EXPERIMENTAL STUDY ON DOUBLE SKINNED STEEL TUBULAR COLUMNS SUBJECT TO MONOTONIC LOADING

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***Abstract*: The steel tube in a Concrete Filled Tubular Column (CSFT) acts as both longitudinal and lateral reinforcement, and is thus subjected to biaxial stresses. An experimental study was conducted to understand the behaviour of Short and long doubled skinned concrete Filled Steel Tubular Columns (DSCSFT) under axial compression to failure.**

An analytical study was also done to compare with the experimental results. A total of 52 specimens (48 specimens were filled with concrete of which 16 specimens were only filled in inside of the tube, 16 specimens were filled in outer diameter and remaining 16 were filled in both infill and out fill of the specimen, 4 specimens were kept hollow and 3 specimens were only concrete) having different cross-sections were tested to investigate the load carrying capacity in particular and behaviour as a whole. The results shows excellent matching of the results which indicates, the manual experimentation can be replaced computer based numerical techniques which eliminates the need of tedious experimental set up, destructive testing and skilled labour.

***Keywords*: Monotonic loading, ANSYS, Double skin friction, Buckling load etc.**

1. INTRODUCTION

Columns are the most important elements in the construction activities. Columns mainly fail by buckling loads. Steel has the maximum strength but it is expensive. So hallow steel tubes are used for which concrete will be filled. Concrete has little capacity for torsion and bending. Concrete has almost 1/10 of compressive strength. So steel is provided around the concrete to provide bending and torsion resistance.
Strength is the most important terminology of either civil or mechanical engineering. Higher strength is always desired for optimum working of the engineering components. So stress estimation is important and many methods are available to find the value of stress and deformation.

2. PROBLEM DEFINITION

Structural analysis using experimental techniques on columns with steel tubes either filled or unfilled configurations under buckling for various configurations of L/D, D/t is the main definition of the problem.
Column is an essential structural member in the engineering assemblies for carrying the buckling loads. Failure of the column is catastrophic in the structural design. Also proper design is very essential to reduce the overall weight and cost of the assemblies. To find the optimum design, it is always better to analyse the structural geometrical parameters like length, inner diameter, outer diameter and thickness. Buckling is the failure of the members under compressive loads and it is mainly effected by length. So effect of the length is also need to be analysed.

3. METHODOLOGY

- Preparation of the components (total of 52 samples)
- Separation of filled and unfilled components
- Curing for the required time
- Testing under Universal testing machine which has SCODA software which records the values in digital form
- Comparative analysis
- Finite element analysis for Validation of certain components for numerical validation.

4. SPECIFICATIONS

Total specimens: 52

48 were filled with concrete

- out of which 16 are filled only inside
- 16 were filled out side
- 16 were filled both outer and inner

4 were hallow and 3 are only concrete

L/D ratio: 8,10,12,14

Diameter to thickness ratio: 10

Steel tube are steel grade of 310

Thickness of tube wall: 2.5 mm and varied

Tube steels : inner diameter: 19mm outer diameter: 31.75mm

5. MODELING USING ANSYS SOFTWARE

Three dimensional finite element meshes is used for representation of the problem. Colors shows variation of material in the column structure. Three dimensional element solid45 is used for representation of the problem. The element is defined with 8 nodes with three degree of freedom at each node. Initially three dimensional geometry is built and meshed with finite number of elements and nodes. The element is a isoparametictype with first order displacement polynomial and suitable for any type of geometry for analysis.

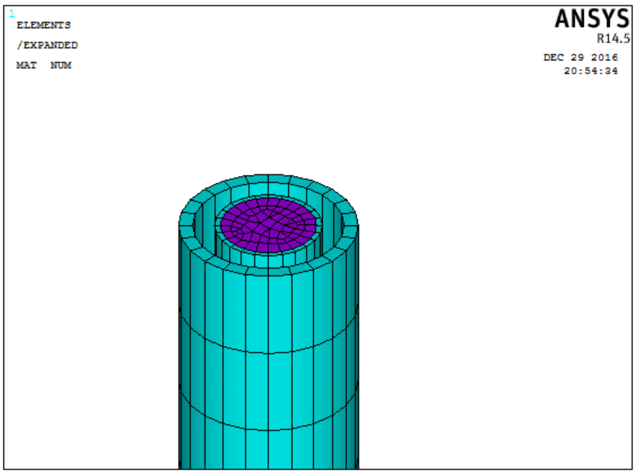

Fig 1: Only Inner Fill

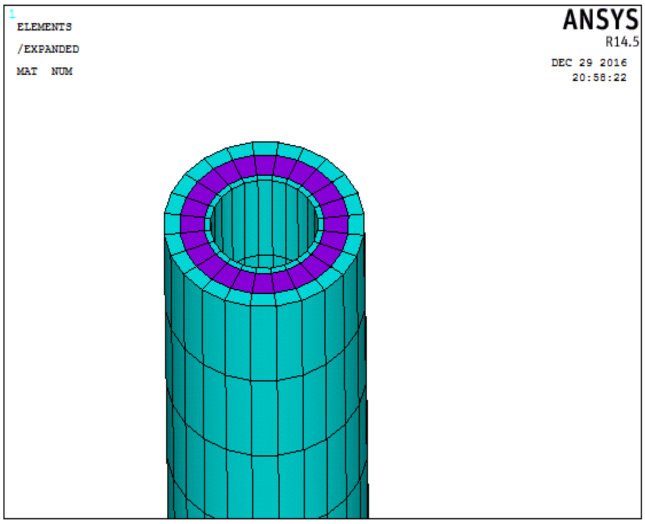

Fig 2: Outer (Geometry with outer concrete fill)

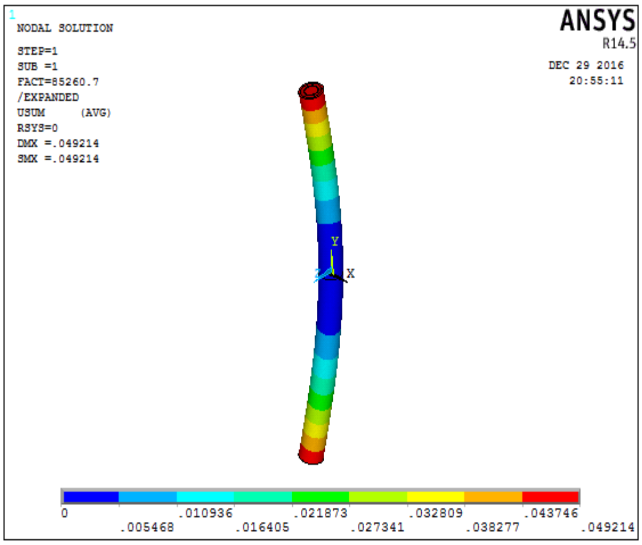

Fig 3: Buckling Load Capacity of the Column for only inner fill

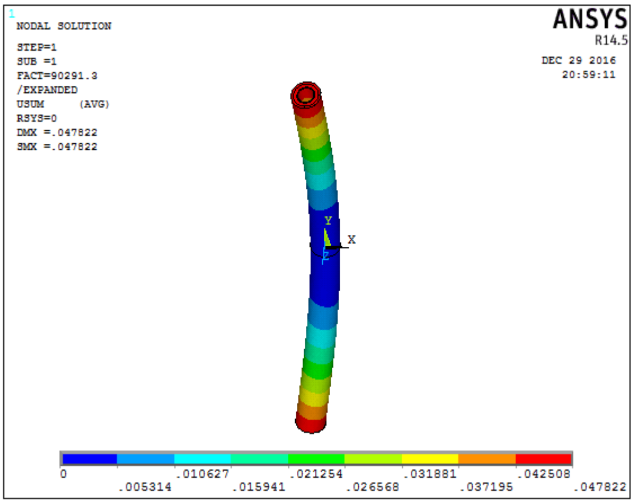

Fig 4: Buckling Load Estimation from Ansys(Only outer filled)

6. RESULTS OF EXPERIMENTAL ANALYSIS

The table 1 shows Load carrying capacity of the columns for different arrangements. From the observation, it can be concluded that outer filling has more effect compared to the inner fill. Also Combined filling has more strength compared to either inner fill or outer fill. But stresses are not following any particular patterns.

Table 1:

Method of Filling	Grade	Inner Diameter	Outer Diameter	Length(L)	Failure Load(KN) SAMPLE1	Failure Load(KN) SAMPLE2
Inner	M20	19	31.75	254	85.9	86.12
Inner	M20	19	31.75	317.5	80.3	81.01
Inner	M20	19	31.75	381	57.55	57.87
Inner	M20	19	31.75	444	45.62	46.15
BI	M20	19	31.75	254	94.66	93.99
BI	M20	19	31.75	317.5	78.75	79.01
BI	M20	19	31.75	381	65.2	66.01
BI	M20	19	31.75	444	42.8	42.14
OUTER	M20	19	31.75	254	92.3	92.13
OUTER	M20	19	31.75	317.5	82.65	82.85
OUTER	M20	19	31.75	381	79.55	80.15
OUTER	M20	19	31.75	444	72.6	78.78
INNER	M30	19	31.75	254	94.66	94.77
INNER	M30	19	31.75	317.5	85.7	85.77
INNER	M30	19	31.75	381	83.4	83.33
INNER	M30	19	31.75	444	82.96	82.44
Outer	M30	19	31.75	254	79.25	79.126
Outer	M30	19	31.75	317.5	93.9	92.12
Outer	M30	19	31.75	381	92.34	90.12
outer	M30	19	31.75	444	75.4	76.12
BI	M30	19	31.75	254	80.15	81.23
BI	M30	19	31.75	317.5	97.99	98.12
BI	M30	19	31.75	381	92.92	91.13
BI	M30	19	31.75	444	75.15	76.12

The table 2 shows variation of load levels with different L/D ratio's. Keeping the diameters constant and increasing the length definitely reduces the buckling strength of the structure. Even this can be validated through theoretical concepts.

Table 2:

Description	L/D	Buckling Load(KN) Experiment value	Buckling Load(KN) Technicalvalue	Error
M20- Inner	8	85.90	86.26	0.8
	10	80.65	81.15	0.5
	12	57.71	58.13	0.42
	14	45.88	46.89	1.01
M20-Outer	8	92.325	93.12	0.79
	10	65.60	66.56	1.05
	12	42.47	43.34	0.87
	14	92.21	93.56	1.35
M20-Inner and Outer	8	94.75	95.45	0.7
	10	70.94	71.23	0.29
	12	77.16	78.92	1.76
	14	79.68	80.23	0.54
M30-Inner	8	78.45	79.45	1.00
	10	83.36	84.45	1.09
	12	82.7	83.14	0.44
	14	79.18	80.12	0.94
M30-outer	8	93.01	94.14	1.13
	10	91.23	92.12	0.89
	12	90.34	91.01	0.67
	14	75.23	76.44	1.21
M30-Inner and Outer	8	80.69	81.23	0.54
	10	98.55	99.18	0.63
	12	92.02	92.98	0.96
	14	75.62	76.90	1.28
Hollow tubes	8	81.17	81.17	-
	10	80.52	80.52	-
	12	83.12	83.12	-
	14	79.12	79.12	-

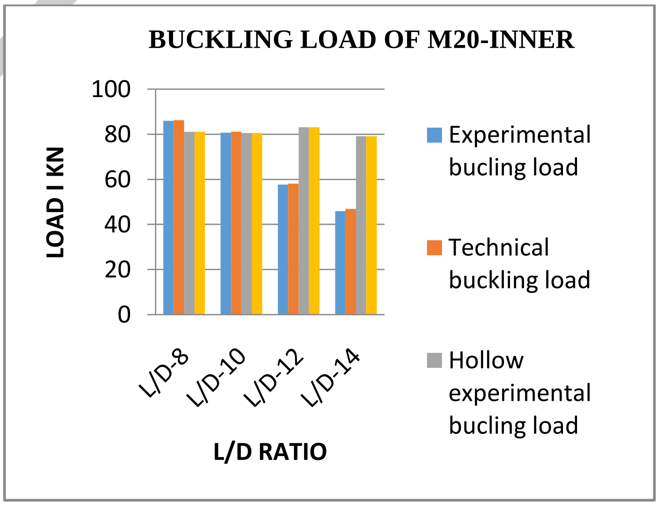

Chart 1: Buckling load of M20 inner for different L/D ratio with hollow tube

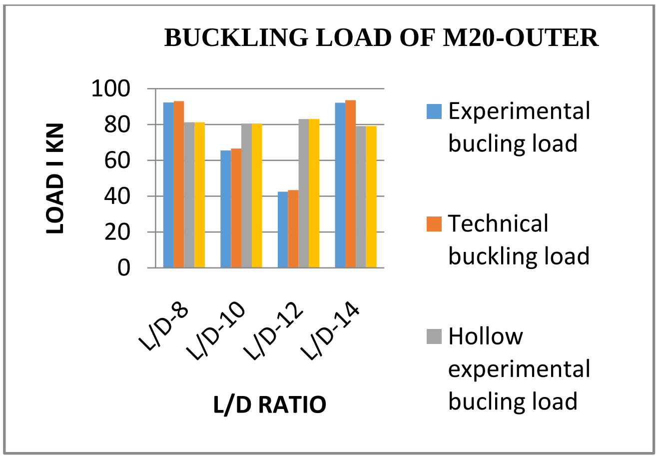

Chart 2: Buckling load of M20 outer for different L/D ratio with hollow tube

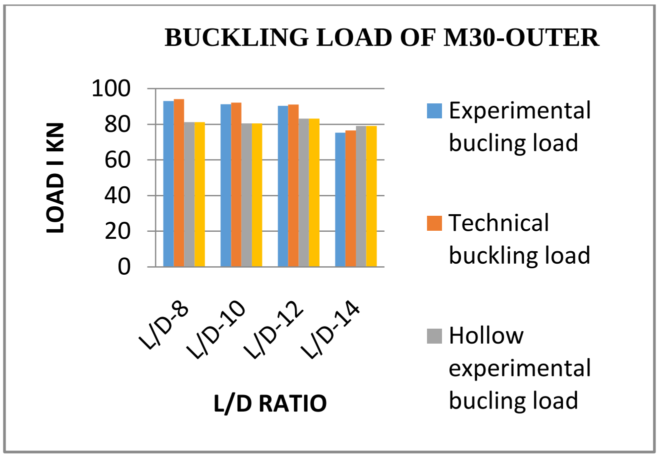

Chart 5: Buckling load of M30 outer for different L/D ratio with hollow tube

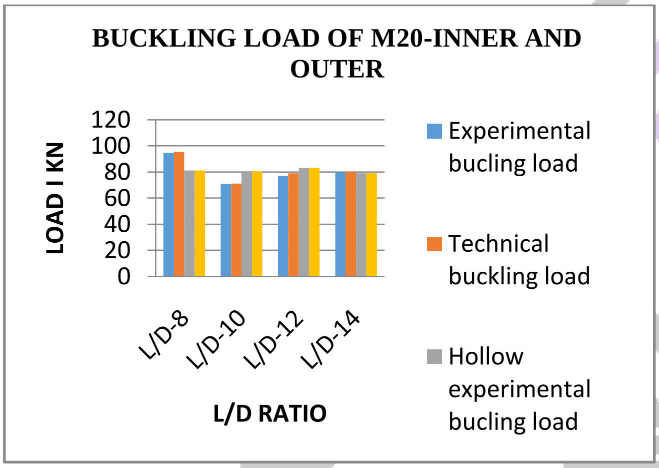

Chart 3: Buckling load of M20 inner and outer for different L/D ratio with hollow tube

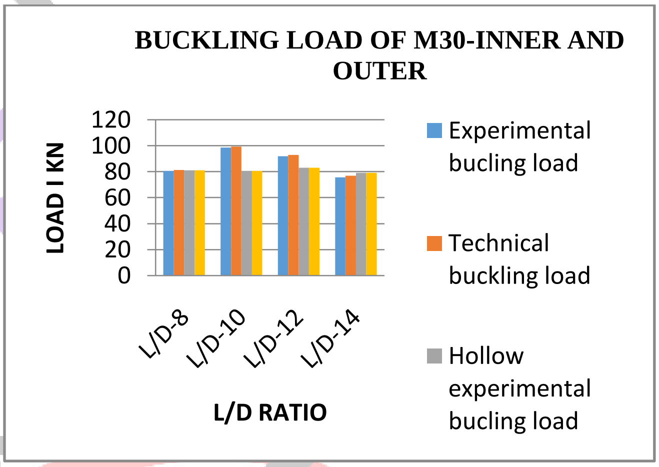

Chart 6: Buckling load of M30 inner and outer for different L/D ratio with hollow tube

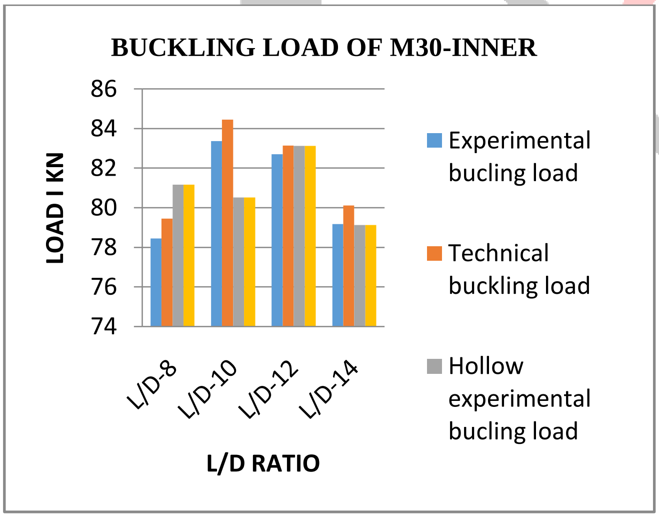

Chart 4: Buckling load of M30 inner for different L/D ratio with hollow tube

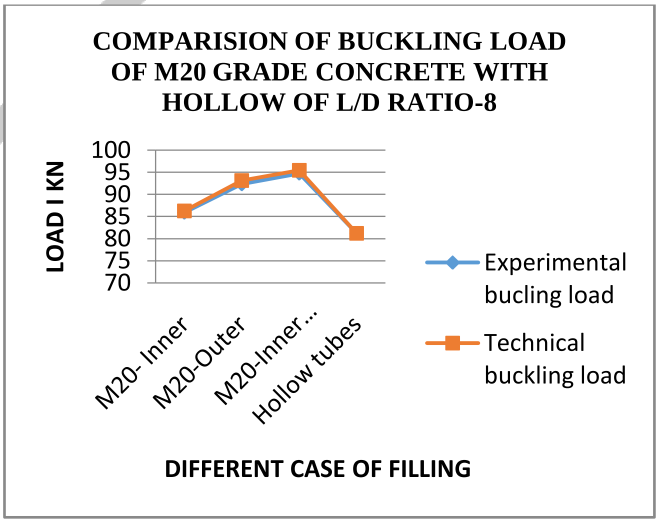

Chart 7: Buckling load of M20 of different case for L/D ratio-8

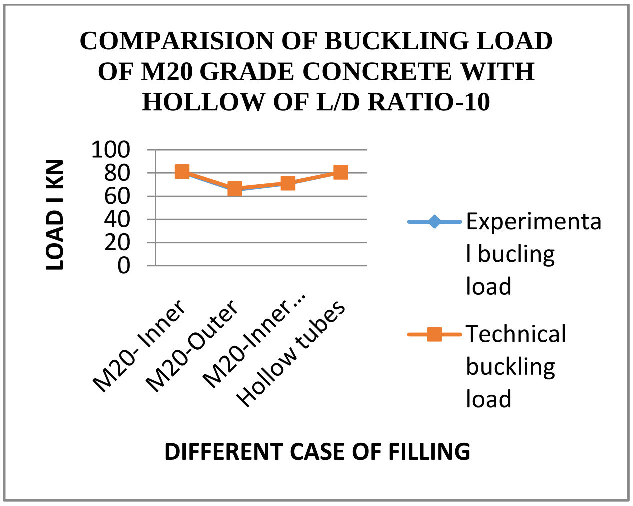

Chart 8: Buckling load of M20 of different case for L/D ratio-10

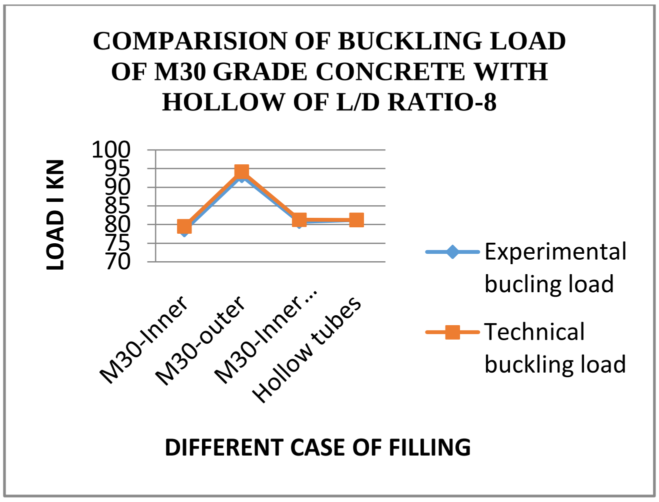

Chart 11: Buckling load of M30 of different case for L/D ratio-8

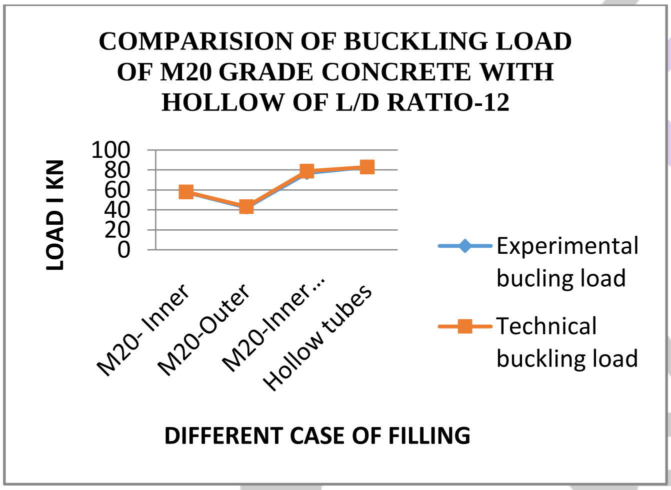

Chart 9: Buckling load of M20 of different case for L/D ratio-12

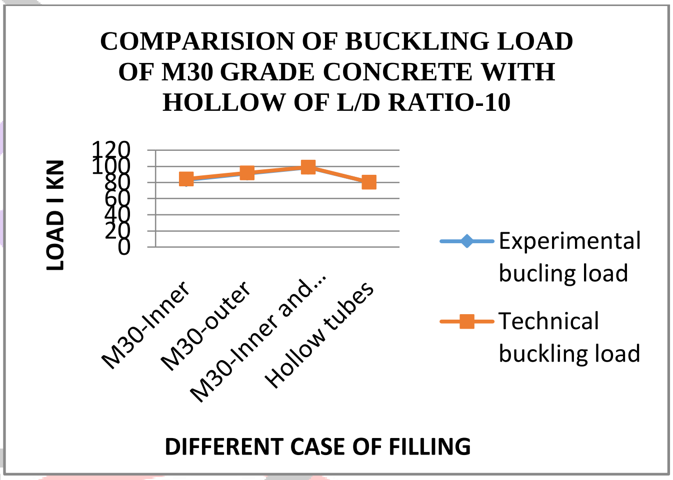

Chart 12: Buckling load of M30 of different case for L/D ratio-10

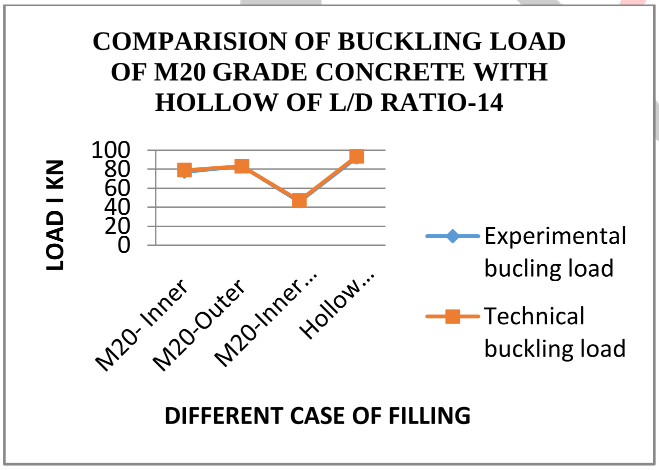

Chart 10: Buckling load of M20 of different case for L/D ratio-14

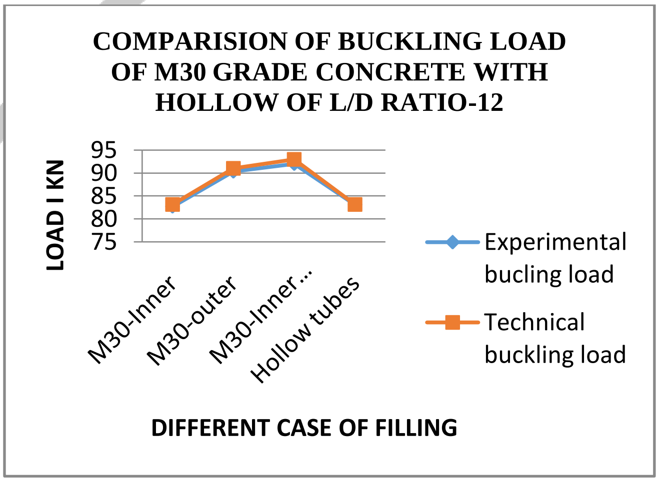

Chart 13: Buckling load of M30 of different case for L/D ratio-12

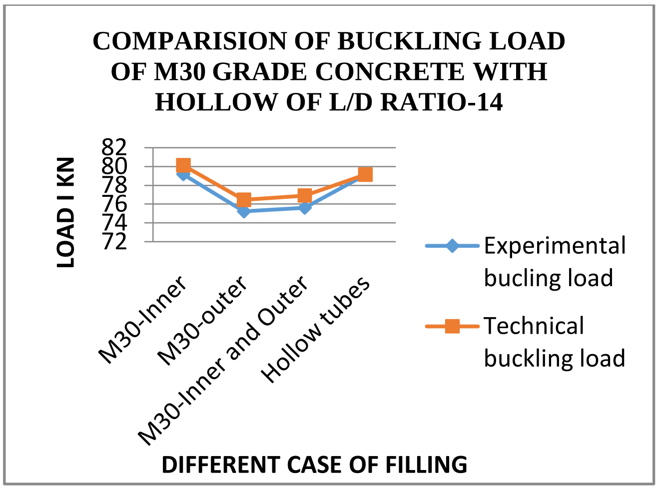

Chart 14: Buckling load of M30 of different case for L/D ratio-14

CONCLUSIONS:

Columns are very important structural members to take the loads. The main failure mode of columns is buckling and so methods need to be explored to find the best arrangement for increasing the load carrying capacity. In the present work both experimental and numerical methods are applied to find load carrying capacity based on certain design parameters like L/D ratio and grade of cement.

Finally finite element analysis is used to verify the experimental results. The results shows excellent coincidence with the experimental results. So finite element analysis can be applied for the problems by eliminating the complex experimental analysis for the further models. A three dimensional analysis based of solid45 element is used in the problem.

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