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Research Study on Behavior of Composite Stub Column Experimentally and Analytically

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Abstract: *The structural behaviour of concrete - filled steel tube (CFST) columns has been investigated using, ANSYS Software, experimental and analytical studies (Rankine's). The effect of concrete compressive strength, thickness of steel tube, stiffeners and longitudinal reinforcement were considered. Specimens that have been studied consist of twenty one circular samples of 150 mm diameter and 5mm thickness and height of 300 mm. The tested samples were studied analytically using workbench by ANSYS S (ver. 12) computer program. The results obtained from analytical method shows that, the convergence between analytical and experimental method failure load varied from (16.49 to 56.78 %) While the effect of compressive strength of concrete on columns having diameter/thickness (d/t) is 30 . Deformations of columns filled with normal concrete (25 MPa). The effect of diameter/thickness (d/t) ratio on the ultimate strength of (CFST) columns will have a reverse action, when of (d/t) decreases the caused increasing in ultimate load capacity of columns for circular samples depending on the type of stiffened, compressive strength of concrete and ratio of (d/t).*

Keywords: *Stub column, Composite column, Concrete-filled steel tube column.*

I. INTRODUCTION

Steel-concrete composite columns were used for over a century. At the beginning it was used to provide fire protection to steel structures. Afterwards, the concrete encased columns strength properties were also considered in the design. However, the researches into concrete filled steel tubes (CFST) did not begin until the 1960. Nowadays, the composite structural elements are increasingly used in tall buildings, bridges and other types of structures. The steel concrete composites are considered as an advantageous system for carrying large axial load benefitting from the interaction between the concrete and the steel section. The steel section reinforces the concrete to resist bending moments, tensile and shear forces. The concrete in a composite column reduces the potential for buckling of the steel section in addition to resisting compressive loading. There are two types of steel-concrete composite columns which are commonly used in buildings. Those with steel section in-filled with concrete and those with steel section encased with concrete.

II. MATERIALS AND METHOD

- A. Following are some models which are studied during this project
- B. It consists of mild steel column is 300mm long. One end is fixed and other end hinged. The outer diameter of column is 160mm and 5mm thickness and the grade of concrete is
- C. There were total seven numbers of models made details of each shown in a below table.
- D. Diagrammatic representation of all the models has been also shown in fig no1
- E. Total number of models

Model M ₁	Hollow circular pipe.
Model M ₂	Hollow circular pipe provided with stiffener at the middle section
Model M ₃	Hollow circular pipe provided with stiffener at the top and bottom.
Model M ₄	Hollow circular pipe filled with concrete and stiffener provided at the middle section.
Model M ₅	Hollow circular pipe filled with concrete and stiffener provided at top and bottom.

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Model M₆ Hollow circular pipe carrying longitudinal reinforcement without concrete.

Model M₇ Hollow circular pipe filled with concrete and carrying longitudinal reinforcement.

F. Method of analysis

The models are analysed by three methods given below.

1) *Analytically by Rankine's method:* It is an empirical formula used for calculation of ultimate load both for short and long column. Rankine's formula is also known as Rankine-Gordon formula. It gives the ultimate load that column can bear before failure. If column is short, calculate load will be known as crushing load. And load will be buckling or crippling load, in case of long column. This formula only gives the ultimate load, but columns are designed on safe load. In order to get safe load, divide ultimate load (load obtained from Rankine's formula) with factor of safety (F.O.S)

2) *Sample calculation for model 1:* Rankine's formula

$$E = 2 * N / = 320 \text{ N/}$$

$$= =$$

$$= 7319.42$$

$$.K = = 54.95 \text{ mm}$$

$$L_e = 212.13 \text{ mm}$$

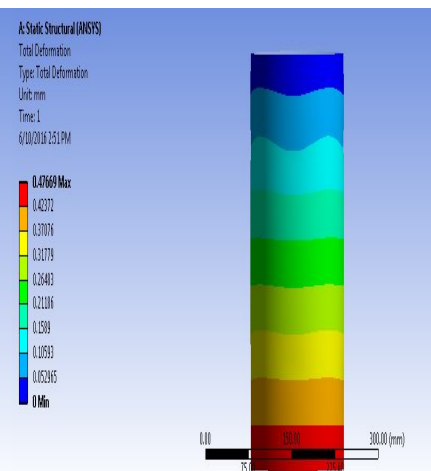
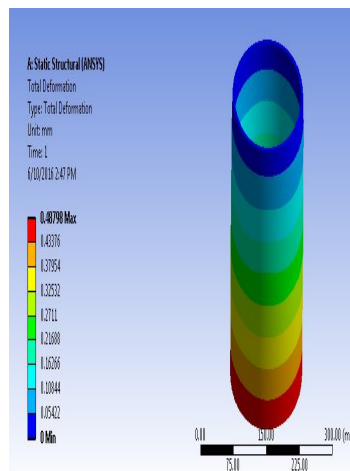
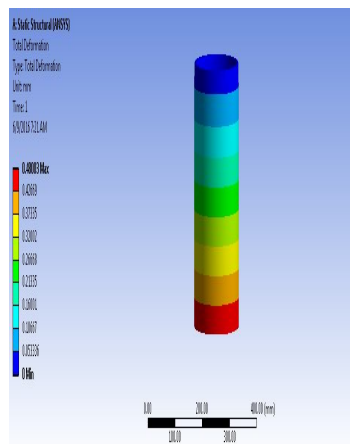
$$. = 777 \text{ kN}$$

Deformation calculation

$$\delta = = = 0.48 \text{ mm}$$

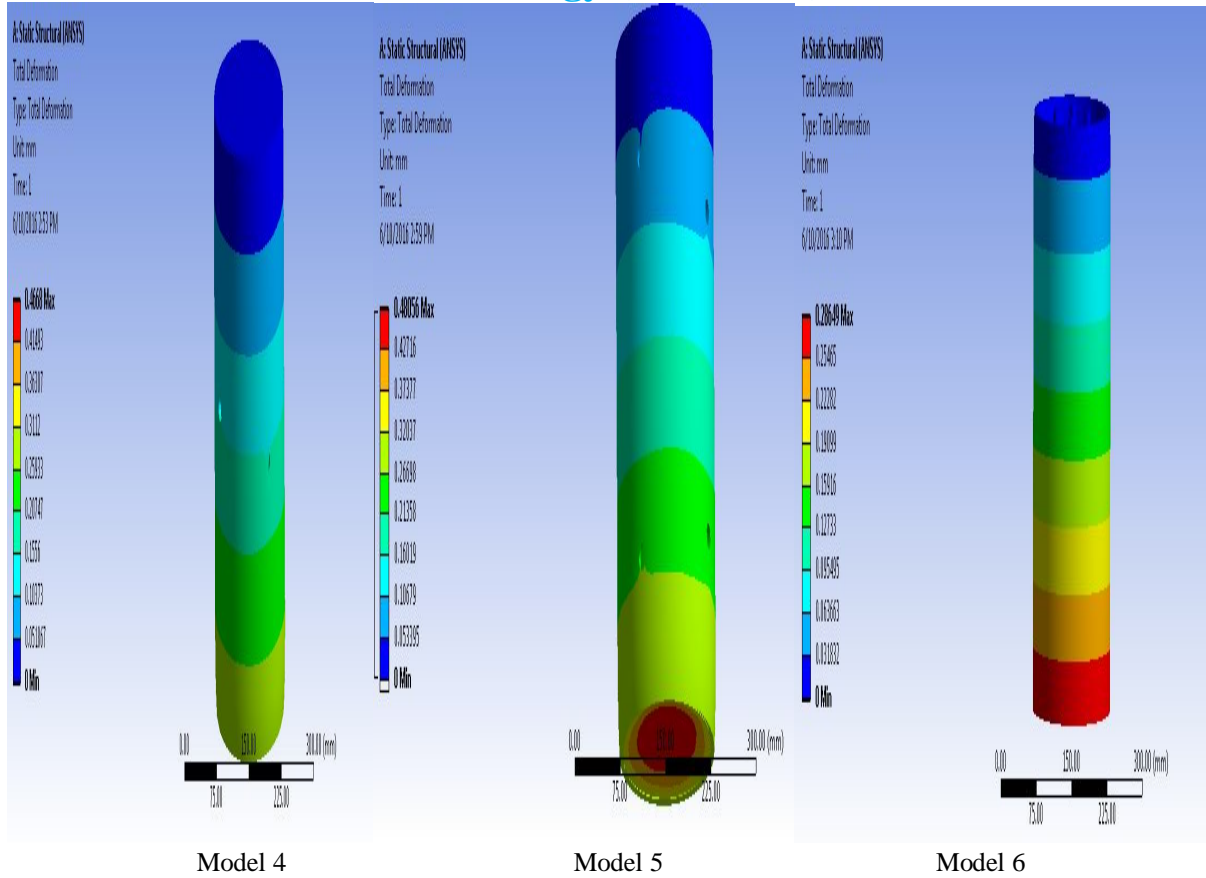
3) *ANSYS software:* ANSYS is a structural analysis program that is most widely used for modeling and analyzing a number of structures. ANSYS is a complete FEA package used by engineers in virtually all fields of engineering. ANSYS Mechanical is a finite element analysis tool for structural analysis, including linear, nonlinear and dynamic studies. This computer simulation product provides finite elements to model behavior, and supports material models and equation solvers for a wide range of mechanical design problems. ANSYS as a software is made to be user-friendly and simplified as much as possible with lots of interface options to keep the user as much as possible from the hectic side of programming and debugging process. ANSYS works on the principles of FEM i.e. finite element method. FEM has the advantages of improved visualization, lesser design cycle time, lesser number of prototypes, lesser number of testing required, and decrease in cost of production. ANSYS 12 is the easiest, most productive solution. The FEM model of composite column was developed considering above physical properties in FEM commercial software package ANSYS 12.

For modeling, the composite stub column was taken in workbench, real constants like area, moment of inertia and material properties like modulus of elasticity (E) was given in workbench and column was created through sketch. Displacements on column were applied and model was analyzed.



Model 1 hollow circular pipe Model 2 hollow with one stiffener at mid span Model 3 hollow with two cross mid span stiffener at mid span

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4) *Experimental investigation:* The models of stub columns are prepared and tested experimentally by using compressive testing machine (CTM) of capacity 3000 kN. Concrete of grade M25 is prepared for the models and grade of steel is Fe 415. Rate of loading is kept 5kN/s during testing of models. Models were tested after 14 days of curing. During the experiment buckling load and deformation along the line of action are measured.



Hollow pipe

one cross stiffener

two cross stiffener

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Making hole



Smoothing surface



Compacted by iron rod



Casting



Testing



Failure specimen

Fabrication and casting of columns, all specimen arranged before casting the concrete, then concrete mix was placed and well compacted by means of iron rod, the top surface of columns was finished level. Before testing, the top surface of CFST columns were smoothed by a scraper machine to make the surfaces of concrete and steel lying on the same elevation, and therefore ensuring a transfer of load to both concrete and steel at all levels. Compressive testing machine with capacity of 3000kN was used to deformation of columns.

III. RESULTS AND DISCUSSION

All the models are analyzed by three different method as shown above result obtained by each method and comparison of result is

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shown and discussed below.

Table 1: Result of failure load and deformation of stub column by analytical study .

MODEL	LOAD (kN)	along the line of action load
	777	0.49
	814.37	0.45
	852.43	0.42
	1517.24	0.41
	1589.93	0.39
	928.56	0.24
	1546.48	0.22

Table 2: Result of deformation of stub column by ANSYS software method.

Model	Load (kN)	Pressure (Mpa)	Deformation along the line of action load. (mm)
M ₁	777	320.58	0.487
M ₂	814.37	335.99	0.480
M ₃	852.43	351.7	0.476
M ₄	1517.24	75.5	0.466
M ₅	1589.93	79.11	0.480
M ₆	928.56	380.63	0.286
M ₇	1546.48	77.12	0.403

Table 3: Result of failure of load and deformation of stub column by Experimental method.

Model	Avg. Axial load failure (kN)	Avg. Vertical deformation (mm)
M ₁	948.33	5.06
M ₂	973.4	5.36
M ₃	993.07	5.27
M ₄	2263.87	4.63
M ₅	2280.68	4.62
M ₆	1074.33	5.07
M ₇	2424.33	4.13

The percentage difference of result deformation and buckling load by two different method has been calculated. Buckling load obtained by three different method has been also compared

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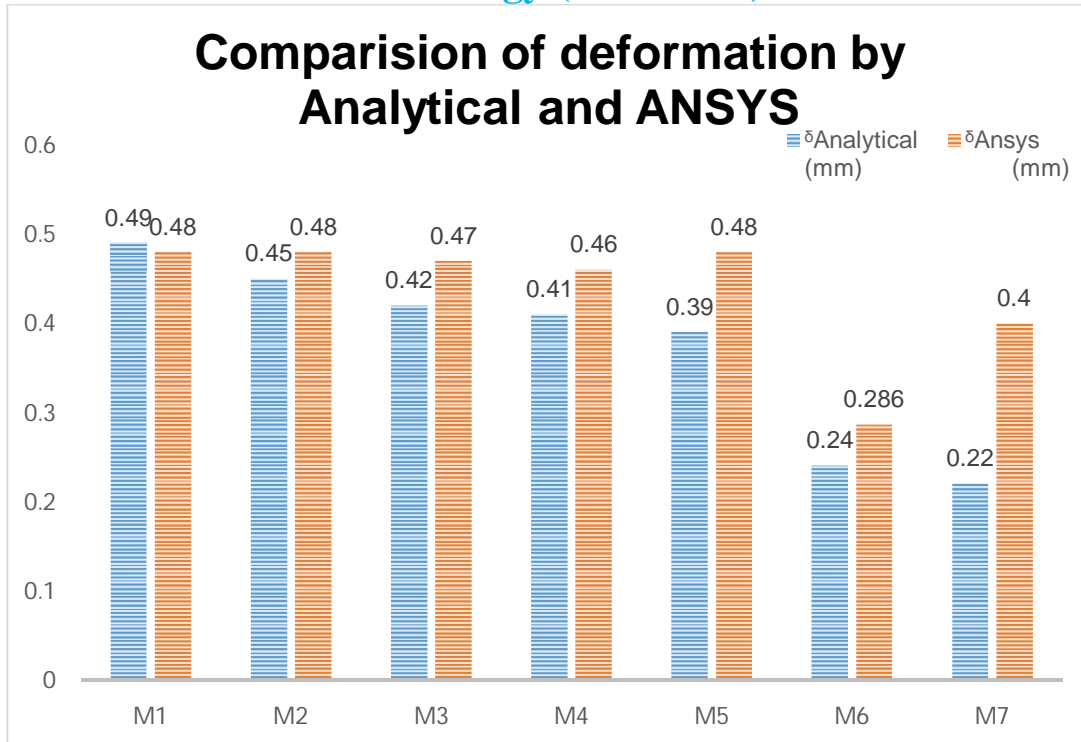


Fig: 1 Graphical Representation of Comparison of deformation between analytical method and ANSYS software

From the graph it has been observed that maximum percentage difference for deformation is for model seven (M₇ which is (Hollow circular pipe carrying longitudinal reinforcement filled with concrete)) by two distinct method.

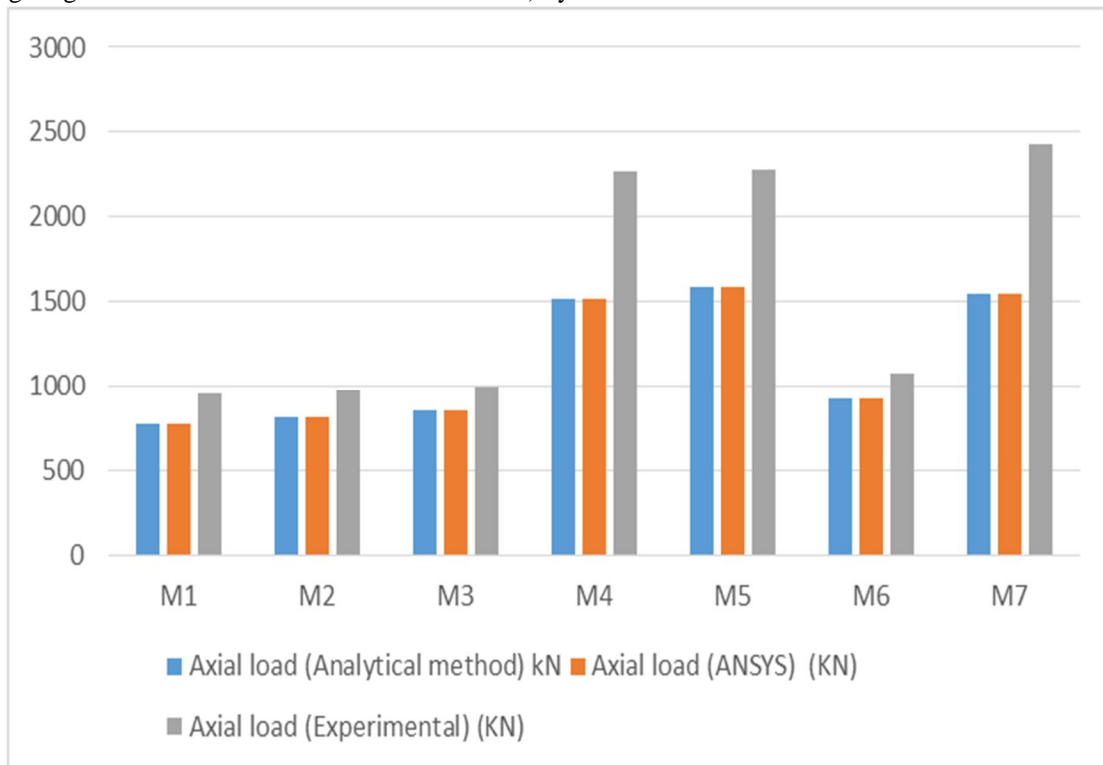


Fig: 2 Graphical Representation Comparison of failure of load by analytical method, ANSYS software method and Experimental method of stub column.

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The experimental and analytical results of the tested specimens (twenty one concrete-filled steel tube stub columns) have been studied. Effect of compressive strength of concrete, steel tube thickness, scheme of stiffeners and longitudinal reinforcement have been studied. Graph above indicating higher value of failure load during experimental investigation.

IV. CONCLUSION

From experimental results, CFST columns show higher ductility after maximum load. The load can reach up to 56.78% of the ultimate load capacity of CFST columns, especially for reinforced and stiffened columns.

The effect of (diameter-thickness) ratio on ultimate strength of CFST columns will have a reverse relation. When increasing thickness of tube this ratio will decrease, then ultimate strength will increase. The effect of compressive strength on unstiffened CFST columns is more than for stiffened and reinforced CFST columns. The ultimate load capacity for two cross stiffened CFST columns is more than for one cross stiffened CFST columns and more than for unstiffened CFST columns. The ultimate load capacity for reinforced (circular) CFST columns is more than for unstiffened (circular) CFST columns. The filling concrete will enhance the steel carrying capacity so that all the section will reach its limit state and avoid the possibility of buckling until cracking induced in concrete at high load levels. At the same time the steel shell will confine the concrete and improve its strength and ductility.

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