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Analysis of Stiffened Concrete Filled Single and Double Skinned Thin Walled Steel Tubular Column

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ABSTRACT: Concrete filled steel tubular (CFST) members comprise of a steel hollow section of circular or rectangular shape filled with plain or reinforced concrete. They are widely used in high-rise and multi-storey buildings as columns and beam-columns, and as beams in low-rise industrial buildings where a robust and efficient structural system is required. The objective is to validate the Analytical results obtained by using ANSYS software with the Experimental results, evaluate the Compression effect of concrete filled steel tubular columns, observe the behaviours of the confined and unconfined concrete columns subjected to axial loading, understand the behaviour of stiffeners in confined columns, compare the compression effect with conventional columns, & Evaluating the stress – strain & deflection curve for confined and unconfined specimens.

KEYWORDS:Concrete filled steel tubes, Hollow steel tube, Single skinnedsteel tube, Double skinned steel tube.

I. INTRODUCTION

Concrete filled steel tubular (CFST) members utilize the advantages of both steel and concrete. They comprise of a steel hollow section of circular or rectangular shape filled with plain or reinforced concrete. They are widely used in high-rise and multistory buildings as columns and beam-columns, and as beams in low-rise industrial buildings where a robust and efficient structural system is required. There are a number of distinct advantages related to such structural systems in both terms of structural performance and construction sequence. The concrete core gives the greater contribution to resisting axial compression.

Since 1970, extensive investigations have verified that framing systems consisting of concrete-filled steel tube (CFT) columns have more benefits than ordinary reinforced concrete and steel systems, and as a result, this system has very frequently been utilized in the construction of middle- and high-rise buildings in Japan.

In recent days, due to the expansion of cities it is required to construct the high storey buildings. Composite buildings prove to be promising for multi storey building. As a result, composite columns have recently undergone increased usage throughout the world, which has been influenced by the improvement of high strength concrete enabling these columns to be considerably economized. Columns are designed toresist the majority of axial force by concrete alone can be further economized by the use of thin walled steel tube.

II. RELATED WORK

In 1961, Naka, Kato, et al., wrote the first technical paper on CFT in Japan. It discussed a circular CFT compression member used in a power transmission tower. In 1985, five general contractors and a steel manufacturer won the Japan‟s Ministry of Construction proposal competition for the construction of urban apartment houses in the 21st century. Since then, these industries and the Building Research Institute (BRI) of the Ministry of Construction

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started a five-year experimental research project called New Urban Housing Project (NUHP), Research findings obtained from this project formed present design recommendations for the CFT column system.

[1] PanduRangaKirankumar.T, 2016 did a comparative Study of Concrete Filled Steel Tube Columns under Axial Compression. The study discusses about the behaviour of the composite column and various codal provisions. Experimental research carried out by comparative study between experimental results and analytical results for hollow steel tube (HST) and concrete filled steel tubes (CFST) under axial compression. To compare the experimental results of CFST with AISC-LRFD 2005 and Eurocode-4 is used. The investigation is carried out on HST & CFST specimens of Rectangular cross section with three different

[2] Shankar Jagadesh, 2014 conducted a study about the behaviour and the characteristics of CFST columns are the prime need of the hour. This paper presents the innovative experimental investigations conducted on CFST columns and the load deflection response characteristics of columns are also addressed. A comprehensive summary of various analytical and numerical studies on modelling of CFST members is portrayed in this paper. The design specifications and standards by AIJ, Eurocode-4, ANSI/AISC and AIK are addressed.

[3] Lin-Hai Han, Wei Li, ReidarBjorhovde, 2013 conducted an experimental study on the development of the family of concrete-filled steel tubular structures to date and draws a research framework on CFST members. The research development on CFST structural members in most recent years, particularly in China, is summarized and discussed. The current design approaches from various countries are examined briefly. Some projects in China utilizing CFST members are also introduced. Finally, some concluding remarks are made for CFST members.

[4] BaoChun Chen, 2009 performed study on present situation of concrete filled steel tube (CFST) arch bridges in China. More than 200 CFST arch bridges were investigated and analysed based on the factors of type, span, erection method, geometric parameters, and material. Some key issues in design calculation were presented, such as check of strength, calculation of section stiffness, and joint fatigue strength. It will provide a comprehensive reference of CFST arch bridges for the bridge designers and builders.

III. SCOPE

The scope of this study is to make valuable changes in the strength of the column by simple methods. Also itwill help in the practical applications of using Stiffened concrete filled steel tubes in various structural works.The present study can be extended to include cases of other types of loading. More complicated type of CFST specimens with various cross sections can be tried. Scope for future study based on varying the shape of Stiffeners andaltering the confinement is possible.The work can be extended to study the behaviour of cyclically loaded CFST beams

IV. MODEL

In this paper,10 models were created and analysed in ANSYS software to determine the axial capacity and failure modes of these models and to compare them with the others. The top and bottom surfaces of the concrete – filled steel tube circular columns were fixed against all degrees of freedom except for the displacement at the loaded end, which is the top surface, in the direction of the applied load. This was done using remote displacement support for the top surface and fixed support for the bottom surface.For all the specimens, the grade of concrete (M20) and steel (Fe315) are same.

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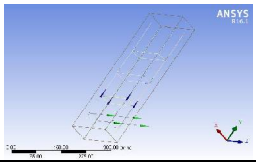
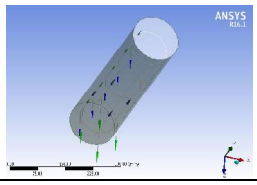
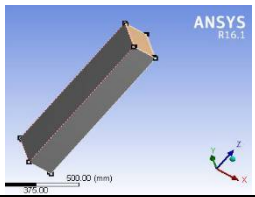
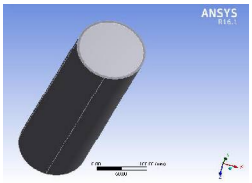
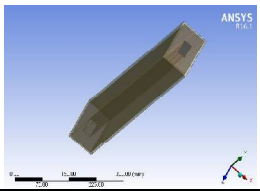
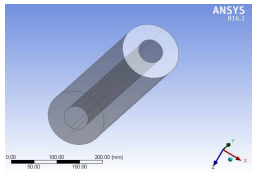
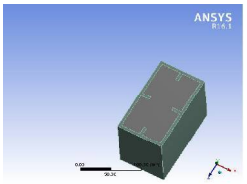
Table 1 The ANSYS models used for the paper

SL NO:	MODEL NAME	SPECIFICATIONS	ANSYS MODEL
1	Conventional rectangular column	B = 82 mm, D = 145 mm, L = 500 mm 10mm dia 4 main bars and 6mm dia ties at 100mm c/c.	
2	Conventional Circular column	D = 139.7 mm, H = 500 mm 10mm dia 4 main bars and 6mm dia ties at 100mm c/c	
3	Single skinned Rectangular column	B = 82 mm, D = 145 mm, L = 500 mm Thickness of Steel tube= 4.8 mm	
4	Single skinned Circular column	D = 139.7 mm, H = 500 mm, Thickness of steel tube = 4.8 mm.	
5	Double skinned Rectangular column confinement	Thickness of steel tube = 4.8mm Outer Steel skin B=82mm, D=145mm, H=500mm Inner Steel skin B=25mm, D=50mm, H=500mm	
6	Double skinned Circular column	Thickness of steel tube = 4.8mm Outer Steel skin D=139.7 mm, H=500mm Inner Steel skin D=55.8 mm, H=500mm	
7	Stiffened single skinned Rectangular column	Thickness of steel section = 4.8 mm B = 82 mm, D =145 mm, H = 500 mm Stiffener dimension = 15x5x500 mm	

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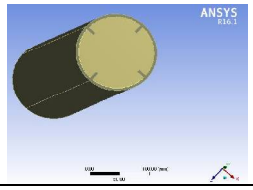
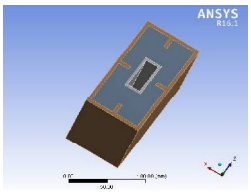
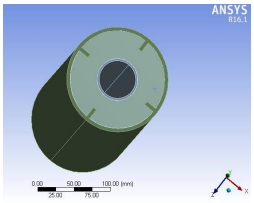
8	Stiffened single skinned Circular column	D = 139.7 mm, H = 500 mm, T = 4.8 mm Stiffener dimension =15x5x500 mm	
9	Stiffened Double skinned Rectangular column	Thickness of steel tube = 4.8mm Outer Steel skin B=82mm, D=145mm, H=500mm Inner Steel skin B=25mm, D=50mm, H=500mm Stiffener dimension =7.5x5x500 mm	
10	Stiffened Double skinned Circular column	Thickness of steel tube = 4.8mm Outer Steel skin D= 139.7 mm, H=500mm Inner Steel skin D= 55.8 mm, H=500mm Stiffener dimension =7.5x5x500 mm	

V. RESULTS

The CFST specimens were analysed using finite element analysis in ANSYS workbench. The results of the finite element analysis are included in this chapter.After analysing the specimens, the deformations at each and every load were obtained from ANSYS. Non-linear analysis was carried out for all the specimens.
The ultimate load carrying capacity of the various specimens from the analysis is indicated in Table 2. The length of specimen is 500 mm and the thickness of steel tube is taken as 4.8 mm for every models.

Table 2 Ultimate Compressive strength of columns

SL NO:	SPECIMEN	DIMENSIONS (mm)						DIMENSION OF STIFFENERS IF USED (mm)	COMP. STRENGTH (kN)
		BREADTH		DEPTH		DIAMETER			
		Outer skin (B1)	Inner skin (B2)	Outer skin (D1)	Inner skin (D2)	Outer skin (d1)	Inner skin (d2)		
1	Conventional rectangular	82	-	145	-	-	-	-	256.93
2	Conventional circular	-	-	-	-	139.7	-	-	346.78
3	Single skinned Rectangular	82	-	145	-	-	-	-	851.71
4	Single skinned Circular	-	-	-	-	139.7	-	-	911.93

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5	Double skinned Rectangular	82	25	145	50	-	-	-	982.91
6	Double skinned Circular	-	-	-	-	139.7	55.8	-	1013.5
7	Stiffened single skinned Rectangular	82	-	145	-	-	-	15*5*500	941.02
8	Stiffened single skinned Circular	-	-	-	-	139.7	-	15*5*500	1015.20
9	Stiffened double skinned Rectangular	82	25	145	50	-	-	7.5*5*500	1052.70
10	Stiffened double skinned Circular`	-	-	-	-	139.7	55.8	7.5*5*500	1111.90

Here we tested 10 specimens for determining their axial load carrying capacity. We selected two different cross section of rectangular and circular. The cross section dimension of circular column is taken from IS-1161, which deals with hollow steel tube section. At first we modelled and analysed a conventional rectangular and a circular column. The conventional rectangular column has an axial compressive strength of 256.93kN and for conventional circular column the axial compressive strength is 346.78kN.The load deformation graphs for various specimens are shown in Fig.2

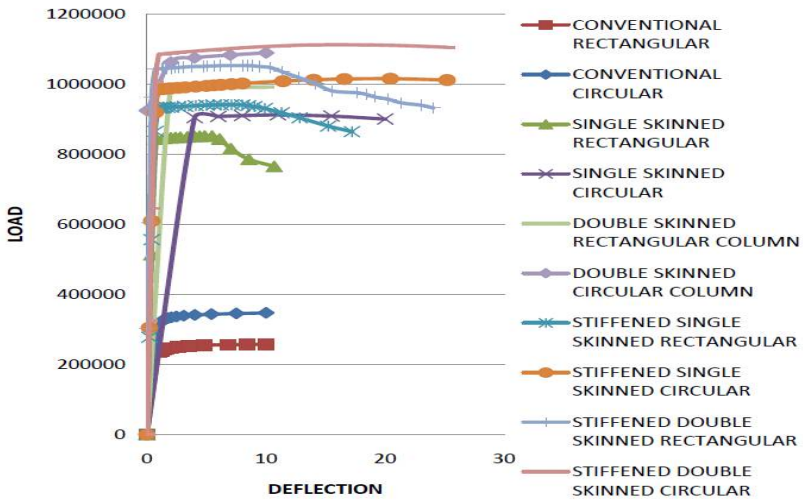

Fig 2 Load – deformation graph for all specimens

VI. CONCLUSION

The finite element analysis of stiffened concrete filled single and double skinned thin walled steel tubular column specimens were carried out for studying the ultimate load carrying capacity and behaviour. Ten different specimen models were analysed for this. A conventional column with rectangular and circular cross section was first modelled

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and analysed for validation. Then a circular and a rectangular column are modelled by providing outer skin only without providing conventional reinforcement and analysed. Then in addition to the outer skin, the specimen were analysed by providing an inner steel skin. Then the test is repeated by providing Stiffeners inside the column throughout the length and analysed for all the cases.

When the stiffened double skinned Rectangular column is compared with conventional Rectangular one , the compressive strength is increased by 309.72 %. When the stiffened double skinned circular column is compared with conventional circular one , the compressive strength is increased by 297.79 %. It is noticed that the rectangular column shows greater change than circular column when stiffener is used. Also when double skin is provided , it also increases the load carrying capacity well as compared to conventional specimens.

The present study can be extended to include cases of other types of loading.More complicated type of CFST specimens with various cross sections can be tried. Study based on varying the shape of Stiffeners in the CFST.Study based on altering the confinement. The work can be extended to study the behaviour of cyclically loaded CFST beams

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