Modal Analysis of CFST Using Ansys

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Abstract- *Concrete filled steel tubular (CFST) columns are widely used in construction of high-rise buildings and peers of bridges to increase the lateral stiffness of the buildings, the axial load capacity, ductility, toughness, and resistance of corrosion of the columns. The CFST columns have much superior characteristics compared with traditionally reinforced concrete columns. The position of the concrete and steel tube in the cross-section of the CFST column is the most appropriate solution in terms of the strength and ductility. The steel tube, which is placed outside of the cross-section of the column, withstand the bending moment effectively. The concrete that is placed into the steel tube delay the local buckling of the steel tube and increase the axial load capacity of the column due to continually lateral confining. In this study, different shape of CFST column like rectangular and circular are modelled in ansys workbench 16.0 software as per code standard. Further it is compared dynamic response of the structure at different mode shapes.*

Keywords- Ansys work bench 16.0,Concrete filled steel tube

I. INTRODUCTION

1.1 GENERAL

Concrete filled steel tube is a composite material which is currently being increasingly used in the construction of buildings. The use of concrete-filled steel tubular beams in high rise buildings has become popular in recent years. Concrete filled steel tube beams can provide excellent seismic resistant structural properties such as high strength, high ductility and large energy absorption capacity.

In the present era, creation of infrastructure facilities for the development of a country is the most important task of Civil Engineers. A multi-storeyed building plays a vital role in the development of infrastructure facilities. In the light of construction of high rise buildings concrete filled steel tubes is one of such an innovative new building material, which can sustain worst combination of loads, with high stiffness and facilitating speeder construction and maintaining economy

The concrete-filled steel tube (CFST) column system has many advantages compared with the ordinary steel or the reinforced concrete system. One of the main advantages is the interaction between the steel tube and concrete: local buckling of the steel tube is delayed by the restraint of the concrete, and the strength of concrete is increased by the confining effect of the steel tube. Extensive research work has been done in Japan in the last 15 years, including the “New Urban Housing Project” and the “US-Japan Cooperative Earthquake Research Program,” in addition to the work done by individual universities and industries that presented at the annual meeting of the Architectural Institute of Japan (AIJ). This paper introduces the structural system and discusses advantages, research findings, and recent construction trends of the CFST column system in Japan. The paper also describes design recommendations for the design of compression members, beam-columns, and beam-to-column connections in the CFST column system

1.2. STRUCTURAL SYSTEM

Figure 1.2 and Figure 1.3 shows typical connections between a CFST column and H-shaped beams often used in Japan. The connection is fabricated by shop welding, and the beams are bolted to the brackets on-site. In the case of connections using inner and through-type diaphragms, the diaphragm plates are located inside the tube, and a hole is opened for concrete casting. A cast steel ring stiffener is used for a circular CFST column. In the case of a ring stiffener and an outer diaphragm, there is no object inside the tube to interfere with the smooth casting of the concrete. Concrete casting is usually done by Tremie tube or the pump-up method. High strength and ductility can be obtained in the CFST column system because of the advantages mentioned below. However, difficulty in properly compacting the concrete may create a weak point in the system, especially in the case of inner and through-type diaphragms where bleeding of the concrete beneath the diaphragm may produce a gap between the concrete and steel. There is currently no way to ensure compactness or to repair this deficiency. To compensate, high-quality concrete with a low water-content and a super plasticizer for enhanced workability is used in construction.

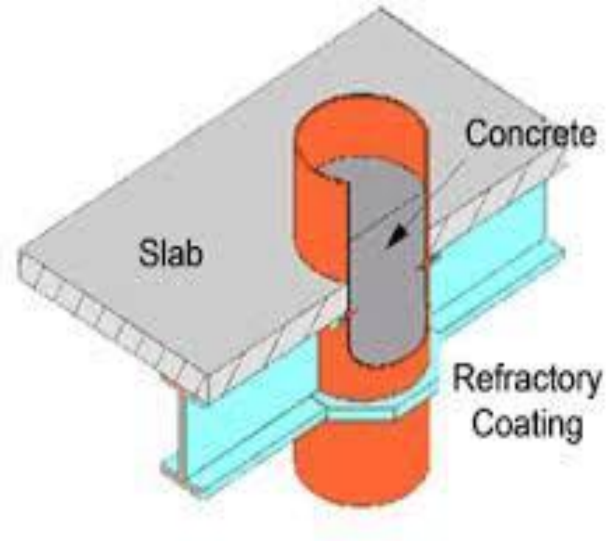

Fig.1.2Typical connections between a CFST column and H-shaped beams

1.3 ADVANTAGES OF CFST COLUMN

1.3.1 Advantages of Concrete Filled Steel Tube (CFST) Applied In Resident Buildings

1. **The frame-tube system is adopted**
   The RC elevators can be used as structure to resist the lateral loads. For official buildings the frame-shear structure system can be used also. In which the shear-walls or braces are set on the symmetrical positions of plan.
2. **Large span of columns (column's net) can be adopted** the span of columns includes two rooms even more. Then, the inside space can be arranged wantonly. The foundations are reduced with the reduction of columns, hence, the economic benefit will be more. Owing to the large span of columns, the vertical loads acting on columns are increased and the compressive bearing capacity of CFST columns can be bring into play sufficiently.
3. **The span of frame beam is large**
   The span of frame beam reaches 7~8m even more. Hence, steel beams should be used, but it should toke welding I-beam for save steel and construction cost. The SRC beams can be adopted also.
4. **Story structure system**
   As mentioned above, the span of story beams is 7~8m always, even reaches to 10m. Hence, the story structure system may be as following kinds.

a) Composite steel story system as shown in Fig. 5.

b) Steel beam with pre-stressed RC plate the pre-stressed RC plate is set on the steel beam, and then pours RC deck with ~110mm thickness on it.

c) Two direction dense ribs story structure As shown in Fig. 6. SRC beams are used for two direction beams, hence, this type of story structure system is conveniently for construction and the cost can be cheaper.

d) Pre-stressed RC story structures system This story structure system is composed of pre-stressed RC beams without adhesion and RC plate. This type of story structure system is more complexly.

e) The dimension of CFST column is nearly with the outline dimension of steel column. Hence, the space occupied by CFST column does not more than that of steel column. As everyone knows, the volume of core concrete of CFST column is about 10% of total volume of column. And the density of concrete is one third of the density of steel. Then, the weight of CFST column does not more than that of steel column.

f) The seismic, corrosion and fire resistant behaviors of CFST column are better than that of steel column.

Fig. no1.4 Composite steel story system

Fig. no.1.5 Two direction dense ribs story system

1.4 LIMITATIONS OF CONCRETE-FILLED STEEL TUBES

A primary deterrent to widespread use of CFSTs is the limited knowledge regarding their behavior. A number of factors complicate the analysis and design of concrete-filled steel tubes. A CFST member contains two materials with different stress-strain curves and distinctly different behavior. The interaction of the two materials poses a difficult problem in the determination of combined properties such as moment of inertia and modulus of elasticity. The failure mechanism depends largely on the shape, length, diameter, steel tube thickness, and concrete and steel strengths. Parameters such as bond, concrete confinement, residual stresses, creep, shrinkage, and type of loading also have an effect on the CFST's behavior. Axially loaded columns and, in more recent years, CFST beam-columns and connections, have been studied worldwide and to some extent many of the aforementioned issues have been reconciled for these types of members. However, researchers are still studying topics such as the effect of bond, confinement, local buckling, scale effect, and fire on CFST member strength,load transfer mechanisms and economical detailing strategies at beam-to-CFST column connections, and categorization of response in CFSTs and their connections at all levels of loading so as to facilitate the development of performance-based seismic design provisions. It should also be noted that, despite a recent increase in the number of full-scale experiments, the majority of the tests to date have been conducted on relatively small specimens, often 6 inches in diameter or smaller. This is due to the load limits of the testing apparatus and the need to run the tests economically.

1.5OBJECTIVES OF STUDIES

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1. To Prepare the geometry of CFST columns using Solid Works and then linking them to ANSYS to perform the rest of modal analysis.
2. To Compare the circularCFST column section with rectangular CFST using mild steel and Duplex stainless steel
3. To study natural frequency, Mode shape of CFST columns having different geometry.
4. To compare the vibrations of Circular and Rectangular CFST section.

II. MATERIAL PROPERTIES

Table2a.properties of materials used

Sr.No.	Material	Property	Value
1	Concrete	Compressive strength fsc(MPa)	30
2	Structural steel	Yield strengthf_{sy}(MPa)	275
		Ultimate Tensile strength f_{su}(MPa)	410
		Young's modulus Es(MPa)	200×10^3
		Poisson's ratio µ	0.3
		Ultimate tensile strain et	0.25
3	Duplex steel	Yield strengthf_{sy}(MPa)	435
		Ultimate Tensile strength f_{su} (MPa)	530
		Young's modulus E_s(MPa)	200×10^3
		Poisson's ratio µ	0.31
		density	7.8

III. RESULT AND DISCUSSION

Modal Analysis:-

Modal Analysis of circular CFST and rectangular CFST section having same quantity of material using conventional as well as duplex steel is performed to compare the different mode shapes and natural frequencies,

Mechanical properties of duplex steel like Poissons ratio -0.31, Tensile strength – 530 MPa, Density 7.8 gm./cm3 are inserted. Boundary condition one end fixed and other free support is used. For that mode shape vs. natural frequency bar chartis drawn compered. Results obtained are as below.

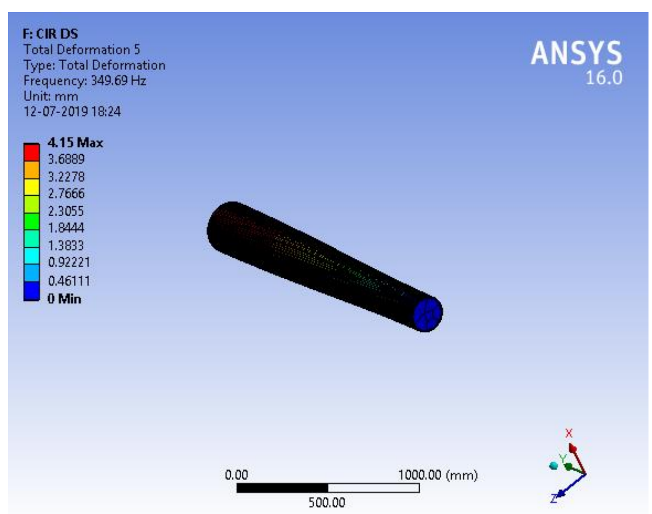

Fig. Mode shape 5 of circular DS CFST

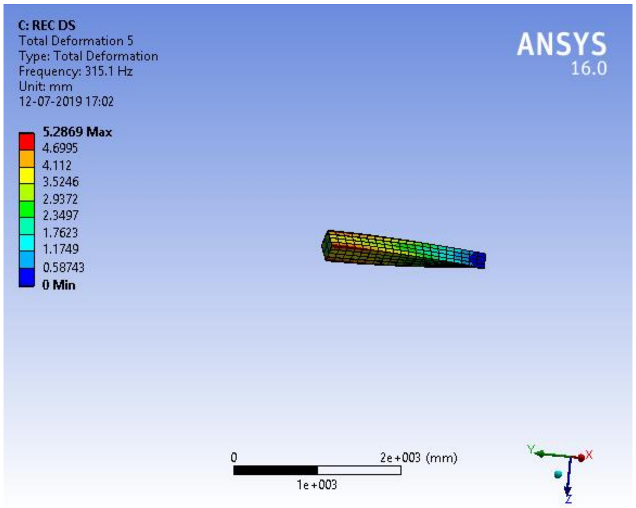

Fig. Mode shape 5 of rectangular DS CFST

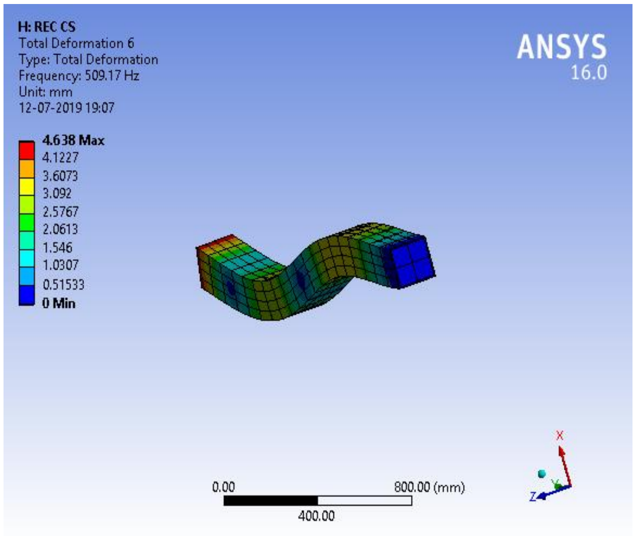

Fig. Mode shape 5 of rectangular CS CFST

Table No. Natural Frequencyof circular and rectangular CFST

Natural Frequencies				
	Rectangular Column		Circular Column	
Mode Shape	CS	DS	CS	DS
1	32.075	32.085	33.659	33.671
2	33.737	33.748	33.723	33.735
3	192.79	192.84	201.56	201.61
4	202	202.05	201.91	201.97
5	315.87	315.1	350.57	349.69
6	509.17	509.25	520.43	520.66

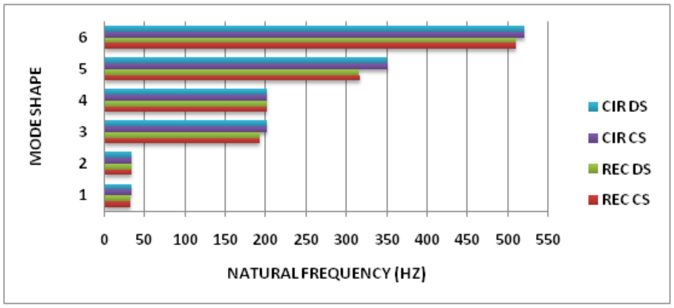

Figure No. 6.23 Natural Frequency vs. Mode shape Bar chart

VI. CONCLUSION

This study focuses on modelling of concrete filled steel tube (CFST) column having same mass of materials using several codes of practices; the Euro Standard (BS-EN1994-1-1-2004) and the American Standard (AISC).. Parametric study of 4 CFST columns was performed using finite element analysis with steel having different mechanical properties..

Further, Modal Analysis of circular CFST and rectangular CFST section using conventional as well as duplex steel is performed to compare the different mode shapes and following conclusions can be drawn,

- As shown in Fig 6.23 natural frequency of circular CFST is more than rectangular CFST Hence Vibrations are more in Circular CFST having same mass each
- Results shows that the rectangular CFST can withstand vibrations more reliably for different mode shapes.

REFERENCES

[1] J. C. McCormac, Structural Steel Design, 4th ed., pearson prentice hall, 2007.

[2] S. H. Abdalla, "BEHAVIOR OF CONCRETE FILLED STEEL TUBE (CFST) UNDER DIFFERENT LOADING CONDITIONS," American University of Sharjah, Sharjah, United Arab Emirates, 2012.

[3] Webb, J. and Peyton, J.J., "Composite concrete filled steel tube columns," in The Institution of Engineers Australian, Structural Engineering Conference, 1990.

[4] R. W. Furlong, "Strength of steel-encased concrete beam-columns," J. Struct. Div., ASCE, vol. 93, no. 5, pp. 113-124, 1967.

[5] Gardner, N. J., and Jacobson, E. R., "Structural behavior of concrete filled steel tubes," ACI J., vol. 64, no. 7, pp. 404-412, 1967.

[6] R. B. a. P. R. Knowles, "Strength of conrete-filled steel tubular columns," J. Struct. Div., ASCE, vol. 95, no. 12, pp. 2565-2587, 1969.
[7] M. Y. K. a. M. Y. Tomii, "Experimental studies on concrete filled steel tubular stub columns under concentric loading.," Proc., Int. Colloquium on Stability of Struct. Under Static and Dyn. Loads,, pp. 718-741, 1977.
[8] K. T. M. a. W. K. Sakino, "Sustaining load capacity of plain concrete stub columns by circular steel tubes," Proc., Int. Spec. Conf. on Concrete-Filled Steel Tubular Struct., pp. 112-118, 1985.
[9] E. Y. B. a. L. D. Ellobody, "Behaviour of normal and high strength concrete-filled compact steel tube circular stub columns," Journal of Constructional Steel Research, no. 62, pp. 706-715, 2006.
[10] Gupta, P. K., Sarda, S. M. and Kumar, M. S, "Experimental and computational study of concrete filled steel tubular columns under axial loads," Journal of Constructional Steel Research, no. 63, pp. 182-193, 2007.
[11] D. Lam and L. Gardner, "Structural design of stainless steel concrete filled columns," Journal of Constructional Steel Research, no. 64, pp. 1275-1282, 2008.
[12] J.Y. Richard Liew and D.X. Xiong, "Ultra-High Strength Concrete Filled Composite," Advances in Structural Engineering, vol. 15, no. 9, pp. 1487-1503, 2012.
[13] European Committee for Standardization, "Eurocode 4: Design of composite steel and concrete structures — Part 1-1: General rules and rules for buildings," in EUROPIAN STANDARD, vol. 4, BS EN 1994-1-1:2004, 2004, pp. 1-122.
[14] Buick Davison & Graham W. Owens, Steel Designers' Manual, 7th ed., Wiley-Backwel, 2012.
[15] European Committee for Standardization, "Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for building," in EUROPIAN STANDARD, BS EN 1993-1-1:2005, 2005, pp. 1-93
[16] Standards Australia Committee, Australian Standard - Steel Structures, Australia: Standards Australia, AS 4100-1998, 1998.