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COMPARATIVE STUDY OF A MULTI STOREY COMPLEX BUILDING WITH CFST COLUMNS

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ABSTRACT- From the last few decades, the use of concrete-filled steel tubular (CFST) columns has been very popular particularly Due to rapid on-going horizontal development and restricted vertical development of buildings has resulted in congestion of cities and shrinkage of agricultural land, particularly in high seismic zones. For vertical development, there is a need for the construction of buildings as high as possible. The restriction to the vertical development is due to the reason that high rise structures are more vulnerable to lateral loads acting on the building resulting from the seismic events. With a background in view, the current work studies the seismic responses of a multi-storey complex building with concrete-filled steel tube columns (CFST).
In the present study, three buildings with plan dimensions 35m x 30m of G+12 stories, with earthquake zone-V and soil type medium were modelled with varying columns types. The design and analysis were carried out using equivalent static method and response spectrum method as per IS-1893 2016. The total height of the building was taken as 42m with the height of each floor as 3.5m. The conclusion was made after studying parameters like Base Shear, Max. story displacement, Max. storey drift, Total Dead load of the structure, Max. time period, and Storey Shear. All the building models meet the allowable limit for safe design. It was concluded that the building with CFST columns has better resistance at high seismic zones and the cross-sectional dimensions required by building with CFST columns to pass the design check are lesser than the other types of columns.

KEYWORDS- Earthquake zones, multi-storey building, CFST columns, ETABS computer code program, complex buildings.

I. INTRODUCTION

Composite structure has gained fame in the current world due to its advantages of stiffness and strength. It has proposed the most economical solution to the various engineering problems and design requirements[1]. The use of composite members has become common practice for the construction of multi-storey buildings in many developing countries [2]. In European countries, the use of composite members is increasing particularly for high rise industrial buildings [3]. These composite structures mainly consist of concrete-filled steel tubular column sections supporting concrete encased beams or steel I-beams which intern supports the composite slab floor overlaid above those beams [4]. This is the most relevant economical solution for the buildings which are constructed in high seismic zones or buildings that require resistance towards earthquake loads. Another reason why these composite members perform so well in high seismic zones is there great ability to dissipate energy due to the high ductility of their composite members [5]. Compared to other developing countries the use of steel is very low in the construction industry. In the ongoing development in India, there is a need to increase the volume of steel in the construction industry [6].

II. LITERATURE REVIEW

Mahesh Suresh Kumawat and L G Kalurkar (2014) carried out a parametric study to compare RCC building and composite building with G+9, stories and plan dimensions of 24m x 36m, located in seismic Zone-III with hard soil type as per IS 1893-2016 classification. The overall height of the building was taken as 38.5m with the height of each floor as 3.5m. The bay spacing in both directions was taken as 6m. The buildings were modelled and analyzed using SAP-2000 software.

- Sunil DhananjayRathod and Swati Sham Bhokare (2016) carried out a study to compare various parameters of RCC, [6]steel and composite multi-storey building with G+11 stories and plan dimensions of 31m x 19m, located in seismic Zone-III and zone-V with medium soil type as per IS 1893-2016 classification. The overall height of the building was taken as 33.2m with the height of each floor as 3.0m[7]. Beam dimensions of 300mm x 650mm were taken for all buildings with varying column dimensions. All three buildings were analyzed using pushover analysis on ETABS along with linear, static and dynamic analysis[8].
- A. Sattainathan Sharma, R. AnjughapPriya, R. Thirugnanam (2016) conducted a study to compare a multi-storey framed building constructed by using Reinforced cement concrete another with composite material situated in seismic zone-IV as per IS 1893-2016 classification[9]. The plan dimension of the buildings has been taken as 30m x 24m with G+20 stories. The overall height of the building was taken as 60m with the height of each floor as 3.0m. The bay spacing was taken as 6m

in longitudinal direction and 4m in the transverse direction[10]. For RCC building the size of the beam was taken 300mm x 650mm and size of the column as 450mm x 1000mm and for composite building, the ISMB450 beam and concrete-filled steel tube column were used. The equivalent static method was utilized for seismic analysis as per IS 1893-2002 using SAP-2000 and E-tabs software[11].

- Asha B.R and Mrs. Sowjanya G.V (2015) carried out a study to investigate the seismic behaviour of building frames one with composite columns and another with steel columns. All the buildings have the same plan dimension of 40m x 30m with G+12 stories situated in seismic zone III and V with hard soil type as per IS 1893-2016 classification[5]. The spacing of bay in the longitudinal and transverse direction is 8m and 6m respectively. The building frame consists of 125mm RC slab and 250mm thick shear wall. Two types of ordinary moment-resisting frames were analyzed with varying column type i.e. Composite column of 480mm dia. and a 16mm thick hollow steel ring filled with concrete in one frame and steel column of 2 ISMB450 with ISMC400 on both top and bottom flanges are used in another frame[6].

III. METHODOLOGY

The methodology of this study is scheming the unstable effects caused by an earthquake in multi-storey buildings with composite & steel columns having constant build-up space with varying soil type. And additionally compared with totally different unstable zones as per IS 1893 (Part 1): 2002 codal provisions. The building model is made and analysed by ETABS package. The methodology concerned during this study is given below:

- Extensive literature survey by referring books, technical papers carried out to understand basic concept of topic.
- Selection of type of structures.
- Modelling of building on ETABS.
- Result and discussion.

IV. RESULTS

Table 1 shows the Time period of buildings.Figure 1 shows the variation of Dead weight of buildings.Figure 2 Shows Variation of maximum displacement of Building. Figure 3 Shows variation of maximum Time period of buildings.

Table-1 Showing the Time Period of buildings

Mode	BB-1	BB-2	BB-3	BB-4	BB-5
1	1.962	2.103	2.21	2.283	1.434
2	1.717	1.815	1.95	2.157	1.259
3	1.441	1.551	1.648	1.76	1.031
4	0.728	0.808	0.862	0.893	0.548
5	0.619	0.687	0.766	0.856	0.477
6	0.587	0.661	0.728	0.789	0.44
7	0.405	0.475	0.52	0.542	0.319
8	0.328	0.391	0.458	0.524	0.266
9	0.326	0.387	0.453	0.5	0.26
10	0.238	0.291	0.327	0.343	0.194
11	0.184	0.228	0.283	0.331	0.156
12	0.179	0.222	0.266	0.298	0.148
13	0.167	0.215	0.248	0.264	0.141
14	0.125	0.165	0.211	0.256	0.109
15	0.125	0.162	0.204	0.234	0.107
16	0.123	0.161	0.196	0.211	0.107
17	0.093	0.123	0.165	0.206	0.082
18	0.09	0.123	0.162	0.191	0.081
19	0.089	0.12	0.15	0.163	0.079
20	0.072	0.102	0.127	0.159	0.066

Models	Dead weight of building in kN	Maximum Time Period in Sec	Base Shear in kN	Max. Displacement in mm	Maximum Drift	Maximum Overturning moment kN-m
BB-1	56987.979	1.962	2053.8271	35.513	0.001336	32594.2307
BB-2	54577.8787	2.103	1882.2817	37.504	0.001426	30287.5617
BB-3	50187.625	2.21	1647.8173	39.402	0.001501	27263.687
BB-4	49108.3077	2.283	1466.8056	40.657	0.001551	24998.226
BB-5	50264.4333	1.434	2533.308	27.984	0.001068	43769.0458

Figure. 1: Shows variation of Dead weight of buildings

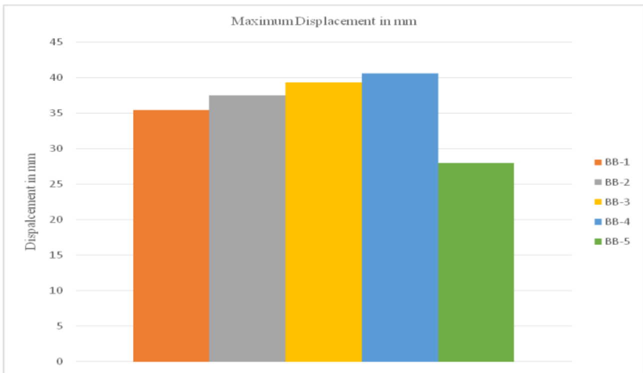

Figure. 2: Shows Variation of maximum displacement of building

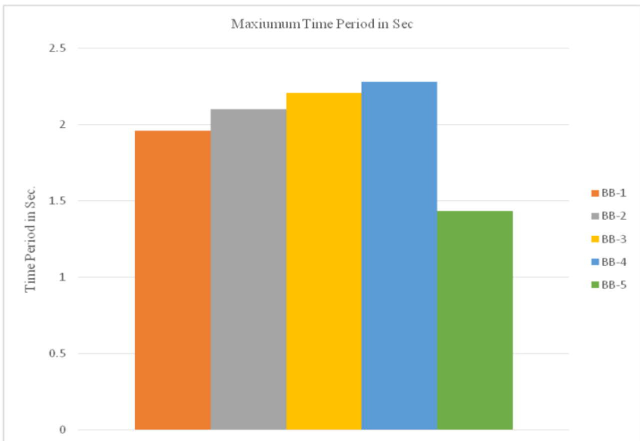

Figure. 3: Shows variation of maximum Time period of buildings

Figure 4 shows the variation of maximum Over-turning moment of buildings. Figure 5 shows the variation of maximum base shear of buildings. Figure 6 Shows variation of maximum drift of buildings.

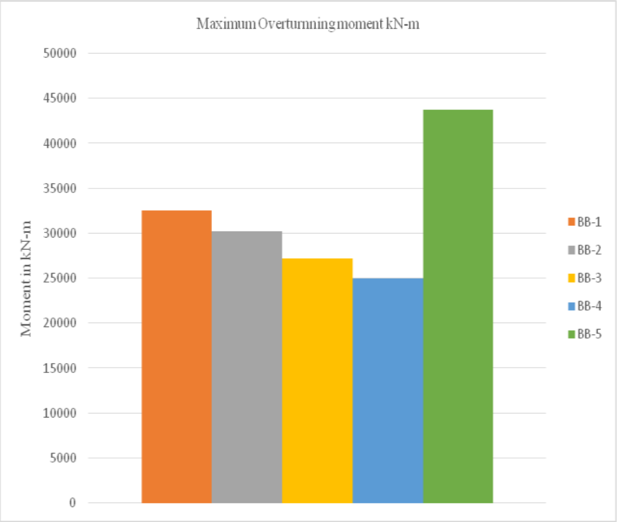

Figure. 4: Shows variation of maximum Over-turning moment of buildings

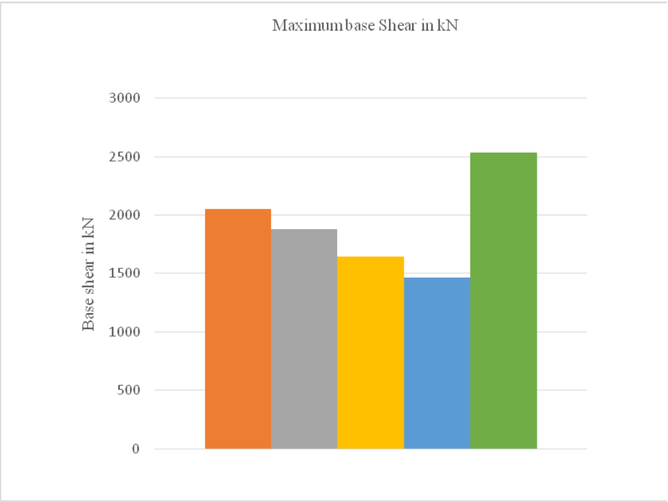

Figure. 5: Shows variation of maximum base shear of buildings

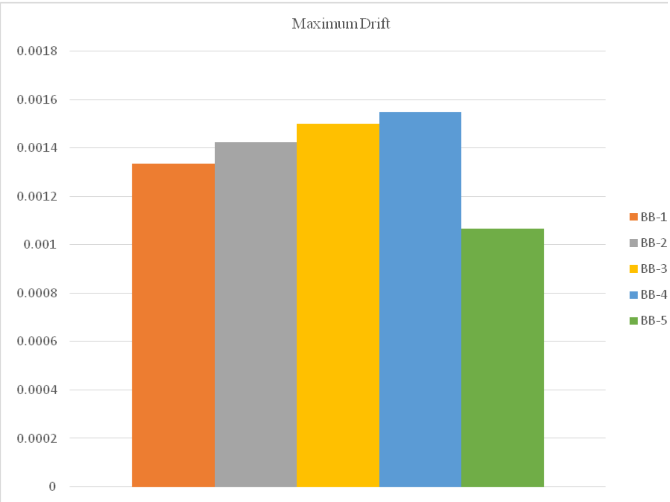

Figure. 6: Shows variation of maximum drift of buildings

V. DISCUSSION ON RESULT

After analyzing the buildings, it was observed that the total dead load of building BB-1 is found to be greater than building BB-2 and building BB-5 has a less dead load on comparison to BB-1 and BB-2. Also, as the size of CFST columns is reduced as in the case of BB-3 and BB-4 the dead load of the buildings is reduced to a greater extend. The time period was found to be greater in BB-2 when compared to BB-1. Building BB-5 has less time period among all the buildings. It is observed from the plots that as the CFST column size reduces in building BB-3 and BB-4 the time period increases which results in the decrease of the stiffness of the building.

VI. CONCLUSIONS

- In the case of building BB-1 with RC beam and CFST columns, the total dead load of the structure is increased by 4% than building BB-2 with RC beam and column of the same dimensions. The total dead load of building BB-5 with ISWB550 beam and CFST column is reduced by 7.9% than building BB-2.
- In the case of building BB-1 with RC beam and CFST columns, the time period was reduced by 6.7% than building BB-2 with RC beam and column of the same dimensions. The time period of building BB-5 with the ISWB550 beam and CFST column is reduced by 31.8% than building BB-2 with RC beam and column of the same dimensions. Hence, the stiffness of building increases with the utilization of CFST columns.
- In the case of building BB-1 with RC beam and CFST columns, the base shear is enhanced by 8.3% than building BB-2 with RC beam and column of the same dimensions. The base shear of building BB-5 with ISWB550 beam and CFST column is enhanced by 25.6% compared to building BB-2 with RC beam and column.

VII. FUTURE SCOPE

A complex multi-storied irregular structure with rectangular concrete-filled steel tubular column along with variation in cross-sectional dimensions of columns, situated in seismic zone-v, with medium soil type is considered for analysis. A comparison between buildings with CFST columns and another with RCC columns is obtained by studying various parameters. A residential building of plan dimensions 40 x 45m (G+12 storied) with a total height of 42m has been considered for the study. Equivalent static analysis and response spectrum analysis are performed to analyses the seismic nature of the building using ETAB software as per provisions of IS: 1893 (Part1)-2016.

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