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An Analytical and Experimental Study of Concrete Encased Column

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Abstract - ***This paper investigates the Concrete Encased Column behaviour under axial loading. Now a day's usage of concrete filled steel tube (CFST) is increased. Concrete encased column is the one of the type of concrete-filled steel tube and it has better advantages than normal column. This concept is new to the Indian construction industry. For high raised building providing composite column give more strength gain to the structure. In concrete encased column the steel case is filled with concrete same as CFT but the steel case is then surrounded with the plain concrete or reinforced concrete. The existing building with normal concrete-filled steel tube column outer surface having a big problem of weather and lack of fire resistance this problem leads to spending lot of money in fire resisting paint. This type of problem can be rectified by the concrete encased column. All the analytical work are carried out with ANSYS software. There is no Indian codal provision for concrete encased column. In this paper concrete encased column is designed by Indian codal provision with the reference of Eurocode 4 and the interaction curve is plotted between compressive resistance and moment resistance. Results from analytical, numerical and experimental work are compared.***

Key Words: **CFST, concrete encased column, interaction curve, ANSYS software, Eurocode 4.**

1.INTRODUCTION

The steel concrete composite has gained wide acceptance worldwide as alternative of pure steel and pure concrete construction. Using reinforced concrete member increase the cost of construction. This results with the evaluation of composite section. The main advantage of composite section is to utilize the properties of both concrete and steel. One such construction is concrete encased column. The main reason to provide concrete encased column is it increase the compressive resistance of the column. The expansion of the concrete can be restricted of the steel case and the buckling of the steel will be restricted by the concrete provision. Both the steel and the concrete resist the load by interacting together by friction and chemical bond. Eurocode 4 is the vast reference for concrete encased column. Indian construction industry also referring to that code and some projects are going on. But there is a lack of Indian code. In this paper all the works are done with the reference of Eurocode 4 and getting results with Indian code.

Identical cross section with different load and moment resistance can be produced by varying steel thickness, the concrete strength or reinforcement. This allow the outer dimension of a column to be held constant over a number of floors in a building, thus simplifying the construction and architectural. The main advantages of concrete encased column is, good fire resistance, corrosion protection in encased column, increased stiffness leading to reduced slenderness and increase buckling resistance and increased strength for a given cross sectional dimensions.

Concrete encased column is the one of the type of concrete filled steel tube. Normal CFST column having good advantages whereas concrete encased column have advantages like improving strength and decreasing the fire production cost. To test the concrete encased column compressive resistance and moment resistance are important criteria.

In this paper following are detailed. theoretical work are done with the help of Eurocode 4, numerical investigation is carried out with the help of ANSYS workbench 14.5 and the experimental work did with the help of LAB VIEW software. All the investigations are compared with the interaction curve plotted between the above three investigation

2. DETAILS OF CONCRETE ENCASED COLUMN

The early development of composite columns was based on the need for providing effective fire production for structural steel building. It was common practice to encase the steel stanchions in concrete. The week concrete

employed resulted in very little strength enhancement. Increased in strength and stiffness ignored in the past, although it was recognized that the buckling resistance for the column was increased. Supplementary reinforcement in the concrete encasement prevents excessive spalling of concrete both under normal load and fire condition. Concrete encased steel composite column become the preferred structure from for many earthquake resistance structure in Japan.

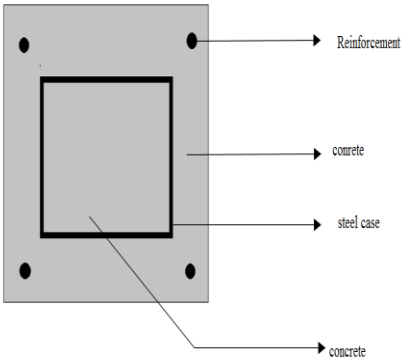

Fig.1 Concrete Encased Column

The inherent buckling problem related to thin walled steel tube is either prevented or delayed due to the presence of concrete core and outside concrete reinforced concrete. The performance of the concrete inside and outside also improved due to the confinement effect exerted by the steel shell. The distribution of material in the cross section also made the system very efficient in terms of its structural performance

3. *THEORETICAL WORK*

The following are the details of the concrete encased column and the calculation is calculated with simplified method referred from Eurocode 4. The concrete encased column is analysed for the compressive resistance and moment resistance. The interaction diagram is analytically plotted between the compressive resistance and moment resistance.

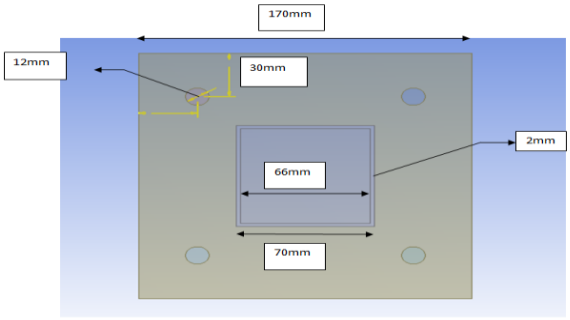

Fig. 2 concrete encased column from ANSYS with dimension

Table 1 Material Property

DESCRIPTION	Grade	Second modulus of elasticity (N/mm^2)	Partial safety factor
CONCRETE	F_{ck}= 30	E_{cm} = 27386	γ_c=1.5
STEEL	F_a= 250	E_a = 200000	γ_a=1.05
REINFORCEMENT	F_{sk}= 415	E_s= 200000	γ_s= 1.15

Simplified Method

The simplified method is for composite column with doubly symmetrical cross-sections. The calculations of various design parameters are covered and the checks for structural adequacy of a composite column under applied loads and moment are fully presented.

Compressive Resistance

$N_{pl,Rd}$= Aa×fy/γa + αc×Ac×Fck/γc + As×fsk/γs

= 852.48

Moment Resistance

M_{plRd}= 5.96

Final Theoretical Result

Case 1: when axial load present and absence of moment

A) $N_A = N_{plRd} = 852.48KN$
B) $M_A = 0$

Case 2: when axial load absend and moment persent

A) $N_B = 0$
B) $M_B = M_{plrd} = 4.02KNm$

At point C: when both load and momet present

(incresing load value)

A) $Nc = N_{pmrd}$ (or Ncrd) = Ac fcd = 426.24KN
B) $Mc = M_{plrd} = 4.02KNm$

At point D: when load and moment present (incerasing momet value)

A) $N_D = N_{pmrd} / 2 = 213.12$ KN
B) $M_D = M_{max.rd} = 5.96$ KNm

The interaction graph is ploted between compressiveresistance and moment resistace from the theoretical value gain from simplified method using reference of Eurocode 4 and indial code.

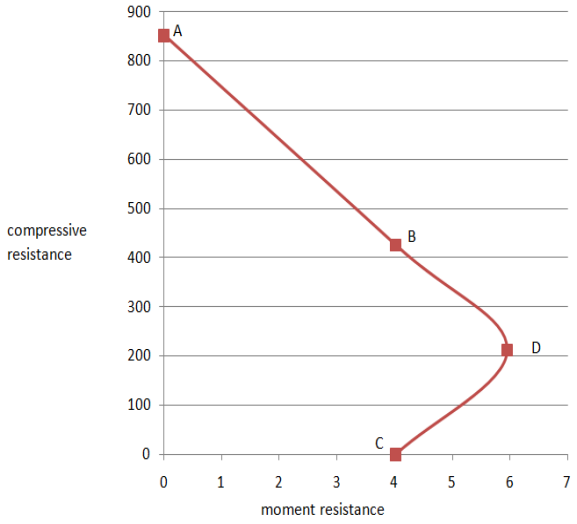

Fig 3 Interaction Curve Between Compressive Resistance and Moment Resistance

4. Numerical Work

The concrete encased column was numerically analysed by the ANSYS work bench 14.5. The properties of concrete encased column such as concrete, steel and reinforcement details are given as input. The model of the concrete encased column was created in the ANSYS software.

The property of the steel and concrete provided to the ANSYS software are as follow, Steel: Young's Modulus E=200GPa, Poisson's Ratio μ=0.3, Density P=7800kg/m3. Concrete: Young's Modulus E=27386Mpa, Poisson's Ratio μ =0.16 Density p=2400kg/m^3. Reinforcement: Young's Modulus E= 200GPa.

The element used in ANSYS software is solid 65, this type of elements are used for the three dimensional modelling of solid with or without reinforcing bars and its capable of cracking in tension and crushing in compression. For steel tubes simulation element 20 nodded solid 186 is chooses for thin to moderately thick structures and reinforcements

A) Modelling Detail of Concrete Encased Column

Specification of Fig 1 as below

Size of the column = 170×170×900mm

Inner concrete square size = 66×66 mm

Steel encasement thickness = 2mm

Reinforcement size = 4 no's of 12mm diameter bars

Outer concrete square column size 170 × 170 mm

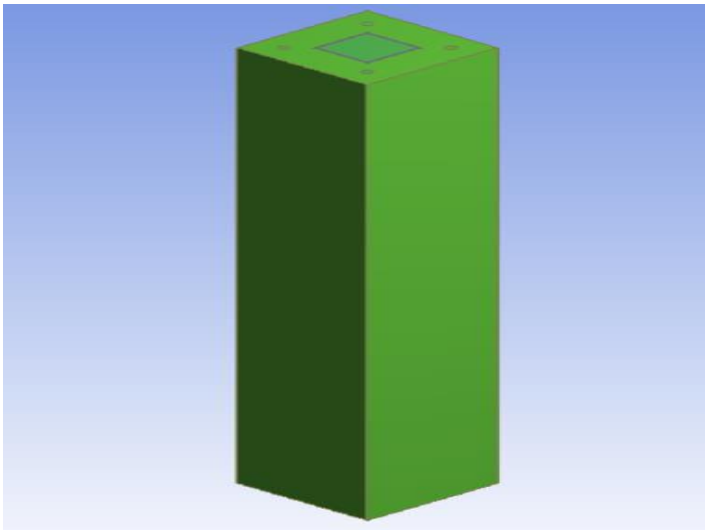

Fig 4 Concrete Encased Column Model from ANSYS

B) Support and Loading Condition

Bottom of the column (end A) is fixed support and the top of the column is loaded (end B).

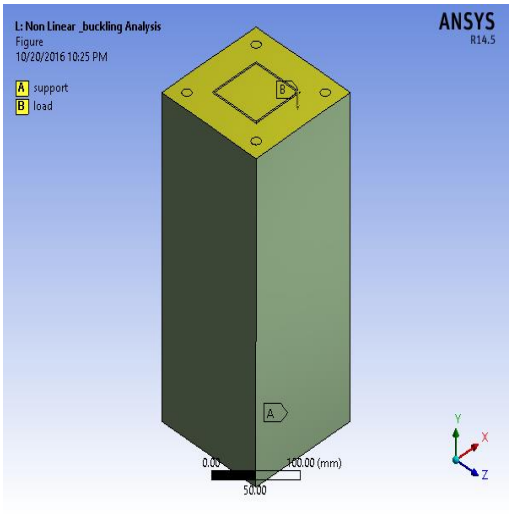

Fig 5 Support and Loading Condition

A) Meshing

Concrete encased column is meshed by the hexahedron meshing and tetrahedron meshing using ANSYS. Full concrete encased column is hexahedron meshing and the reinforcement is tetrahedron meshing.

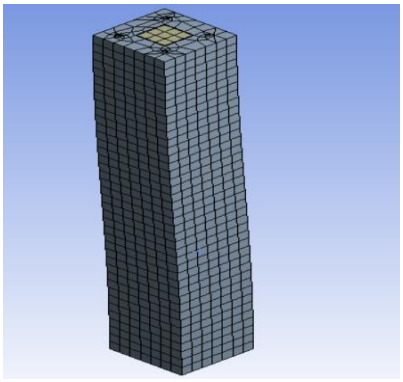

Fig 6 Meshed Model

B) Total Deformation

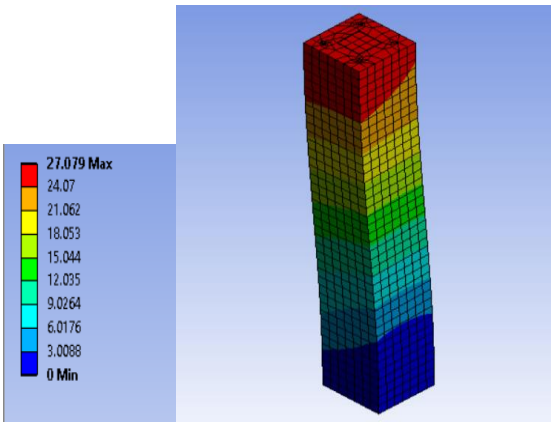

Fig 7 Total Deformation

Total deformation of the column is calculated by the nonlinear analysis carried out by ANSYS. Von-misses stress is applied and the maximum total deformation stress is calculated from the ANSYS report.

C) Effect of Steel Encasment in Concrete Encased Column

The deformation effect of steel casing remaining was checked using ANSYS. The deformation stress calculated only for the steel casing is 250MPA.This deformation is equal to the steel grade used in this concrete encased column.

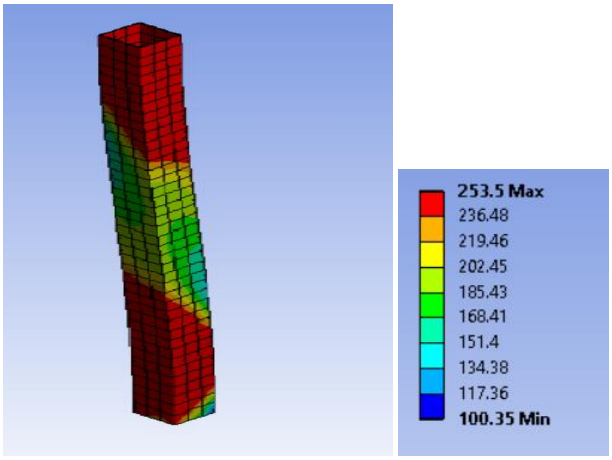

Fig 8 Effect of Steel Encasement

D) Effect of Reinforcement in Concrete Encased Column

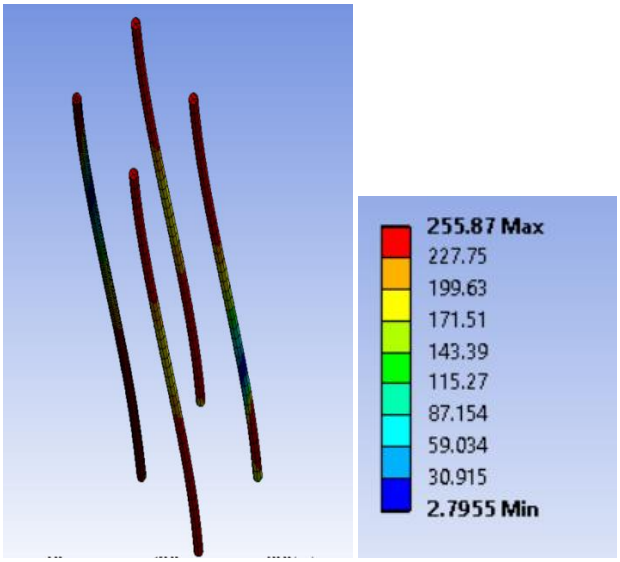

Fig 9 Effect of Reinforcement in Concrete Encased Column

Table 2 Numerical Compressive Resistance and Moment Resistance

Compressive Resistance (KN)	Moment Resistance (KNm)
927.5	0
826.31	0.98
765.23	2.01
686.12	2.69
645.78	3.06
538.14	3.87
498.23	4.21
382.49	5.26
231.75	6.14
138.28	5.86
0	4.21

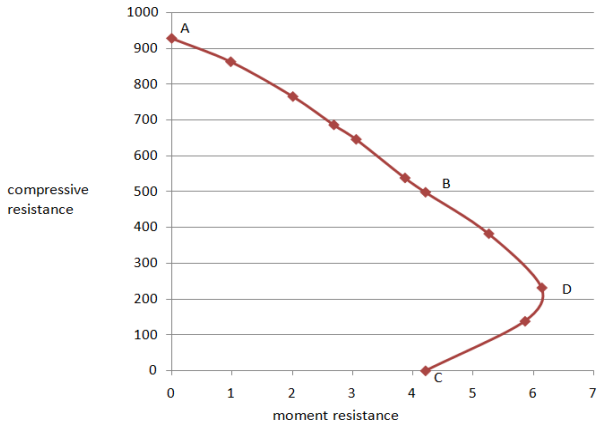

Fig 10 Numerical Interaction curve between compressive resistace and moment resistance

5. EXPERIMENTAL WORK

Experimental work is carried out with the help of lab view software. The concrete encased columns of size 170 * 170 * 900 mm are casted for the experiment. These column are tested in loading frame fitted with load cell and the results were obtained with the lab view software.

Fig 11 Inner Casing and Outer Reinforcement of Concrete Encased Column

Fig 12 casted Specimen

Totally 12 numbers of specimen were casted for the different case of loading and moment condition for the experiment. Each 3 specimen were tested for each case. Such as A) presents of axial load and moment(increase in moment) B) presence of both axial load and moment C) presents of axial load and absence of moment D) absence of axial load and presence of moment.

Fig 13 Loading Setup- bottom end fixed and top end loaded

Fig 14 Mode of Failure

Table 3 Experimental Compressive Resistance and Moment Resistance

Compressive resistance (KN)	Moment Resistance (KNm)
878.53	0
0	4.17
462.35	4.17
215.68	6.03

From the above table the interaction curve is plotted between compressive resistances. From the experimental work the maximum compressive resistance is 878.53 KN and maximum moment resistance is 6.03 knm.

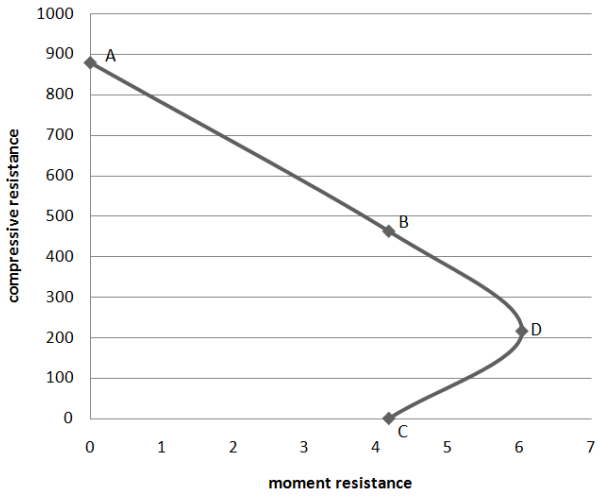

Fig 15 Experimental Interaction Curve Between Compressive Resistance and Moment Resistance

6. Results and Discussion

From the results of theoretical, numerical and experimental work the interaction curve is plotted. And the results were compared.

Table 4 result comparison

sec	THEORETICAL RESULT		NUMERICAL RESULT		EXPERI-MENTAL RESULT	
	Comp.resis (KN)	Moment. Resis (KNm)	Comp.resis (KN)	Moment. Resis (KNm)	Comp. resis (KN)	Moment. Resis (KNm)
A	852.48	0	927.5	0	878.53	0
B	0	4.02	0	4.21	0	4.17
C	426.24	4.02	436.23	4.21	462.35	4.17
D	213.12	5.96	231.75	6.34	215.68	6.03

From the interaction curve it is clear that when the compressive load is applied there will be no moment and only compressive resistance is presented. And when moment is applied there will be no compressive resistance and only moment resistance is presented. At a point C and point B the moment resistance value is equal. At point D when the combination of compressive and moment resistance acted and especially half of the compressive resistance attained the moment resistance will reach the maximum value.

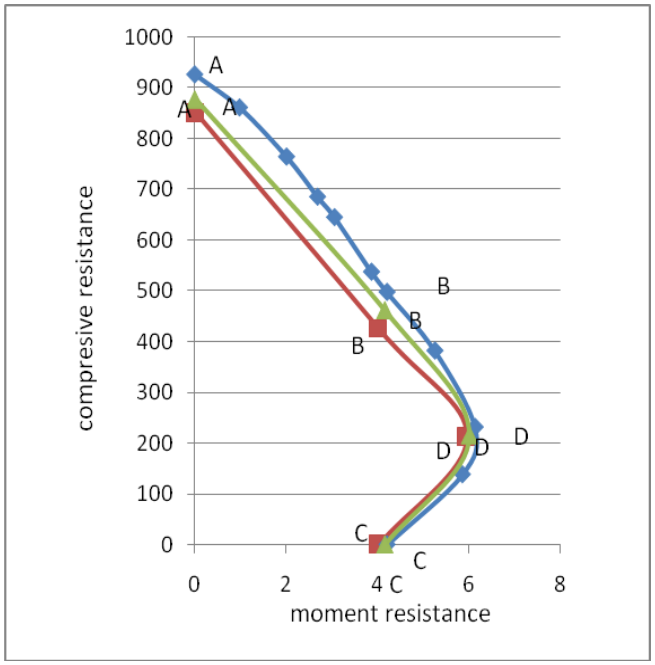

Fig 16 Result Comparison Interaction Curve

7. Conclusion

From numerical, theoretical and experimental work conducted on concrete encased column, the following results were observed regarding the behaviour of the concrete encased column.

A) The analytical investigation was carried out with the reference of simplified method of Eurocode 4. And with the specification are taken from Indian code.

B) Finite element investigation is done in this research to analyse the concrete encased column using ANSYS software package. The result show fairly good agreement with analytical result obtained from simplified method.

C) Experimental works are carried out with the help of lab view software and the results were compared with the theoretical and numerical results. The comparison of results giving the good correlation between them and more or less equal.

D) The interaction curve is the one give the very neat comparison of compressive and moment resistance.

E) When both compression and moment applied on the concrete encased column the column reaches it maximum moment carrying capacity.

F) From the results it is clear that the compressive resistance value is much better than the normal concrete column.

G) The fire resistance production cost can be neglected.

Further study, there is many type of concrete encased column can be tested such as partial concrete encase column and fully encased column of different shape and size from Eurocode 4. The test can be elaborated for fire resistance testing. Thus the clear design of concrete encased column can be provided with Indian standard.

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