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COMPARATIVE STUDY ON SEISMIC BEHAVIOUR OF MULTI-STORIED STRUCTURES WITH COMPOSITE COLUMN ON SLOPING GROUND

Parvathi c[1], Shyam Prasad H.R[2], Dr. H.J Puttabasave Gowda[3]

[1]PG student of PES College of Engineering, Mandya, Karnataka, India
[2]Assistant Professor of PES College of Engineering, Mandya, Karnataka, India
[3]Associative Professor of PES College of Engineering, Mandya, Karnataka, India

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Abstract - *Now days there is a shortage of plain ground due to urbanization & industrialization, construct the building on sloping ground .construction not easy as a plain ground. The behavior of building on sloping ground is asymmetric or irregular in lateral and vertical directions. The Building is more prone to be earthquake. The building must resist all the loads coming on it. To strengthen the building the lateral load resisting system like shear wall, core walls, bracing, composite column are adopted. Concrete Filled Steel Tubular member are more advantages in both steel and concrete. They are commonly used in high rise and multistory buildings used as columns and beam-columns. In present work deals with the fifteen storey building with 2 types of circular composite column such as Concrete Filled Steel Tube and Concrete Encased Steel tube in 0^0,10^0,20^0 sloping ground evaluated through dynamic analysis. As per IS 1893:2002 for seismic Zone IV and medium soil using ETABS-2015 software package.*

Key Words*: *Concrete Filled Steel tube, Encased I section column, regular and horizontal irregular buildings, E-TABS, Response Spectrum Analysis, natural time period and frequency, Storey displacement, storey drift, overturning moment.

1. INTRODUCTION

Now-a-days there is shortage of plain land to build structures in hilly area at faster developing cities; subsequently construction turned its face towards hilly areas. Behavior of structures on hilly areas is totally different to that of constructed on flat ground. The buildings in India are constructed in hilly area are more prone to be earthquake. The economic growth and rapid urbanization in hilly region has accelerated the real estate development. Due to this, Population density in the hilly region has increased expansively. With the use of RCC and the adoption of steel structures is generally restricted to industrial buildings, which have acquired importance to adopting composite structural elements. The most important and most frequently experience combination is steel and concrete with the application in multi-storey structure in commercial buildings factories, as well as in bridges. These materials can be used in composite structural systems. In case of composite structures where members consist of steel and concrete act together. These materials are completely consistent and complementary to each other. They have almost same thermal expansion in ideal combination of strengths with concrete well in order of compression and the steel in tension.

1.1 Composite column types

A steel and concrete composite columns it act as compression member it contain either a concrete encased hot-rolled steel section /concrete filled tubular section of hot-rolled steel and is regularly used as a load bearing member in composite framed structure. The load carrying capacity of composite columns is more than that of the bare reinforced column and the structural steel column included in the system.

Three different types of composite columns are in use, see bellow Figure

• Concrete-encased steel columns (A)

•Rolled section columns

Partly encased in concrete (B).

• CFST tubes (C and D)

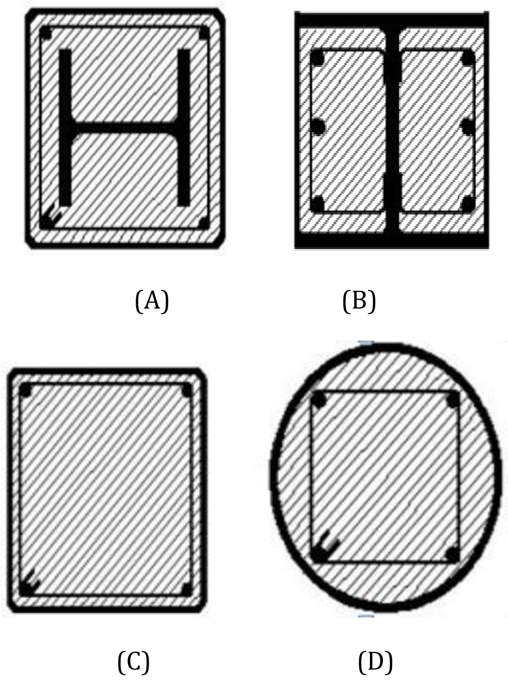

Fig1: Typical cross sections of composite column

2. LITERATURE REVIEW

2.1) **Vidhya Purushothaman** et al. (2017) presented on "**Comparative study on seismic analysis of multi-storied buildings with composite columns**" The objective of this paper is to evaluate the comparison of composite columns with concrete filled steel tube and composite encased I section column. This paper mainly emphasizes the structuralbehavior of the multi-story building for different plan configurations like Rectangular, C, L and H shape with two different column properties. It is also to compare and find which building with the composite column is more effective against lateral loads. Modeling of 15- story buildings are analyzed using ETABS 2015. The results are tabulated, compared and final conclusions are framed. From the outputs of ETABS, various results are obtained. And these results are evaluated by preparing various graphs.

2.2) Gem thomas1 et al. (2018) presented on "**Experimental study of RC framed building on sloping topography subjected to seismic forces".** Here considered a twelve storied bare frame (step back building) for experimental analysis. The sloping ground inclined at varying degrees like 0º, 27º and 40º. Different type of soil conditions like soft, medium and hard soils also considered for analysis. Then core wall is added to the structure followed by the infill wall for all sloping degrees and soil conditions. Modeling is done in ETABS software. Response spectrum analysis is carried out to know the response of the building and the results are compared in terms of story displacement, base shear, story drifts and fundamental time period and are tabulated.

2.3) **G Suresh1** et al. (2014) presented on "**Seismic Analysis of Buildings Resting on Sloping Ground and Considering Bracing System".** Most of the constructions in hilly regions are constrained by local topography which results in the adoption of either a step back/step back &set back configuration. Due to this the structure is irregular by virtue of varying column heights leading to torsion and increased shear during seismic Ground motion. The dynamic analysis is carried out using response spectrum method to the step back & step back &set back building frames. The dynamic response i.e. fundamental time period, storey displacement & drift, and base shear action induced in columns have been studied for buildings of different heights. These results show that the performance of step back & set back building frames are more suitable in comparison with step back building frames. But after considering bracings to the step back building frames, a better performance can be observed when compared with step back & set back building frame.

3. OBJECTIVE

The main objective of this study is

1) Compare the seismic behavior of the different types of building with composite column on sloping ground such as CFST and CES

2) The building such as square-shape, L-shape, C-shape and I-shape are used under medium soil and seismic zone IV.

3) To find the structural behavior of composite column, they are introducing in different types of building.

4) To study the behavior of building with composite column constructed on 0deg, 10 deg and 20deg under medium soil and seismic zone IV.

5) To study the different parameters such as fundamental time period and frequency, storey drifts, storey displacements, storey drift, overturning moment ext.

3.1 SCOPE OF THE STUDY

Main scope of the project is to study the behavior of multistoried structures with composite column on sloping ground. Composite column are having more strength and toughness than the RC structure under seismic .Then to study the behavior of composite columns on different elevation of ground under seismic load is very important. However, it is also important to study the behavior of different types of building with CFST & CES composite column.

4. METHODOLOGY

Methodology employed is response spectrum method in this project.

4.1 Building Plan Dimension Details

Here the study is carried out for behavior of 15 storey's regular, L-shape, C-Shape and I-Shape building with composite column are modeled on 0,10,20 deg sloping ground. The dimension of building is 36m x 36m model constructed using ETABS. 24 models are created in ETABS software. Such as 12 models with CFST and 12 models with CES composite columns in Square, L-shape, C-shape, I-shape building models on 0, 10, 20 deg sloping ground. The bottom storey height is 4.5m and other storey height is 3m.Total height of the building is 46.5m are constructed in 0^0,10^0,20^0 sloping ground the following figures are referred.

1. Rectangular Plan
2. L-shape plan
3. C-shape plan
4. I-shape plan

Properties of building in 0^0,10^0,20^0 sloping ground.	Buildings with composite columns	
	CFST(Concrete filled steel tube)	CES(Concrete encase I section)
Material property		
Grade of concrete	M_{30}	M_{30}

Grade of reinforcing steel	HYSD500	HYSD500
Unit weight of concrete	25 kN/m^2	25 kN/m^2
Sectional properties		
Column Type	Circular	Circular
Column size	D=600mm, t=10mm	D=600mm, t=10mm
Beam size	ISWB 550	ISWB 550
Wall thickness	230mm	230mm
RC slab	150mm	150mm
Building details		
No. of bays in X-direction	7	7
No. of bays in Y-direction	7	7
Width of bays in X-direction	6m	6m
Width of bays in Y-direction	6m	6m
Bottom storey height	4.5m	4.5m
Height of storey	3m	3m
Type of support	Fixed	Fixed
Seismic data		
Damping ratio	5%	5%
Earthquake zone	IV	IV
Poisson's ratio	0.15	
Response reduction factor	5(SMRF)	5(SMRF)
Type of soil	Medium	Medium
Importance factor	1.5	1.5

4.2 Models in ETABS

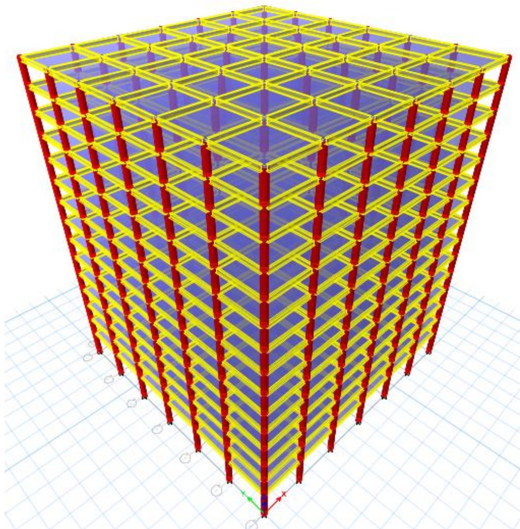

Fig 2: 3D View of Square-shape building on Flat ground

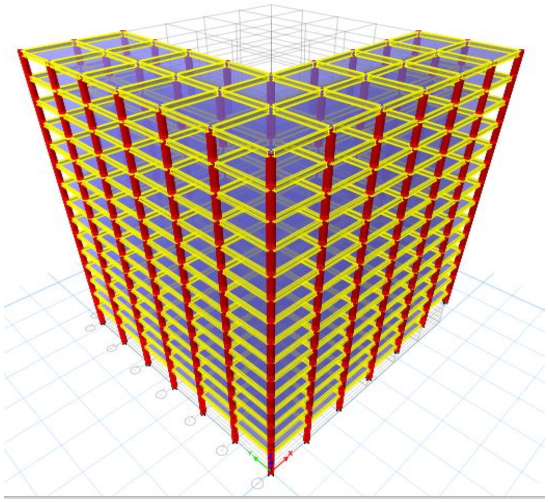

Fig 3: 3D View of L-shape building on10 deg Ground

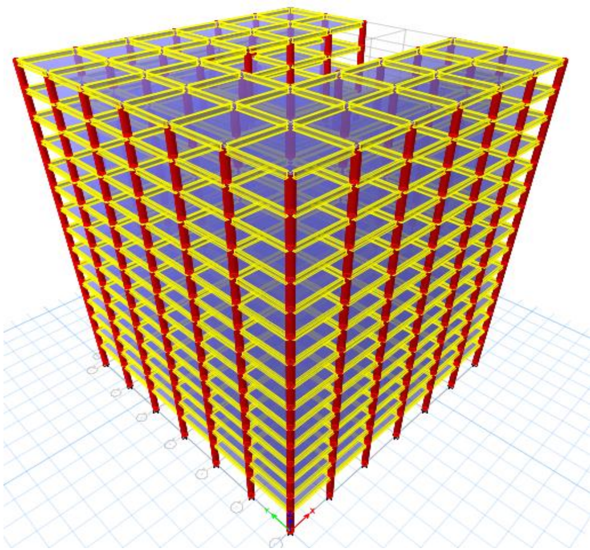

Fig 4: 3D View of C-shape building on Flat ground

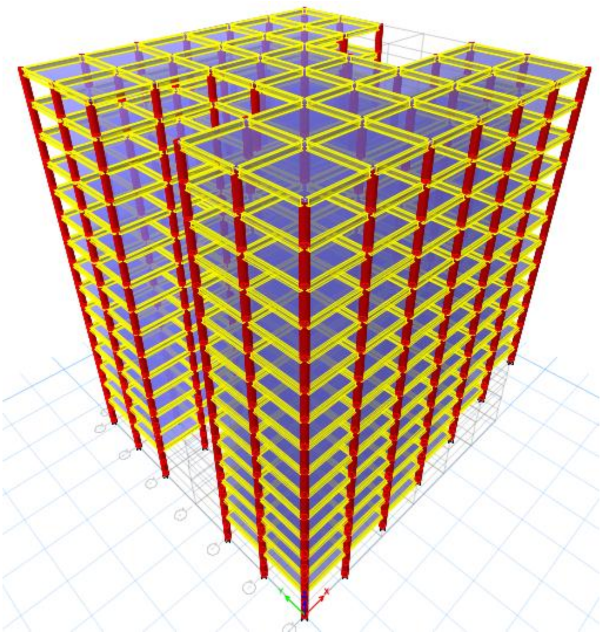

Fig 5: 3D View of I-shape building on 20 deg ground

5. RESULTS AND DISCUSSION

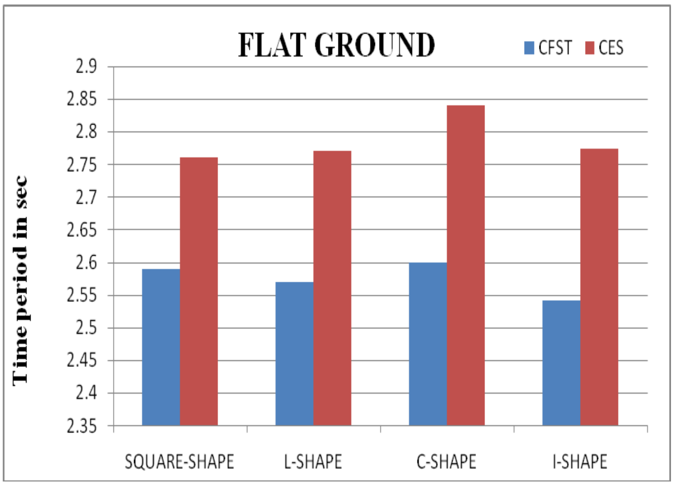

Fig 6: Compare the time period of CFST and CES column

Time period of Square, L-shape, C-shape and I-shape building with CFST and CES column on flat ground a shown in above figure. From the above fig shows more difference in CES and CFST column. I-shape with CFST column performed well, because time period is inversely proportional to stiffness.

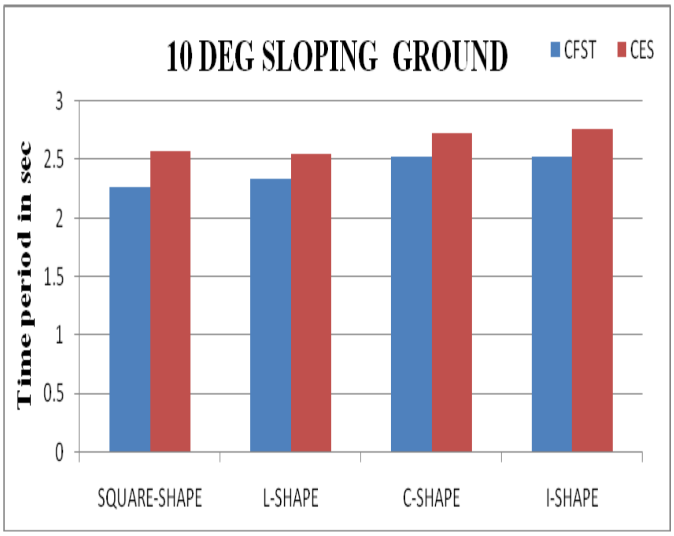

Fig7: Compare the time period of CFST and CES column on 10 deg slope

From the above graph, all building with CFST and CES column on sloping ground are shows no much difference. But compare entire structures, CFST column with Square shape building performed well.

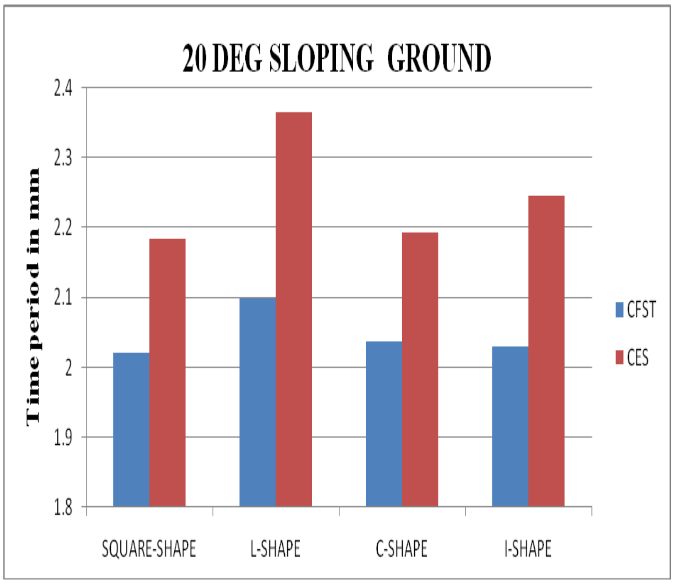

Fig 8: Compare the time period of CFST and CES column on 20 deg slope

From the above graph, all building with CFST and CES column on 20 deg sloping ground are shows more difference between CFST and CES column. Then compare time period of the entire structure, CFST column with Square shape building performed well.

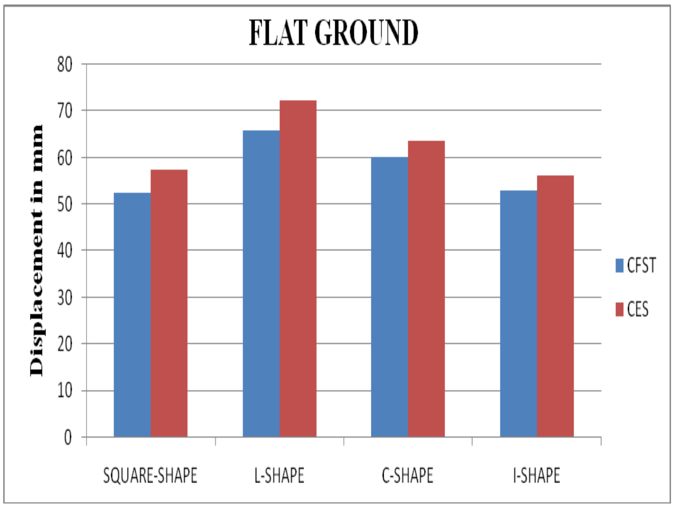

Fig 9: Compare the displacement of CFST and CES column on Flat ground.

From above L-shape with CFST & CES composite column having more displacement compare to others a shown in above. Displacement is inversely proportional to Stiffness, and then Square building with CFST column performed well.

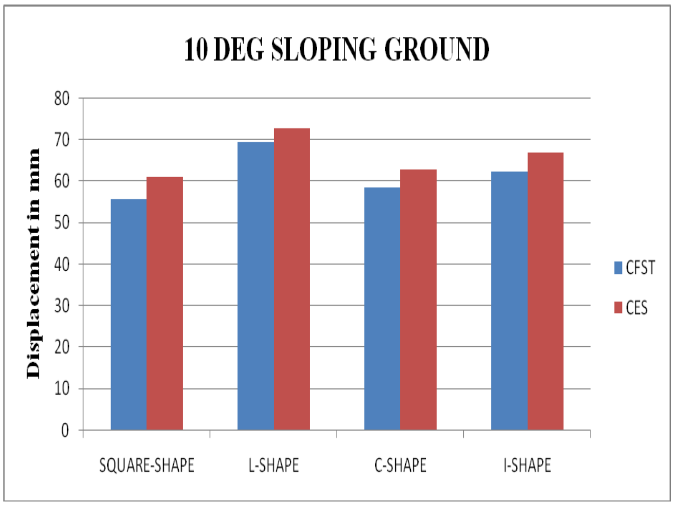

Fig10: Compare the displacement of CFST and CES column on 10 deg slope

From the above graph, all building with CFST and CES column on 10 deg sloping ground are shows no much difference. But compare displacement of all the structure, CFST column with Square shape building performed well.

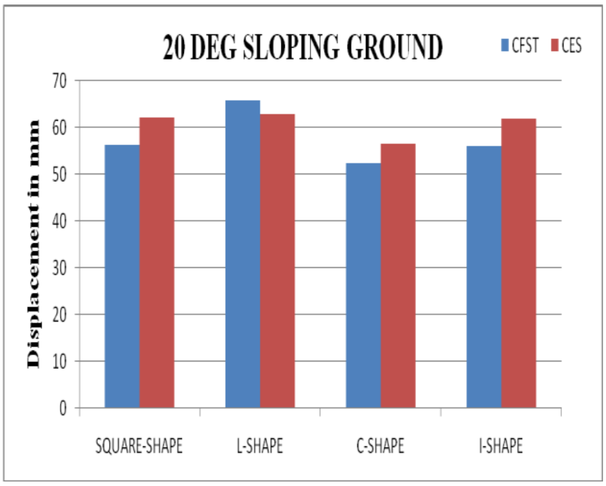

Fig 11: Compare the time period of CFST and CES column on 20 deg slope

From the above graph, all building displacement increase in CES than the CFST but in case of L-shape building opposite of all the building on 20 deg sloping ground are shows in above .no much difference between CFST & CES But compare displacement of all the structure, CFST column with C-shape building performed well.

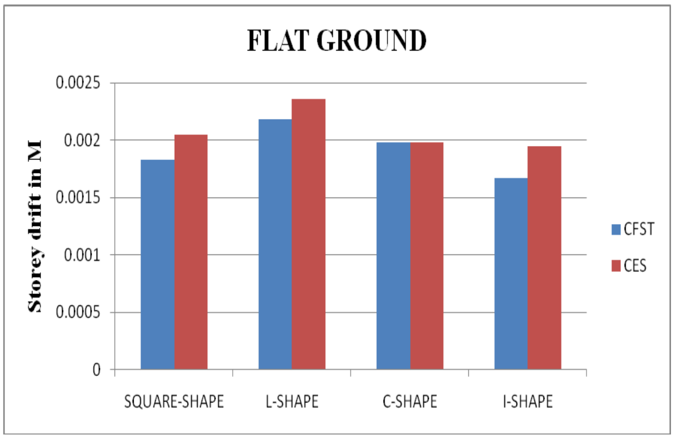

Fig 12: Compare the Storey drift of CFST and CES column on Flat ground

From the above graph all building with CFST and CES column on flat ground are shows no much difference in storey drift. But compare Drift of all the structure, CFST column with I-shape performed well. Because Storey drift inversely proportional to stability of building.

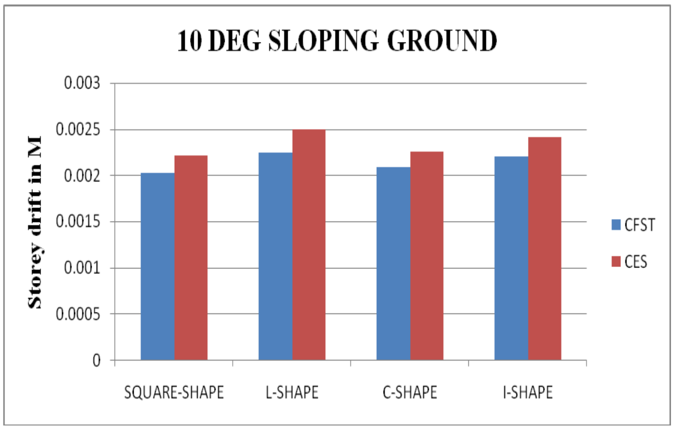

Fig 13: Compare the storey drift of CFST and CES column on 10 deg slope

From the above graph, Storey drift of all building with CFST and CES a shown above. Here compare Drift of all the structure, CFST column with Square-shape building performed well.

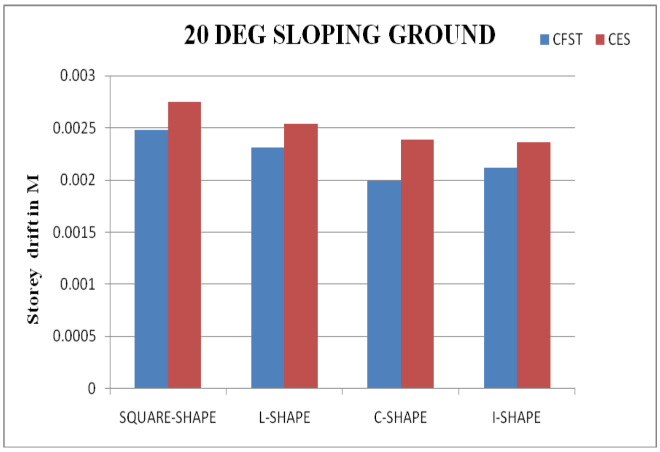

Fig 14: Compare the Storey drift of CFST and CES column on 20 deg slope

From the above graph Storey drift of all building with CFST and CES a shown above. Here compare Drift of all the structure, CFST column with C-shape building performed well

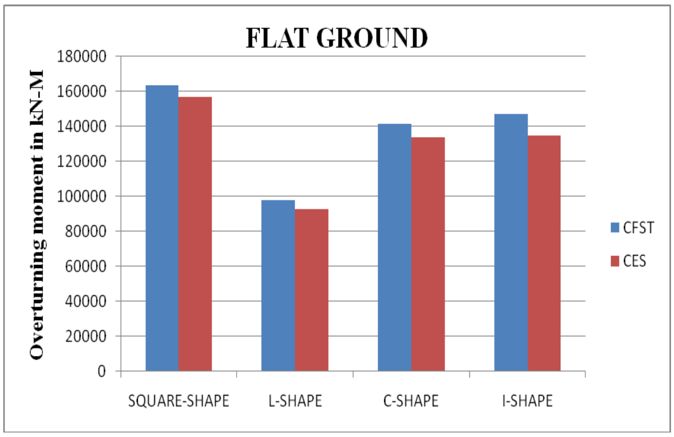

Fig 15: Compare the Overturning moment of CFST and CES column on Flat ground.

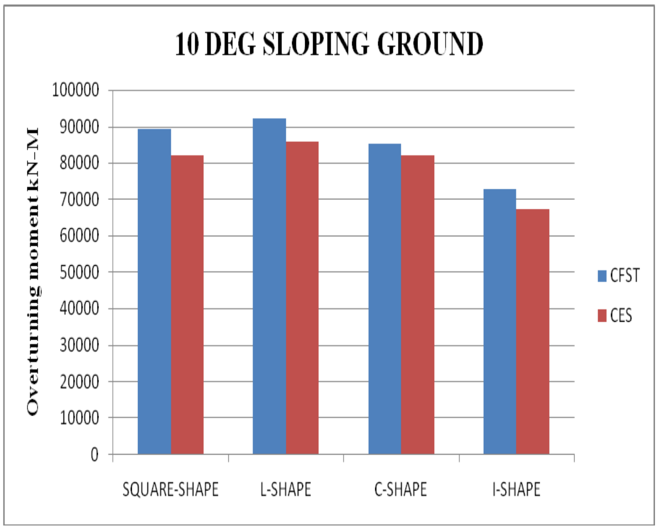

Fig 16: Compare the Overturning moment of CFST and CES column on 10 deg slope

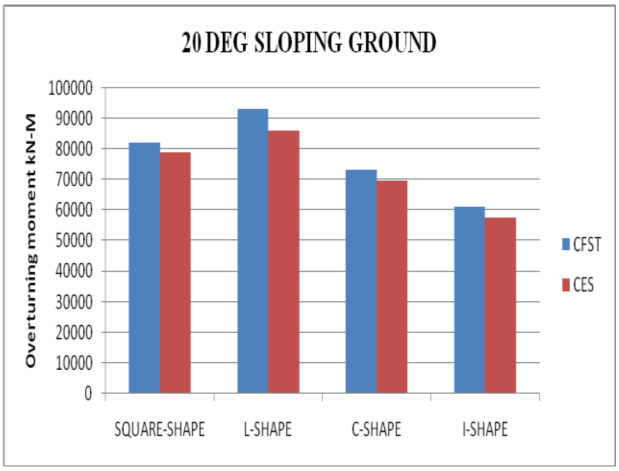

Fig 17: Compare the Overturning moment of CFST and CES column on 20 deg slope

Here compare overturning moment of all the structure on 0,10,20 deg ground, CES column having less overturning moment compare to CFST. Here L –shape in 0 deg, I-shape in 10 deg & I-shape in 20 deg sloping ground having more stable in above conditions.

6. CONCLUSIONS

1. The equivalent static analysis is not sufficient for high rise buildings and it is necessary to perform dynamic analysis (Response spectrum, time history).
2. The time period is inversely proportional to the stiffness of the structure; hence the model with CFST composite column is well & both column in case of I-shape in flat ground, square shape building on 10 & 20 deg.
3. The permissible limit for storey displacement is H/500, i.e. 93mm, all the models are within the limit.

4. Displacement is more in CES composite column but in case of L-shape building on 20deg sloping ground CFST column having more displacement.
5. The CES composite columns have higher global stability and resistance to buckling in respect to reduction in overturning moments.
6. Hence for both regular and horizontal irregular structure it is better to adopt CFST composite columns.
7. Composite structure is the best solution for high rise building on flat and sloping ground.

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