An investigational behaviour of RCC Core Steel Composite Column

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Abstract:
Currently, Composite sections of the steel and concrete have been employed and deliberated around the world, yet filled tubular columns require more reflection. A substantially nonlinear model is proposed using ANSYS software with proper boundary conditions. This paper presents nonlinear finite element analysis of concrete enclosed steel column subjected to reverse cyclic, buckling and monotonic loading condition and to understand maximum deformation, load it can withstand, and stress distribution.

Keywords: *RCC core steel composite column, RC column.*

I. INTRODUCTION

A steel-concrete composite column is a compression member, comprising either a concrete encased hot-rolled steel section or a concrete filled tubular section of hot-rolled steel and is generally used as a load-bearing member in a composite framed structure. Typical cross-sections of composite columns with fully and partially concrete encased steel sections are illustrated in Fig. 1. Fig. 2 shows three typical cross-sections of concrete filled tubular sections. Note that there is no requirement to provide additional reinforcing steel for composite concrete filled tubular sections, except for requirements of fire resistance where appropriate.

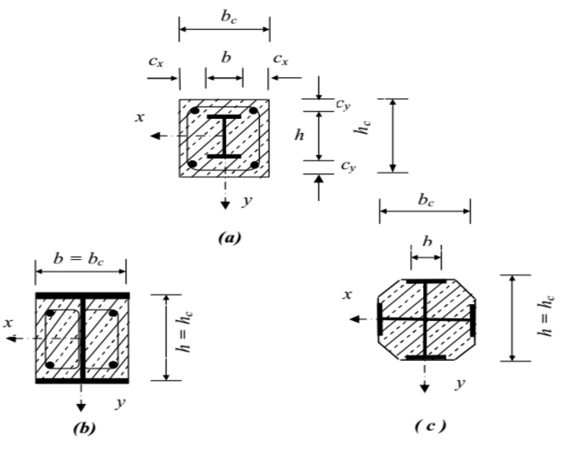

Fig. 1: Typical Cross - Sections of Fully and Partially Concrete Encased Columns

In a composite column both the steel and concrete would resist the external loading by interacting together by bond and friction. Supplementary reinforcement in the concrete encasement prevents excessive spilling of concrete both under normal load and fire conditions. In composite construction, the bare steel sections support the initial construction loads, including the weight of structure during construction. Concrete is later cast around the steel section, or filled inside the tubular sections. The concrete and steel are combined in such a fashion that the advantages of both the materials are utilized effectively in composite column. The lighter weight and higher strength of steel permit the use of smaller and lighter foundations. The subsequent concrete addition enables the building frame to easily limit the sway and lateral deflections. With the use of composite columns along with composite decking and composite beams it is possible to erect high rise structures in an extremely efficient manner. There is quite a vertical spread of construction activity carried out simultaneously at any one time, with numerous trades working simultaneously.

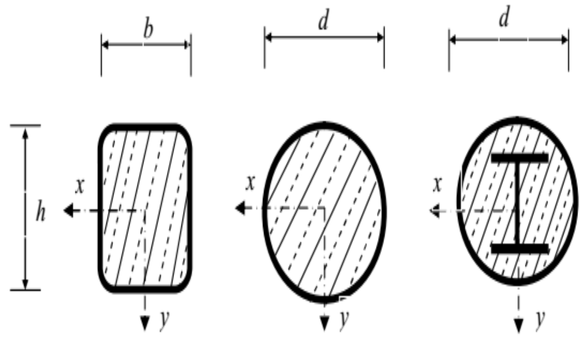

Fig. 2: Typical Cross-Sections of Concrete Filled Tubular Sections

A. *Structural Steel:*

All structural steels used shall, before fabrication conform to IS: 1977-1975, IS: 2062- 1992, and IS: 8500-1977 as appropriate. Some of the structural steel grade commonly used in construction as per IS: 961-1975 and IS: 1977-1975 are given in Table 1.

B. *Concrete:*

Concrete strengths are specified in terms of the characteristic cube strengths, $(f_{ck})cu$, measured at 28 days. Table 2 gives the properties of different grades of concrete according to IS: 456-2000 and the corresponding EC4 values.

Table1 (a): Yield Strength f_y of Steel Sections

Nominal steel grade	Nominal thickness/diameter (mm)	Yield stress, fy (MPa)
t 6	350	Fe 570-HT
6d *t* d28	350	
28 *t* d 45	340	
t 6	350	Fe 540W-HT
6d *t* d16	350	
16 *t* d32	340	
t 6	250	Fe 410-O (not subjected to dynamic loading other than wind)

Table1 (B): Yield Strength F_y of Steel Sections as Per IS 2062:1992

Nominal steel grade	Nominal thickness/diameter (*mm*)	Yield stress, *fy* (*MPa*)
< 20	250	Fe 410W A
20 - 40	240	
> 40	230	
< 20	250	Fe 410W B
20 - 40	240	
> 40	230	
< 20	250	Fe 410W C

Table 2: Properties of Concrete

Grade Designation	M25	M30	M35	M40
(fck)cu (N/mm2)	25	30	35	40
(fck)cy (N/mm2)	20	25	28	32
fctm(N/mm2)	2.2	2.6	2.8	3.3
Ecm=5700 (fck)cu(N/mm2)	28500	31220	33720	36050

II. RELATED WORK

A composite column is a combination of concrete, structural steel and reinforcing steel to provide a 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 behaviour, 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 behaviour of column under fire is one of the main problems to be studied. Joao Paulo et 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 analysed. 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].

III. DESIGN METHODOLOGY

A nonlinear 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 modelled 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 100mmc/c critical zone and 200mmc/c at remaining length of column.

IV. RESULTS AND DISCUSSIONS

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.3 (a) and fig. 3(b) shows the ANSYS model of RC column and core steel composite column provided with lateral loading.

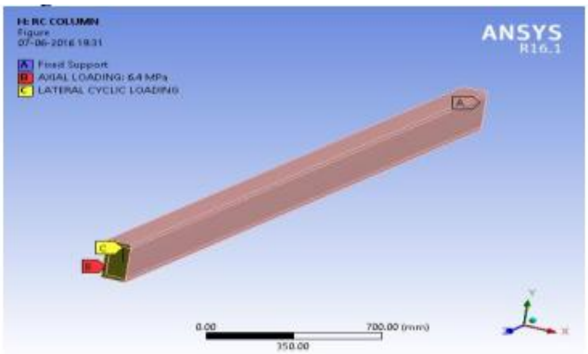

Fig. 3.(a): Lateral Loading RC Column

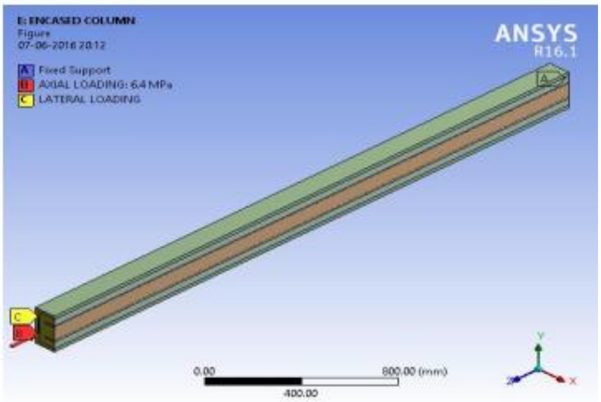

Fig. 3. (b): RCC Encased Column (I Section)

A. 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 occurred in RC column and core steel composite column respectively.

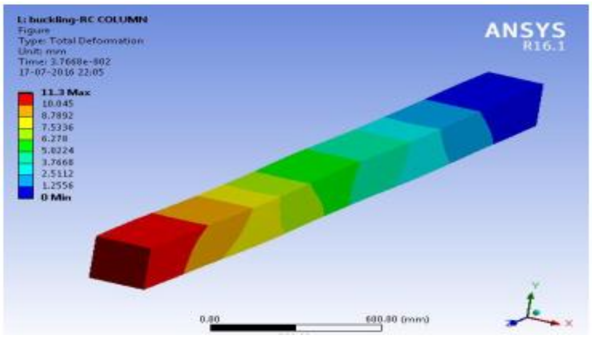

Fig. 4.(a): Total Deformation of RC Column

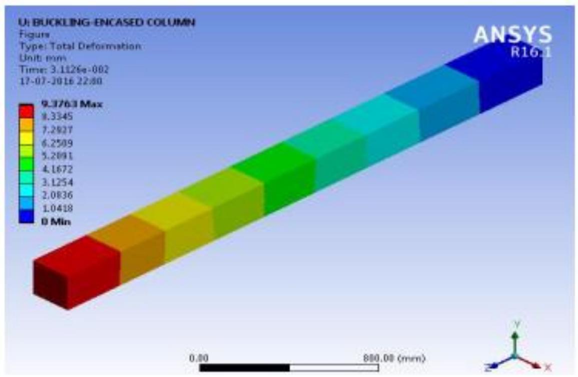

Fig. 4.(b): Total Deformation of RCC Core Steel Column

B. 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.5.(a) and fig. 5b) shows the deformation occurred 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,whereas The core steel column undergoes a maximum deformation of 159.25mm and it takes a maximum load of 26kN.

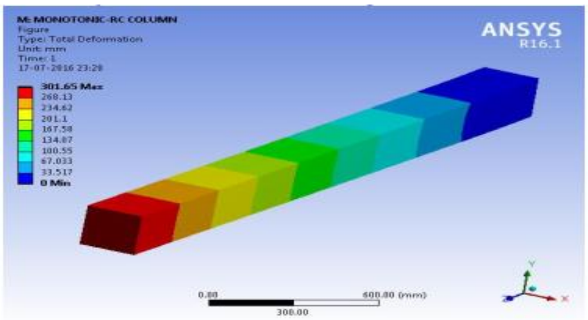

Fig. 5.(a): Total Deformation -RC Column

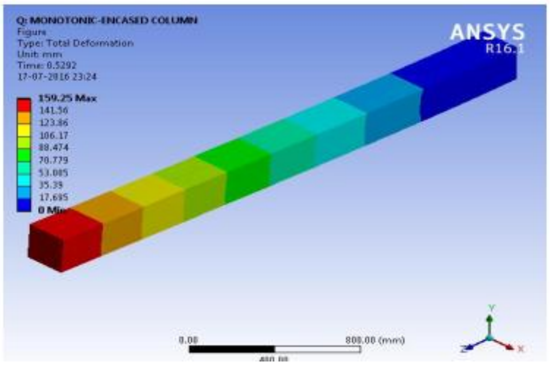

Fig. 5.(b): Total Deformation -RCC Core Steel Composite Column

V. CONCLUSIONS

The foremost aim 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 subsequent 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 thrice that of conventional RC columns.)".

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