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Study of seismic behavior on multi-storied buildings with square composite columns

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Abstract— **The article studies seismic behavior of multi-storied buildings with two types of square composite columns. The main objective of this paper is to evaluate the comparison of square composite columns: concrete-filled steel (CFS) and concrete encased I section (CES). This paper is mainly emphasis on the structural behavior of multi-storied buildings for different plan configurations like rectangles, U shape, L shape, H-shape and irregular plan with two different columns property. It is also to compare and find which building with the composite column is more effective against lateral loads. The present work deals with the seismic behavior of 15 storey building assessed through dynamic analysis (response spectrum method) as per TCVN 9386:2012 for Vietnamese seismic area, using ETABS 2016 software. The results are tabulated, compared and final conclusions are framed. From the output of ETABS, various results are obtained. And these results are evaluated by preparing various graphs.**

Index Terms— **Composite column, Concrete filled steel, Concrete encased I section, seismic load.**

I. INTRODUCTION

Multi-storey buildings are designed with conventional reinforced concrete structure, structural members are very large, heavy, expensive and reducing usable spaces. In recent times, the composite columns are gaining popularity for use in multi-storey buildings by virtue of their excellent static and earthquake resistant properties such as lower mass, high strength, rigidity and stiffness, significantly high toughness and ductility, large energy dissipation capacity. Due to these reasons, composite members are gaining importance for the making of sky-scrapers and especially for high rise structures of seismic regions in the world [1].Composite members utilize the advantages of both steel and concrete. These essentially different materials are completely compatible and complementary to each other, they have almost the same thermal expansion, they have an ideal combination of strengths with concrete efficient in compression and the steel in tension, concrete also gives corrosion protection and thermal insulation to the steel at elevated temperatures and additionally can restrain slender steel sections from local or lateral-torsional buckling A steel-concrete composite column is a compression member, comprising either a concrete encased hot-rolled steel section or a concrete-filled a tubular section of hot-rolled steel and is generally used as a load-bearing member in a composite framed structure. Concrete filled steel tubular members comprise of a steel hollow section of circular shape filled with concrete. Due to excellent static and earthquake resistant properties of concrete-filled steel tubular, they are being used widely in real civil engineering projects. They possess properties such as high strength, high ductility and large energy absorption capacity [2]-[6]. Concrete-encased steel columns have the large load-carrying capacity and high local stability due to composite action, and high-strength materials improve structural safety and space efficiency [7].

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Currently, buildings have very diverse shapes. The shape of the buildings has a great influence on structural behavior, especially buildings subjected to earthquake loads, so designers need to consider carefully [8]-[10].

In other countries and Vietnam, there is a lot of research about the concrete-filled tubular section and concrete encased steel columns [11]. But there are no studies of multi-storey buildings subjected to earthquake loads that use square composite columns. Therefore, the main purpose of the author is to study the structural behavior of multi-storey buildings for different plans with two types of square composite columns subjected to earthquake load.

II. PROPOSED METHOD

A. ETABS 2016 software

ETABS is a program for linear, nonlinear, static and dynamic analysis, and the design of building systems. The input, output and numerical solution techniques of ETABS are specifically designed to take advantage of the unique physical and numerical characteristics associated with building type structures. As a result, this analysis and design tool expedites data preparation, output interpretation, and execution throughput.

B. Modelling of Building

Here the study is carried out for the behavior of 15 storey R.C frame buildings with rectangular, L shape, C shape, H shape, and irregular plans. And also, properties are defined for the frame structure. 10 models have created in ETABS 2016 software with concrete filled steel (CFS) columns and concrete encased steel I section (CES) columns in different plans. This paper analysis of the structure, time period, maximum storey drift, overturning and maximum storey displacement are computed and then compared for all the analyzed cases.

Modeling of RCC frames includes an RCC framed structure is basically an assembly of slabs, beams, columns, and foundation interconnected to each other as a unit. The load transfer mechanism in these structures is from slabs to beams, from beams to columns, and then ultimately from columns to the foundation, which in turn passes the load to the soil. In this structural analysis study, we have adopted cases by assuming different shapes for the same structure, as explained below.

1.Rectangular plan
2.L-shape plan
3.H-shape plan
4.C-shape plan
5. Irregular plan

The Building is 35m x 25m in plan with columns spaced at 5m from the center to center. A floor to floor height of 3m is assumed. The total height of the structure is 45m. The following models are created on ETAB 2016, plan and 3d view of rectangular, L shape, C shape, H shape buildings, irregular plan are given below.

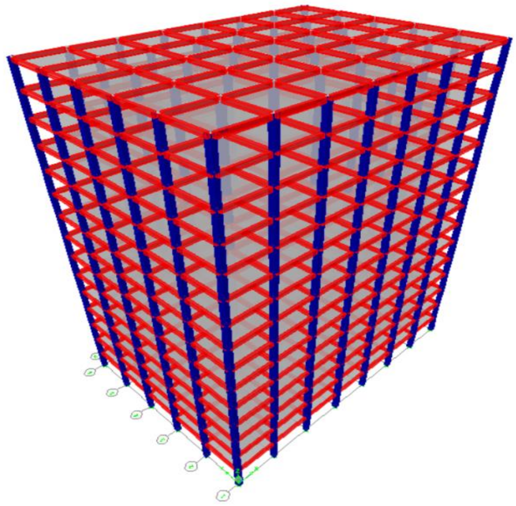


Figure 1.3D view of rectangular building

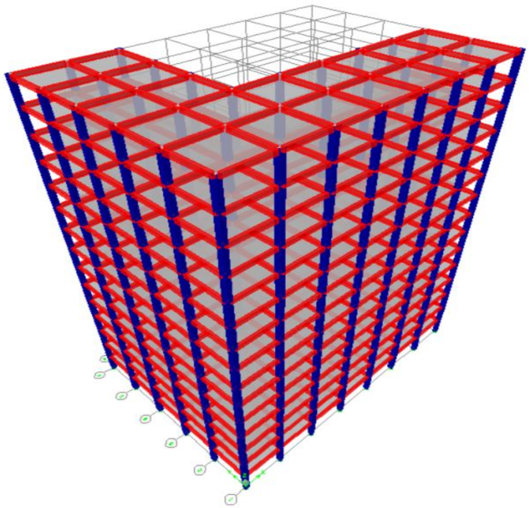


Figure 2.3D view of L shape building

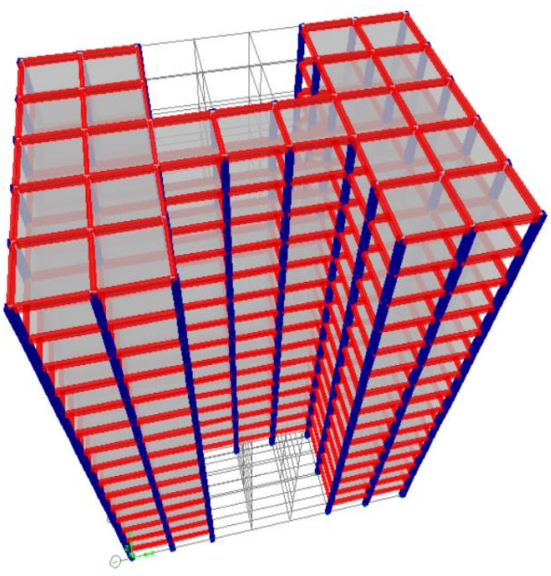


Figure 3.3D view of H shape building

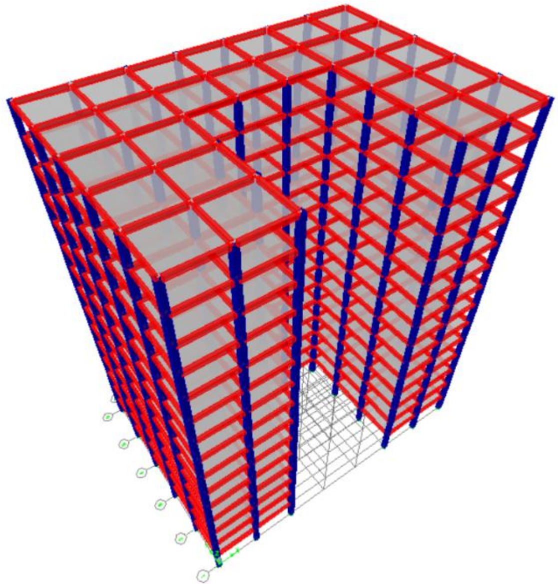


Figure 4.3D view of U shape building

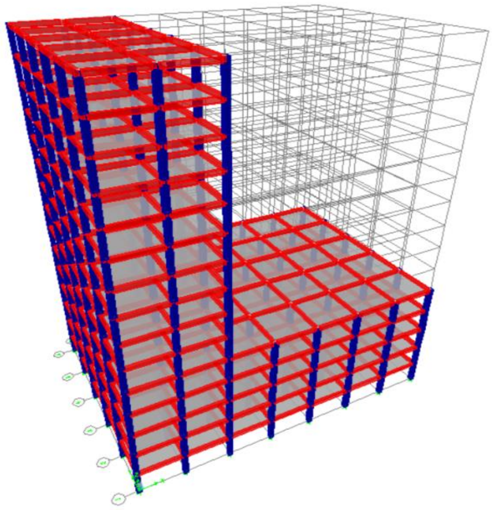
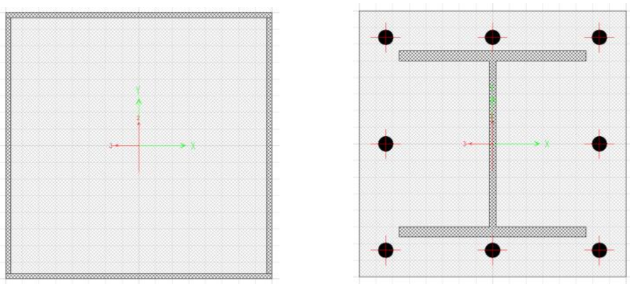


Figure 5.3D view of irregular building

Each type of building plans uses 2 types of square columns CFS (concrete filled steel), CES (concrete encased steel I section). Steel and concrete section of 2 column types were equivalent.



a) (b)

Figure 6. Filled concrete
a) Concrete filled steel
b) Concrete encased steel I section

C. Response Spectrum Analysis

The response spectrum represents an envelope of upper bound responses, based on several different ground motion records. For the purpose of seismic analysis, the design spectrum given in Vietnamese standards is used. This spectrum is based on strong motion records of Vietnamese earthquakes. This method is an elastic dynamic analysis approach that relies on the assumption that dynamic response of the structure may be found by considering the independent response of each natural mode of vibration and then combining the response of each in the same way. This is advantageous in the fact that generally only a few of the lowest modes of vibration have significance while calculating moments, shear and deflections at different levels of the building.

Table I. Model parameters

Properties of building	Buildings with composite columns	
	CFS (Concrete filled steel)	CES (Concrete encased steel I section)
Vietnamese Standards		
Load standard	2737:1995	2737:1995
Seismic standard	9386:2012	9386:2012
Material properties		
Grade of concrete	B30	B30
Grade of reinforcing steel	XCT38	XCT38
Sectional properties		
Column type	Square	Square
Column size (mm) 500x500(mm)	Steel: t=10 Concrete: 480x480	I350x350x19x12; 8d28
Beam size (mm)	250x500	250x500
Slab thickness (mm)	120	120
Building details		
Number of bays in X direction	7	7
Number of bays in Y direction	5	5
Width of bays in X direction (m)	5	5
Width of bays in Y direction (m)	5	5
Height of storey (m)	3	3
Type of support	fixed	fixed
Lateral load (seismic load, wind load in Thai Nguyen, Vietnam)		
Dead load on each floor (KN/m^2)	1.6	1.6
Live load on each floor (KN/m^2)	3.6	3.6
Peak acceleration ag/g	0.0928	0.0928
Type of soil	B	B
Importance factor	1	1
Behavior factor	3.9	3.9
Wind area	IIB	IIB

III. COMPARISION OF RESULTS

A. Period

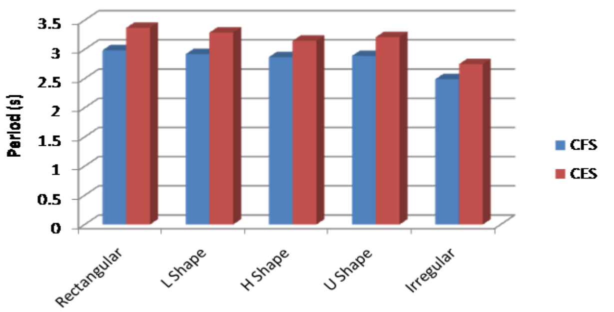


Figure 7. Period of buildings with CFS and CES columns

The time period reduces with the use of CFS column compared to CES column is shown in the above figure for each of the buildings. As the time period reduces the stiffness of the building increases because the time period is inversely proportional to the stiffness of the building.

B. Base shear

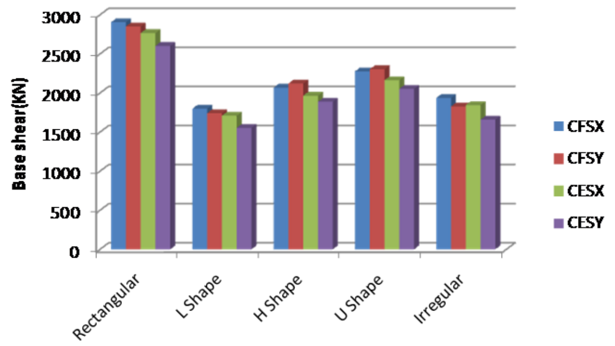


Figure 8. Base shear of buildings in X direction, Y direction with CFS and CES columns.

C. Storey Drift

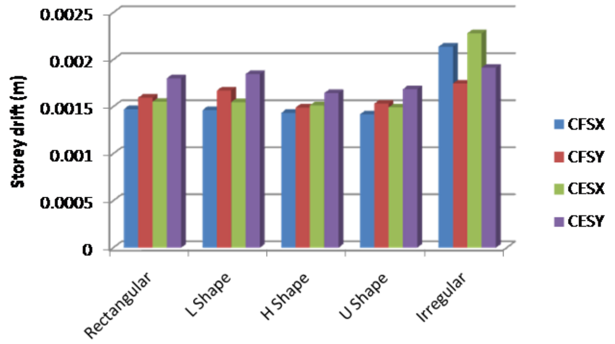


Figure 9. Storey Drift of buildings in X direction, Y direction with CFS and CES columns.

The storey drift is the relatively horizontal displacement of the adjacent two floors. Max storey drift value is shown in 2 directions X and Y. The storey drift were found to be lesser in case of CFS columns compared to CES columns.

D. Storey Displacement

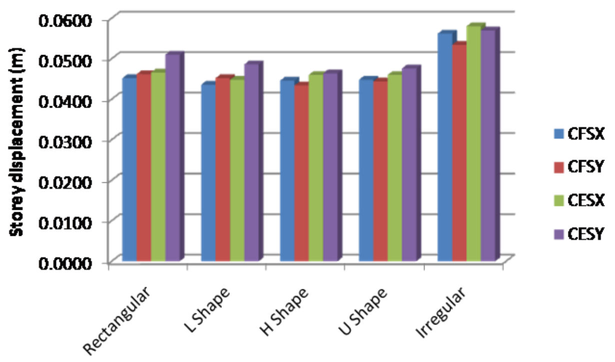


Figure 10. Storey Displacement of buildings in X direction, Y direction with CFS and CES columns.

The limiting displacement is always an important problem to ensure the durability and the normal working of the structure. Both X and Y directions, the storey displacements were found to be lesser in case of CFS columns compared to CES columns in all cases of different plans.

IV. CONCLUSION

In this present study the attempt is made to find which type of composite column is effective to resist the lateral deformation in a multi-storied building by response spectrum analysis. The time period, storey displacement and drift are plotted and compared for each of the model. The following conclusions are made based on analysis:

In case of rectangular building with CFS column the period reduced by 11.4%,the displacement reduced by 3% (X direction) and 9.4% (Y direction) and the storey drift reduced by 5.3% (X direction) and 12% (Y direction), the base shear increased by 3.88% (X direction) and 7.8% (Y direction) compared to CES column.

In case of L shape building with CFS column the period reduced by 11.2%, the displacement reduced by 2.7% (X direction) and 7% (Y direction) and the storey drift reduced by 5.8% (X direction) and 9.8% (Y direction), the base shear increased by 4.1% (X direction) and 10.3% (Y direction) compared to CES column.

In case of H shape building with CFS column the period reduced by 8.9%,the displacement reduced by 3.1% (X direction) and 6.5% (Y direction) and the storey drift reduced by 5.7% (X direction) and 9.6% (Y direction), the base shear increased by 4.2% (X direction) and 10.9% (Y direction) compared to CES column.

In case of U shape building with CFS column the period reduced by 10%,the displacement reduced by 2.6% (X direction) and 6.7% (Y direction) and the storey drift reduced by 5.3% (X direction) and 9.4% (Y direction), the base shear increased by 4.1% (X direction) and 10.9% (Y direction) compared to CES column.

In case of irregular building with CFS column the period reduced by 9.4%, the displacement reduced by 3.1% (X direction) and 6.3% (Y direction) and the storey drift reduced by 6.9% (X direction) and 8.8% (Y direction), the base shear increased by 3.9% (X direction) and 8.1% (Y direction) compared to CES column.

In all four parameters: the period, the storey displacement, the storey drift, and the base shear, there are 3 parameters of the model showed that CFS column is better than CES column. From the above analysis results, it was concluded that CFS columns performed well in all the above five cases compared to CES columns.

REFERECES

[1]. Pham Van Hoi, *Steel - concrete composite structure*, Science and Technics Publishing House, Ha Noi, 2006.

[2]. Phan Dinh Hao, Ngo Huu Cuong, Ngo Truong Lam Vu and Tran Huu Huy, "Nonlinear behavioral analysis of concreted steel pipe structure", *Ministry-level Scientific Research Project - Code*: B2010-TDA01-23-TRIG, 2012.

[3]. Faizulla Z. Shariff -Suma Devi, "Comparative Study on RCC and CFT Multi-Storeyed Buildings", *International Research Journal of Engineering and Technology*, Volume: 02 Issue: 03, pp.1812-1817, June-2015.

[4]. B. R. Asha and G. V. Sowjanya, "Comparison of Seismic Behaviour of a Typical Multi - Storey Structure With Composite Columns and Steel Columns," *Int. J. Civ. Struct. Eng. Res*., vol. 3, no. 1, pp. 360–367, 2015.

[5]. Shilpa Sara Kurian, Dinu Paulose, Sreepriya Mohan, "Study On Concrete Filled Steel Tube", *IOSR Journal of Mechanical and Civil Engineering (IOSR JMCE)*, e-ISSN: 2278-1684,p-ISSN: 2320-334X, pp. 25-33, 2016.

[6]. Truong Quang Vinh, *Analysis of concrete steel composite structure under fire conditions taking into account the heat recovery process*, Thesis for PhD, Ha Noi, 2018.

[7]. Hwang, H. J., Eom, T. S., Park, H. G., & Lee, S. H, "Axial load and cyclic load tests for composite columns with steel angles", *Journal of Structural Engineering*, 142(5), 04016001, 2016.

[8]. Abhay Guleria, "Structural Analysis of a Multi-Storeyed Building using ETABS for different Plan Configurations", *International Journal of Engineering Research & Technology*,(IJERT)ISSN: 2278-0181 IJERTV3IS051552, Vol. 3, Issue 5, pp.1481-1485, 2014.

[9]. Mazen AL-Bdoor, *Behavior of Composite columns subjected to Lateral cyclic loading*, Master of Science in Civil Engineering, Eastern Mediterranean University, July 2013.

[10]. S.Varadharajan, V.K. Sehgal, B.Saini, "Review of different Structural irregularities in buildings" *Journal of Structural Engineering*,Vol. 39, No. 5, pp.538-563, December 2012 - January 2013.

[11]. Sachin S, HR ShyamPrasad, " Study of seismic behavior on multi-storied buildings with composite column", *International Journal for Research in Applied Science & Engineering Technology (IJRASET), ISSN:2321-9653,* Vol. 6, Issue IV, pp.4779-4785, 2018.