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ANALYSIS OF MULTI STOREY BUILDING WITH AND WITHOUT FLOATING COLUMNS BY CONSTRUCTION SEQUENCE ANALYSIS AND COMPARISON WITH EQUIVALENT STATIC ANALYSIS

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Abstract:- *Over a long period of time the multistoried building frame has been analyzed on the assumption that the whole of the load is applied to the completed frame structure with all the loads acting on the building which are applied on the complete frame at a given instant as a single step analysis.*

There is one area; however, which has been ignored by many previous investigators, i.e. the effects of construction sequence analysis (CSA) in a multistorey frame. The structural members are added in stages wise as the construction of a building proceeds storey by storey in a sequential order.

Construction Sequence analysis (CSA) is also known as staged construction analysis, which is a nonlinear static form of analysis which takes into account the concept of incremental loading.

This study examines the adverse impact of the floating columns in the building where the structural members are added in stages as the construction of building proceeds in a sequential order.

The comparative study of seismic analysis & design of multi storey building with and without floating column was carried out by using Equivalent static analysis and Construction Sequence Analysis (CSA) by using ETABS 2016. The results like storey drift, storey displacement, base shear, axial force and Building torsion are studied for G+10 storey building.

Key words: *Construction sequence analysis (CSA), Equivalent static analysis (ESA), floating columns, earthquakes, storey drift, storey displacement, base shear, axial force & building torsion.*

1. INTRODUCTION

Many urban multi storey buildings in India today have open first storey as an unavoidable feature. This is primarily being adapted to accommodate parking or reception lobbies in the first storey. Whereas the total seismic base shear as experienced by a building during an earthquake is dependent on its natural period, the seismic force distribution is dependent on the distribution of stiffness and mass along the height.

The behavior of a building during earthquakes depends critically on its overall shape, size and geometry, in addition to how the earthquake forces are carried to the ground. The earthquake forces developed at different floor levels in a building need to be brought down along the height to the ground by the shortest path; any deviation or discontinuity in this load transfer path results in poor performance of the building. Buildings with vertical setbacks (like the hotel buildings with a few storeys wider than the rest) cause a sudden jump in earthquake forces at the level of discontinuity. Buildings that have fewer columns or walls in a particular storey or with unusually tall storey tend to damage or collapse which is initiated in that storey. Many buildings with an open ground storey intended for parking collapsed or were severely damaged in Gujarat during the 2001 Bhuj earthquake. Buildings with columns that hang or float on beams at an intermediate storey and do not go all the way to the foundation, have discontinuities in the load transfer path.

1.1 FLOATING COLUMN

A column is supposed to be a vertical member starting from foundation level and transferring the load to the ground. The term floating column is also a vertical element which (due to architectural design/ site situation) at its lower level (termination Level) rests on a beam which is a horizontal member. The beams transfer the load to other columns below it.

There are many projects in which floating columns are adopted, especially above the ground floor, where transfer girders are employed, so that more open space is available on the ground floor.

These open spaces may be required for assembly hall or parking purpose. The column is a concentrated load on the beam which supports it. As far as analysis is concerned, the column is often assumed pinned at the base and is therefore taken as a point load on the transfer beam. Floating columns are competent enough to carry the gravity load, but the transfer girder must be of adequate dimensions (Stiffness) with very minimal deflection.

Architectural features that are detrimental to earthquake response of buildings should be avoided. If not, they must be minimized. When irregular features are included in buildings, a considerably higher level of engineering effort is required in the structural design and yet the building may not be as good as one with simple architectural features.

Hence, the structures already made with these kinds of discontinuous members were endangered in seismic regions. But those structures cannot be demolished, rather study can be done to strengthen the structure or some remedial features can be suggested. The columns of the first storey can be made stronger, the stiffness of these columns can be increased by retrofitting or these may be provided with bracing to decrease the lateral deformation.

1.2 CONSTRUCTION SEQUENCE ANALYSIS:

Over a long period of time the multistoried building frame has been analyzed on the assumption that the whole of the load is applied to the completed frame structure with all the loads acting on the building that is self-weight, superimposed load, live load and lateral loads which are applied on the completed form at a given instant as a single step analysis.

But in actual practice the dead load due to each structural component and finishing items is imposed in separate stages as the building frame is constructed story by storey in a sequential order. The performance of a building structure with the various loads applied in a single step differ significantly from that when the loads are applied in stages. Construction sequence analysis is also known as staged construction analysis, which is a nonlinear static form of analysis which takes into account the concept of incremental loading.

The structural analysis of multistory buildings is one of the areas that have attracted a great deal of engineering research efforts and the designer's attention.

Therefore, the distribution of displacement and stresses in a particular storey does not depend on the properties of the members which are yet to be constructed. The correct distribution of the displacement and stresses of any member can be obtained by accumulating the results of the analysis of each stage of building frame structure.

Construction sequential analysis is becoming an essential part during analysis. However, this nonlinear static analysis is not so popular because of the lack of knowledge about its necessity and scope. Like so many other analysis, construction sequential analysis had specific purposes in the design phase of the structures.

As it is mentioned earlier, it deals with nonlinear behavior under static loads in the form of sequential load increment and its effects on structure considering the structural members are starting to react against load prior of completing the whole structure.

1.3 EQUIVALENT STATIC ANALYSIS:

The equivalent static lateral force method is a simplified technique to substitute the effect of dynamic loading of an expected earthquake by a static force distributed laterally on a structure for design purposes. The total applied seismic force V is generally evaluated in two horizontal directions parallel to the main axes of the building. It assumes that the building responds in its fundamental lateral mode. For this to be true, the building must be low rise and must be fairly symmetric to avoid torsional movement underground motions. The structure must be able to resist effects caused by seismic forces in either direction, but not in both directions simultaneously.

2. LITERATURE REVIEW

S.B. Waykule1, Dr. C.P. Pise2, C.M. Deshmukh3, Y.P. Pawar4, S.S. Kadam5, D. D. Mohite6, S.V. Lale7 et al., (2016)

This paper is about analysis of G+5 Building with and without floating column in a highly seismic zone V. Two models are created such as floating column and without floating column building.

Linear static and time history analysis are carried out for the two models and the results are obtained. Modelling and analysis is done by SAP 2000v17 software.

From this study it was concluded that building with floating column has more time period as compared to building without floating columns. It was observed that building with floating column has less base shear as compared to building without floating column.

It was also observed that displacement for floating column building is more as compared to without floating column building. Building with floating column has more storey drift as compared to building without floating column. From dynamic analysis it was observed that floating column at different location results in variation in dynamic response.

Hardik Bhensdadia, Siddarth Shah, et al., (2015)

This paper is about the effects of floating column & soft storey building in different earthquake zones by seismic analysis. For this purpose Push over analysis is adopted because this analysis will yield a performance level of building for design capacity (displacement) carried out up to failure, it helps determine of collapse load and ductility capacity of the structure. To achieve this objective, three RC bare frame structures with G+4, G+9, G+15 stories respectively, will be analyzed and compared the base force and displacement of the RC bare frame structure with G+4, G+9, G+15 stories in different earthquake zones like Rajkot, Jamnagar and Bhuj using SAP 2000 14 analysis package.

From this study it was concluded that the displacement and the base shear of the building increases from lower zones to higher zones, because the magnitude of intensity will be more for higher zones. Formation of Plastic hinges is more in higher seismic zone and Repair or Retrofitting works are required more in higher seismic zone. Performance Level of G+15 new building is in the range of Life Safety level. Plastic moments in Beams are more comparable to the plastic moments in Floating Columns.

In Floating columns, Axial Forces are more in lower zone comparable to higher zone, but moments are less compared to the Axial Forces.

Shrikanth.M.K1, Yogendra.R.Holebau2, et al., (2014)

This paper is about the behavior of a building having only floating column and having a floating column with complexities. High rise building is analyzed for earthquake force. For that purpose created four models and analyzed for lower and higher seismic zones for medium soil condition. Analysis was carried out by using extended 3 dimensional analysis of building a system ETABS version 9.7.4 software.

Results are presented in terms of Displacement, soft storey, storey drift for these four models and tabulated on the basis of linear seismic analysis.

3. OBJECTIVES OF THE STUDY

1. The main objective of this paper to study the comparison of G+10 with and without floating column building with construction sequence analysis (CSA) and equivalent static analysis method (ESA).
2. To compare the parameters, i.e. base shear, storey displacement, store drift & building torsion with construction sequence analysis (CSA) and equivalent static analysis (ESA) method.

4. METHODOLOGY

Considering the G+10 storey building with and without floating columns, analyzing structures by using as per Indian standard code IS 1893 (Part-1) 2002 and ETABS-2016 software. To determine the parameters like base shear, storey displacement, store drift, overturning moments, axial force, and the following method will be adopted for the analysis purpose.

1. Construction sequence analysis method (CSA)
2. Equivalent static analysis method (EQA)

Table -1: BUILDING DATA

PARAMETERS	MODEL - 1	MODEL - 2
Plan	13.4mX12.6m	13.4mX12.6m
Total Height of Building	42.3m	42.3m
Number of Storey	G+10	G+10
Ground Storey Height	3.5m	3.5m
Typical Storey Height	3.3m	3.3m
Grade of Concrete for Columns & Beams	M35	M35
Grade of Concrete for Slab	M30	M30
Grade of Rebar	HYSD550	HYSD550
Slab Thickness	125mm	125mm
Beam Sizes	230X300mm, 230X425mm, 230X500mm & 230X125mm	230X300mm, 300X600mm, 230X425mm, 230X500mm, 300X500mm & 230X125mm
Column Sizes	375mmX375mm	450X450mm & 600X600mm
Live Load	2.0 kN/m^2	2.0 kN/m^2
Floor Finish	1.5 kN/m^2	1.5 kN/m^2
Super Imposed Dead Load	7.2 kN/m & 3.6 kN/m	7.2 kN/m & 3.6 kN/m
Seismic Zone	II	II
Soil Type	II (Medium)	II (Medium)
Response Reduction Factor	5	5
Importance Factor	1	1

Model - 1: Building without floating columns

Model - 2: Building with floating columns

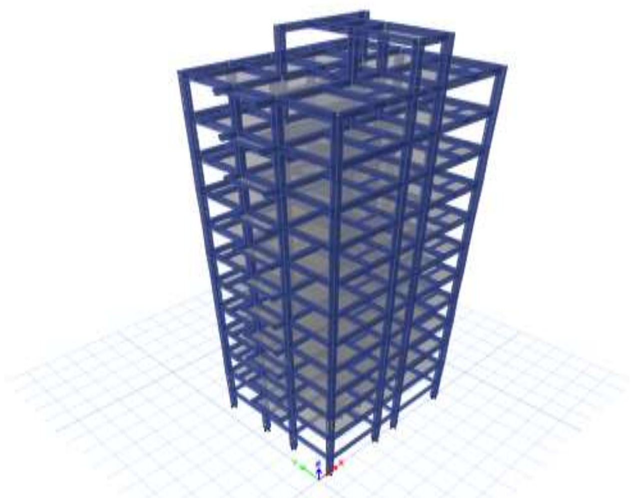


Fig - 1: Elevation of model – 1 Normal Building

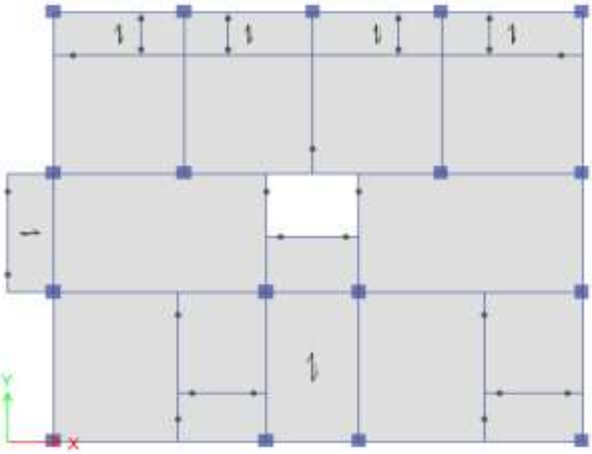


Fig - 2: Plan of model – 1 Normal Building

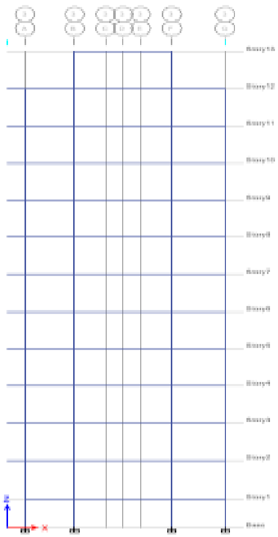


Fig - 3: Front Elevation of model – 1 Normal Building

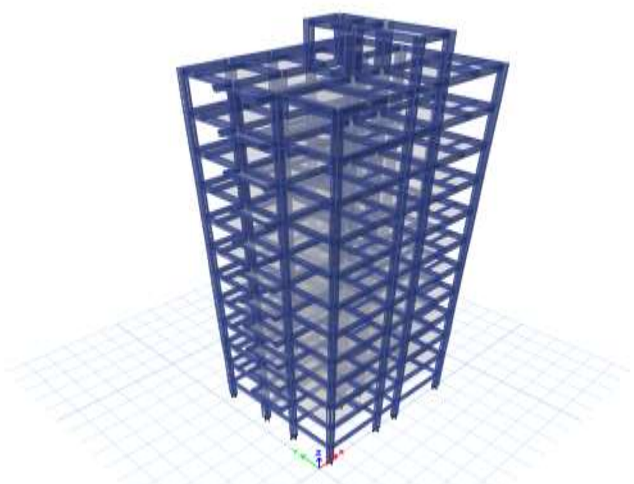


Fig - 4: Elevation of model – 2 Floating Column Building

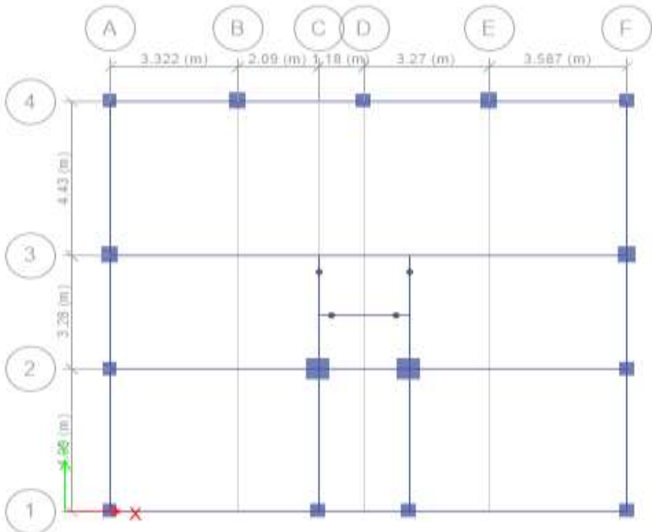


Fig - 5: Plan of model – 2 Ground Floor Column removed

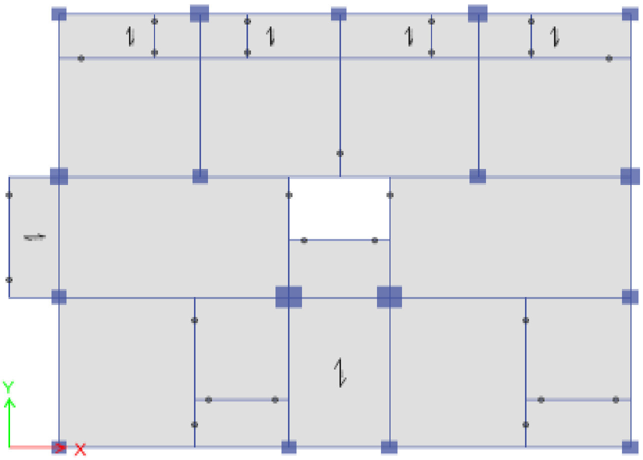


Fig - 6: Plan of model – 2 Building with Floating columns

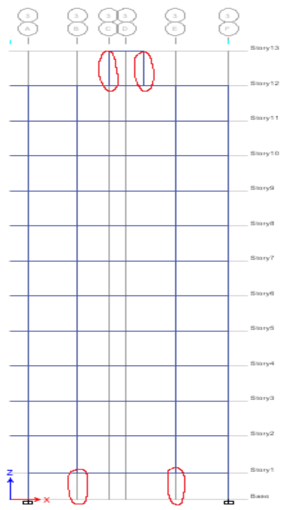
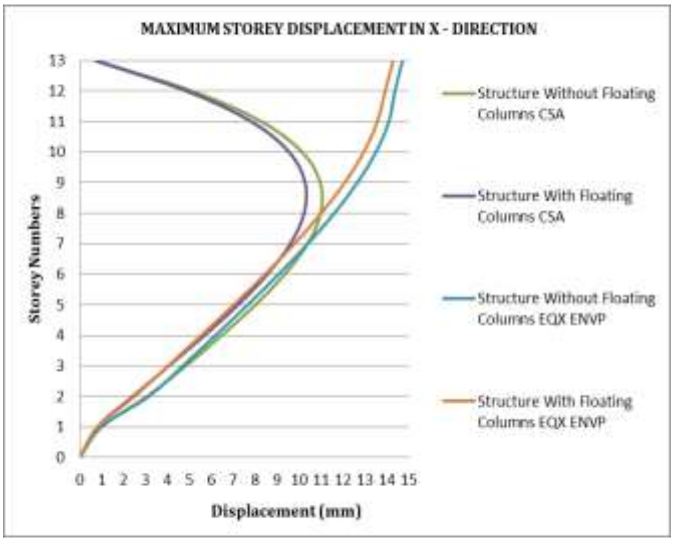


Fig - 7: Elevation of model – 2 Building with Floating columns

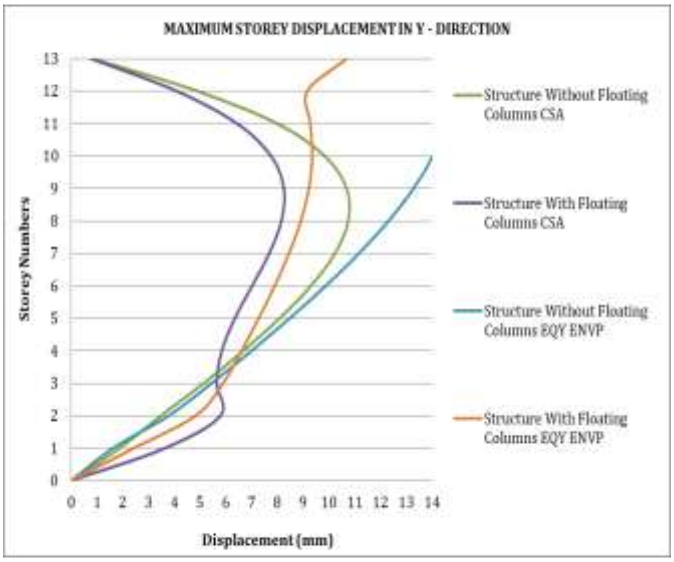
5. RESULTS AND DISCUSSIONS

5.1 MAXIMUM STOREY DISPLACEMENT



Graph - 1: Comparison of maximum storey displacement of model – 1 & model -2 with CSA & ESA in X - Direction

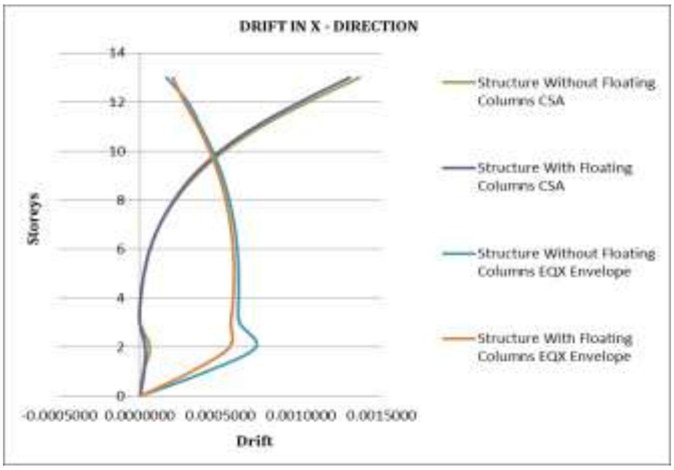
From Graph – 1 It is observed that the displacement for CSA models decreases rapidly from 13% to 95% for both with and without floating columns from 8th to 13th storey when compared with EQX ENVP.



Graph - 2: Comparison of maximum storey displacement of model – 1 & model -2 with CSA & ESA in Y – Direction

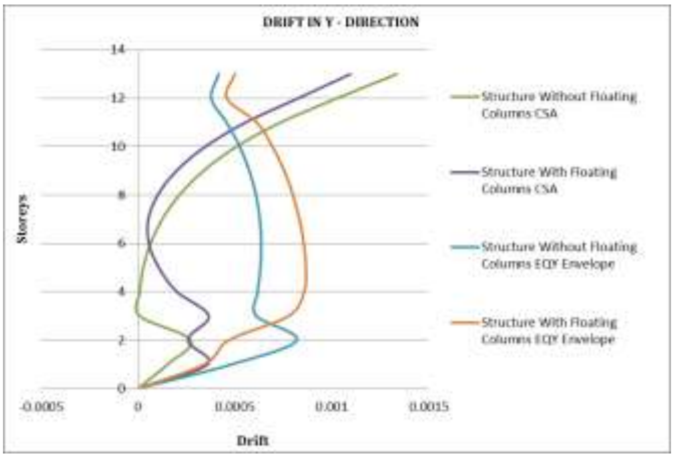
From Graph – 2 It is observed that the displacement for CSA models decreases rapidly from 12% to 94% for both with and without floating columns from 8th to 13th storey when compared with EQY ENVP.

5.2 STOREY DRIFT



Graph - 3: Comparison of storey drifts of Model – 1 & model -2 with CSA & ESA in X - Direction

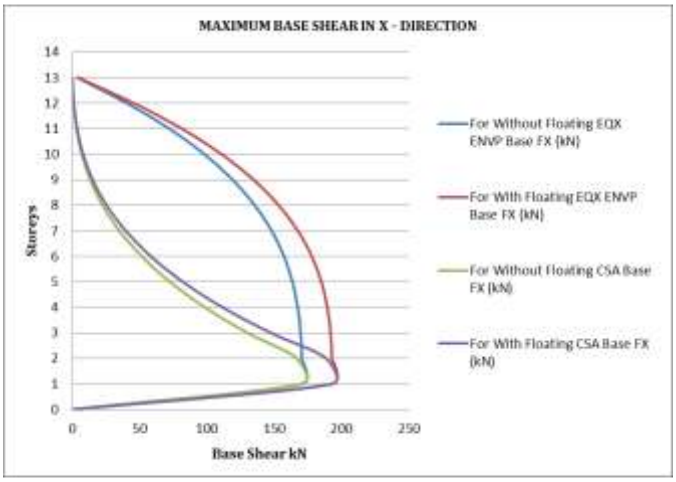
From Graph – 3 It is observed that the Storey drift for CSA models increases rapidly from 13% to 87% for both with and without floating columns from 10th to 13th storey when compared with EQX ENVP.



Graph - 4: Comparison of storey drifts of Model – 1 & model -2 with CSA & ESA in Y - Direction

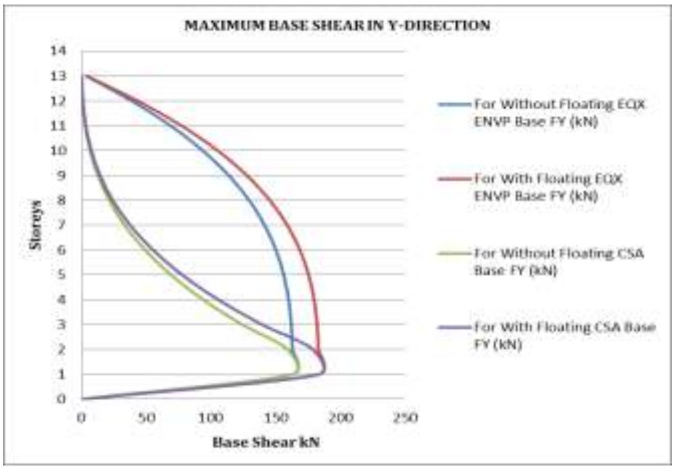
From Graph – 4 It is observed that the Storey drift for CSA models increases rapidly from 3% to 68% for both with and without floating columns from 10th to 13th storey when compared with EQY Envelope and it is also observed that from 3rd to 11th Storey the CSA model values vary from 98% to 38% which is lesser when compare to EQY ENVP.

5.3 MAXIMUM BASE SHEAR



Graph - 5: Comparison of maximum base shear of Model – 1 & model -2 with CSA & ESA in X – Direction

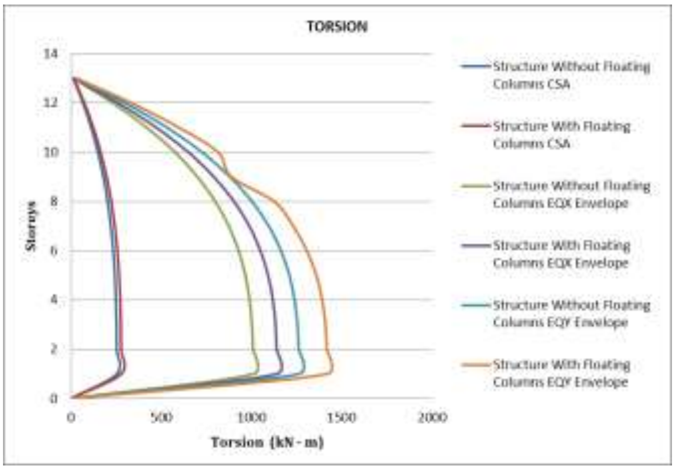
From Graph – 5 It is observed that the Base FX for without floating column for CSA models varies from 2% to 98% from 2nd storey to 13th storey which is lesser when compare to EQX ENVP.The Base FX for with floating column for CSA models varies from 98% to 23% from 2nd storey to 5th storey, 23% to 99% from 5th storey to 13th storey which is lesser when compare to EQX ENVP and it is also observed that the Maximum variation in Base shear appears in between 6th and 7th storey for CSA and EQX ENVP.



Graph - 6: Comparison of maximum base shear of Model – 1 & model -2 with CSA & ESA in Y – Direction

From Graph – 6 It is observed that the Base FY for without floating column for CSA models varies from 2% to 98% from 2nd storey to 13th storey which is lesser when compare to EQX ENVP.The Base FY for with floating column for CSA models varies from 98% to 19% from 2nd storey to 5th storey, 26% to 99% from 5th storey to 13th storey which is lesser when compare to EQX ENVP and it is also observed that the Maximum variation in Base shear appears in between 6th and 7th storey for CSA and EQY ENVP.

5.4 TORSION



Graph - 7: Comparison of Torsion of Model – 1 & model -2 with CSA & ESA

From Graph – 7 it is observed that the Torsion for with a floating column for CSA models varies from 80% to 53% from 1st Storey to 13th storey which is lesser to EQ ENVP (X and Y), The Torsion for without floating column for CSA models varies from 79% to 55% From 1st Storey to 13th storey which is lesser to EQ ENVP (for X and Y)and it is also observed that the Maximum variation in Torsion appears at the 1st storey in between CSA and EQ ENVP (for X and Y).

6. CONCLUSIONS

Following are the conclusions which are drawn on the basis of the above study.

1. It is observed that the displacements in both directions for Construction Sequence Analysis (CSA) models for with floating and without floating are decreased as we go to higher stories which in turn is a key factor when the displacement based design is done, and CSA proves to be more economical for displacement based design of high rise buildings.
2. There is a large variation in the storey drift for Construction Sequence Analysis (CSA) models for with floating and without floating in both directions as compared to EQ models. The storey drift increases as the height increases, which may affect the performance of the structure when subjected to earthquake forces.
3. Base shear for both Construction Sequence Analysis (CSA) models for with and without floating columns are reduced as we go to above storey which in turn reduces the design for economy as compared with Equivalent Static Analysis (ESA).
4. The CSA models for with floating and without floating in both directions have reduced the effect of torsion as the top stories are considered, the design

of high rise structures when accounted for torsion with CSA will give economical design.

5. Although there are large variations for with and without floating column models when analysis is done with both Construction Sequence Analysis (CSA) and Equivalent Static Analysis (ESA), but the variations of CSA are more practical and can be considered for the design of the building.
6. In the design of with and without floating column buildings, it is observed that the area of steel is more in a floating column building when compared with normal building.

REFERENCES

[1] S.B. Waykule1, Dr. C.P. Pise2, C.M. Deshmukh3, Y.P. Pawar4, S.S. Kadam5, D. D. Mohite6, S.V. Lale7 " Study of behavior of floating column For seismic analysis of multistory Building", International Journal of Civil Engineering and Technology (IJCIET) Volume 7, Issue 6, November-December 2016, pages. 676–685.

[2] Hardik. Bhensdadia (2015) Pushover analysis of RC structure with floating column and soft storey in different earthquake zones, frame International Journal of Research in Engineering and Technology. Volume: 04 Issue: 04 | Apr-2015.

[3] Shrikanth. M.K (2014) –Seismic response of complex building with floating column and without floating column, International journal of Engineering Research-Online. A Peer Reviewed International Journal .Vol. 2., Issue.4, 2014 .ISSN: 2321-7758

[4] IS 1893 (Part-1) 2002. "Criteria for earthquake resistant Design of structures for seismic loads."

[5] IS 875 (Part-1) 1987. "Code of practice for Design dead loads for buildings and structures."

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