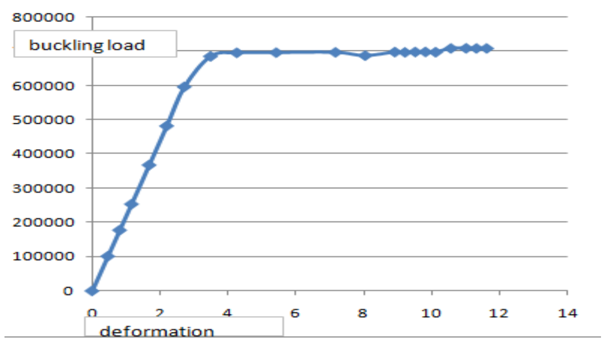

Fig. 5.(a):Load v/s deformation -RC Column

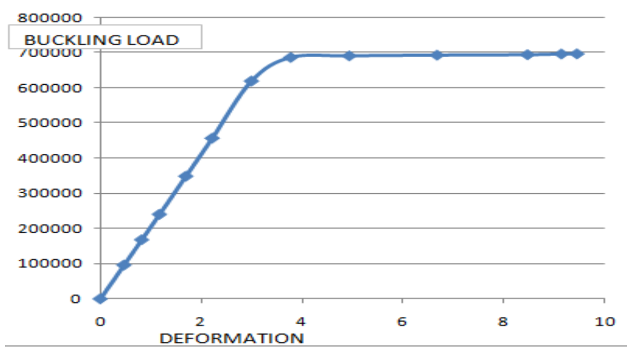

Fig. 5.(b):Load v/s deformation –RCC core steel composite column

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From the graph it is clear that the RC column undergoes a maximum deformation of 11.3mm and the core steel column undergoes a maximum deformation of 9.37mm.Both column takes a buckling load of 700kN. But the RC column fails at 700kN,where as the core stel composite column can able to take more load.The core steel composite column cause less deformation compared RC column.

3.3 Monotonic Load Analysis

Monotonic loading was the standard method for testing because it provided a good indication of the performance under one-directional loading like wind loading. Many studies have evaluated and predicted the performance of column subjected to monotonic loading.

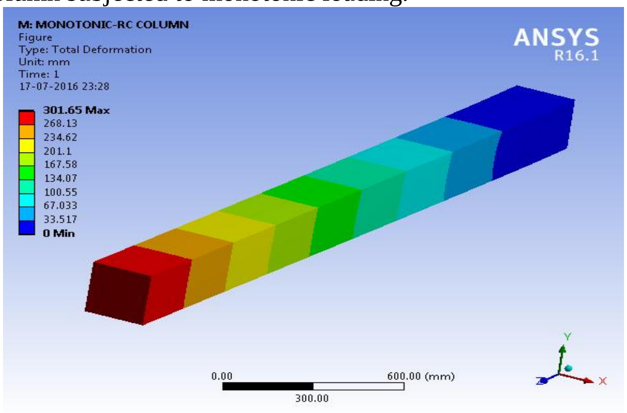

Fig. 6.(a):Total deformation -RC Column

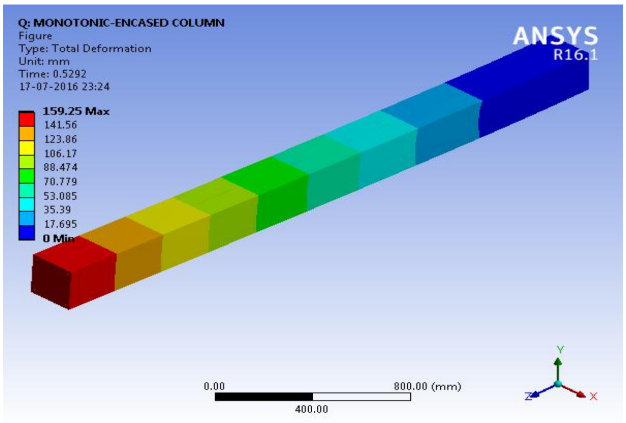

Fig. 6.(b):Total deformation -RCC Core steel composite column

Fig. 6.(a) and fig. 6.(b) shows the deformation occured in RC column and core steel composite column under monotonic loading condition.The monotonic load is applied in horizontal direction of the column(Y direction).The RC column undergoes a maximum deformation of 301.45mm and it takes a maximum load of 20kN,where as The core steel column undergoes a maximum deformation of 159.25mm and it takes a maximum load of 26kN.

Fig. 7.(a) and fig. 7.(b) shows the load- deformation curve of both the columns. The core steel composite column cause less deformation compared RC column and have higher load carrying capacity that of RC column.

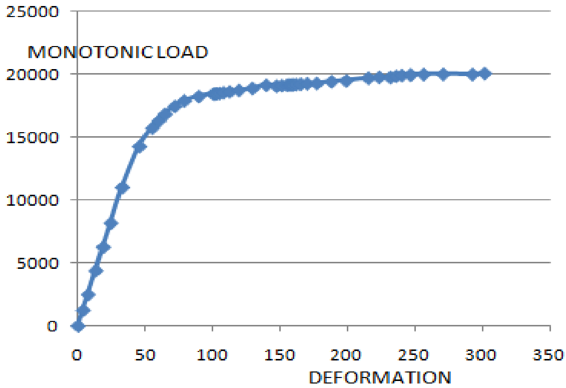

Fig. 7.(a):Load v/s deformation -RC Column

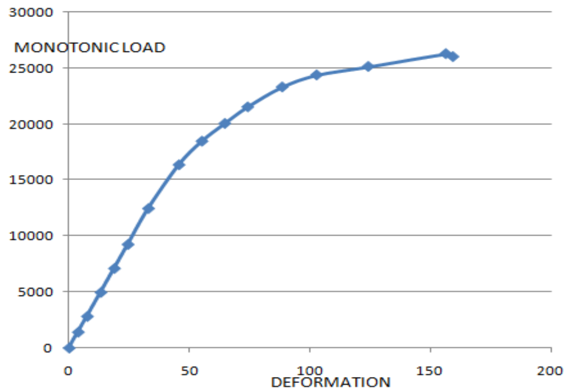

Fig 7.(b): Load v/s deformation-RCC core steel composite column

From the seismic, buckling and monotonic analysis of the following results are obtained. Table 1 shows the tabulated deformation results.

Table 1: Tabulated Deformation Results

specimen	RC column	RCC encased column
Dimension	0.22mx0.22mx3m	0.22mx0.22mx3m
Max. Lateral load	20kN	37kN
Total deformation(lateral load)	280mm	240mm
Max.buckling load	700kN(column fails)	700kN
Total deformation(buckling load)	11.3mm	9.37mm
Max.Monotonic load	20kN	26kN
Total deformation(monotonic load)	301.45mm	159.25mm

4. CONCLUSION

The main objective of this paper is to study the behavior of composite column under static load. So in this paper one composite column and one RCC column is considered. The following conclusion can be drawn based on this study.

1. Core steel section improves the horizontal deformation performances. It shows lesser deformation compared to RC column under cyclic monotonic and buckling load.
2. Lateral load resistance of core steel composite column is twice that of RC column.
3. The maximum buckling load can be taken by an RCC core steel composite column is higher that of conventional RC column.
4. The maximum monotonic load can be taken by an RCC core steel composite column is trice that of conventional RC column.
5. Steel encased column takes more lateral load, buckling and monotonic load. From the study it is observed that RCC core steel composite column has better earthquake resistant properties and hence it can be implemented for structure in seismic zone.

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