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Non Linear Static Analysis of RC Building with and without Floating Column

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Abstract: In present scenario, a building with floating column is a typical feature in the modern multi-storey construction in urban India. The term floating column is vertical element which at its lower level rests on a beam. The beams in turn transfer the load to other columns below it. These floating columns are provided, so that more open space is available in the ground floor. As far as analysis is concerned, the column is often assumed pinned at the base. In this study Push over analysis is adopted because this analysis will yield performance level of building for design capacity (displacement) carried out up to failure, it helps in determination of collapse load and ductility capacity of the structure. Two RC buildings are considered one without floating column and another with floating column which are being analyzed by using ETABS 2015 software. Finally the results of pushover analysis for both the building are compared in terms of Roof displacement, Base shear and Hinge formation.

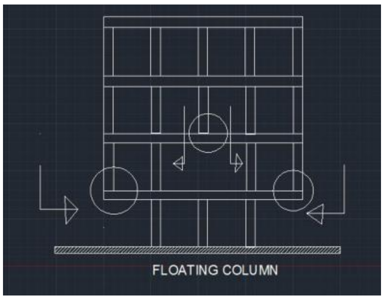
Keywords: Capacity curve, E-tabs, Floating column, Seismic performance.

I. INTRODUCTION

Earthquake is one of the greatest natural disasters on this planet, which is capable of causing immense loss of life or property damage. Early failure has been observed in buildings that were designed according to modern principles of earthquake designs. The main reasons are because of difficulty in prediction of post-elastic seismic response of structures and lack of information regarding regional seismic hazard due to random nature of earthquakes. It means that structural design and seismic assessment should be based on nonlinear deformation, not on the stresses derived by the assumed equivalent lateral loads.

Floating column

Floating column is a type of column which is is constructed over beams or slabs of any intermediate floors of a structure. These columns are not attached to any footings or pedestal. Floating columns are also known as hanging column.



Current Seismic Design Procedure

Structures designed according to current seismic codes satisfy the following criteria:

i) Resist minor level of earthquake ground motions with no damage to structural and non-structural elements.
ii) Resist moderate earthquake without structural damage.
iii) Resist major earthquakes without collapse.

Traditional earthquake resistant design is based on force strength approach. This method aims to achieve only one performance objective life safety. Such a method is inadequate to predict the damage mechanism correctly. As a result, there is a need to improve seismic performance of the built environment through the development of performance-oriented procedures. Therefore, for this reason nonlinear static pushover analysis is carried out for the present work.

Objectives of the Present Work

1. To carry out linear analysis for RCC frames as per IS 1893:2016.
2. To perform the pushover analysis on the RCC structure with and without Floating Column.
3. Comparative study of Linear and Nonlinear Analysis of RCC structures.

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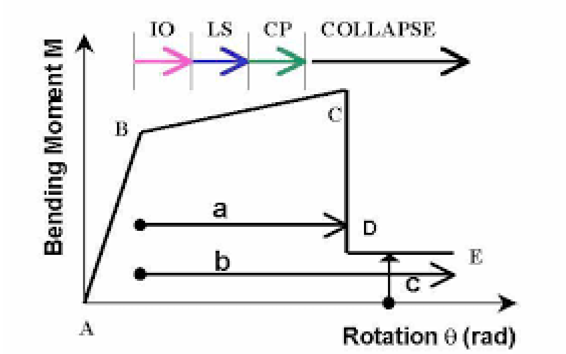
II. METHODOLOGY

In the Present work four building models G+1, G+5, G+8 and G+11 soft storied reinforced concrete frame building with and without floating column situated in zone V with subsoil Type medium - I were analysed in ETAB software. For the analysis of these models various methods of seismic analysis are available but for present work linear and non linear static methods are used. A building should possess main attributes namely simple and regular configuration and adequate lateral Strength, stiffness and ductility for well performance in an earth quake. As per IS 1893 (part-1) 2016, dynamic analysis (Linear or Non-linear) of building is carried out including the strength and stiffness effects and inelastic deformations in the members and the members designed accordingly. The lateral loads due to earthquake were calculated using Response spectrum method as per IS 1893 (part-1): 2002.

Design Seismic Base Shear:
The total design lateral force or design seismic base shear (VB) is calculated according to IS 1893-2016
The total Base shear= V_b =Ah x W Where, A_h is the design horizontal seismic coefficient
A_h = (Z/2) x (Sa/g) x (I/R)
Z = Zone Factor I = Importance Factor R = Response Reduction Factor Sa/g = Spectral acceleration Co efficient
The values of Z, I, R are given in Tables 3, 8, 9 respectively in IS 1893 (part-1):2016.
It is calculated according to Clause 6.4.5 of the Code corresponding to the fundamental time period.
Ta in seconds is given as follows.
For a Moment Resisting Frame without infill Ta = 0.0075 x $h^{0.75}$
For a Moment Resisting Frame with infill Ta = 0.09h / √d Here h = Height of the Building Frame
d = Base dimension of the building at the plinth level in meters, along the considered direction of the lateral loads.

Non Linear Static Analysis (Pushover Analysis)
Pushover analysis which is an iterative procedure is looked upon as an alternative for the conventional analysis procedures. It is a static non-linear analysis used to investigate how far into the inelastic range a building can go before it is on the verge of a total or a partial collapse. In addition, pushover analysis is also used to ascertain the capability of the structure to withstand a certain level of input motion defined in terms of a response spectrum. Local nonlinear effects are modelled and the structure is pushed until a collapse mechanism is developed. At each step, the base shear and the roof displacement can be plotted to generate the pushover curve. At each step, the base shear and the roof displacement can be plotted to generate the pushover curve.

Non-Linear Static Analysis
The widespread damage especially to RC buildings during earthquakes exposed the construction practices being adopted around the world, and generated a great demand for seismic evaluation and retrofitting of existing building stocks. In the figures below different nodes subjecting to different levels of elastic zone are represented with respective colours mentioned at the bottom of the figures. The elastic zone is categorized into three parts likely Immediate Occupancy (IO) Life safety (LS) Collapse prevention (CP).



Building Data
The assumed building data for G+1, G+5, G+8 and G+11 storied reinforced concrete frame building with Floating Column and without Floating Column are mention below. Pushover analysis is carried out for reinforced concrete moment resisting building frame and this analysis is carried out using ETABS 2015.

Table 1 Assumed Seismic Data

Type of Structure	SMRF
Soil Type	Hard – 1
Response Reduction Factor	5
Importance Factor	1
Seismic Zone	V

Table 2 Sectional Properties

Storey	Beam(mm)	Column(mm)
G+1	230 X 300	300 X 300
G+5	230 X 600	300 X 450
G+8	230 X 600	300 X 600
G+11	230 X 600	300 X 750

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Table 3 Dimensions and loads

Floor Height	3m
Wall Thickness	230mm
Loads	
Live Load	3 KN/m2
Floor Finish	1 KN/m2

Table 4 Material Properties

Concrete	M 20
Steel	Fe 415
Depth of Slab	150mm
Poisson's Ratio	0.2
Self Weight Of Rcc	25 KN / m3

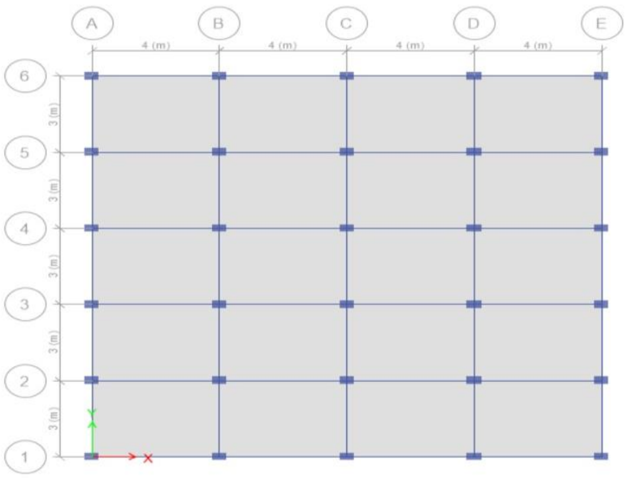


Fig. General Plan view

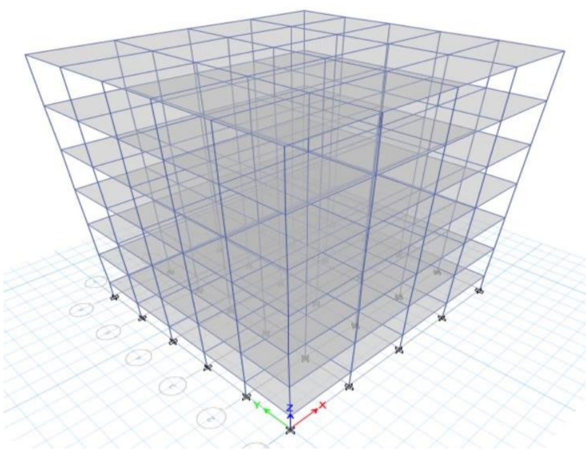


Fig. General 3D view

III RESULTS

Capacity Curves

In pushover analysis, the behaviour of the structure is characterized by a capacity curve that represents the relationship between the base shear and the displacement of the roof.

(Model-1: RC building without floating column and Model-2: RC building with floating column)

Fig. Capacity curve for model 1

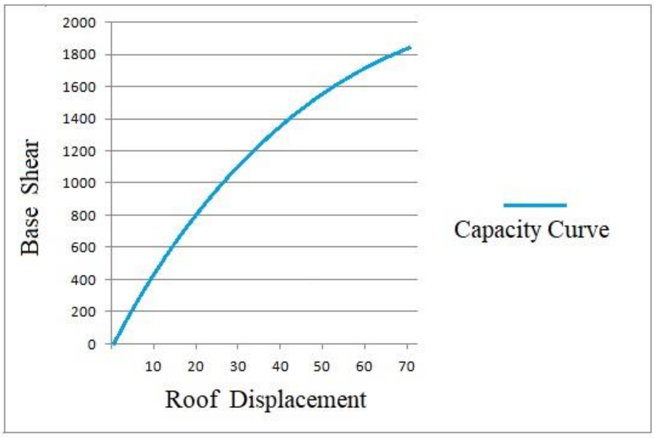
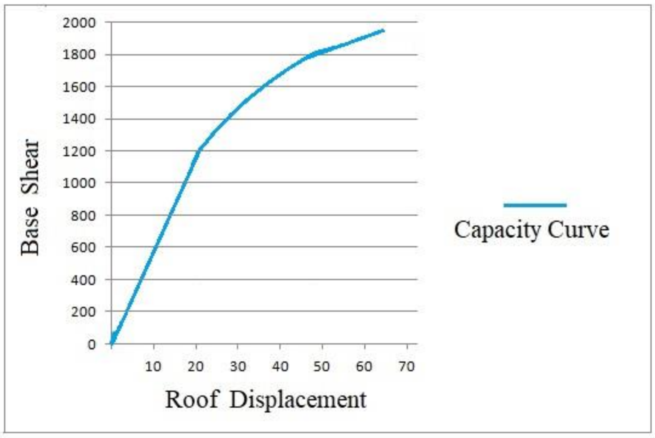


Fig. Capacity curve for model 2



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Comparison of Roof Displacement and Base Shear for RC Buildings with Floating Column and without floating column

Fig. Comparison of Roof Displacement

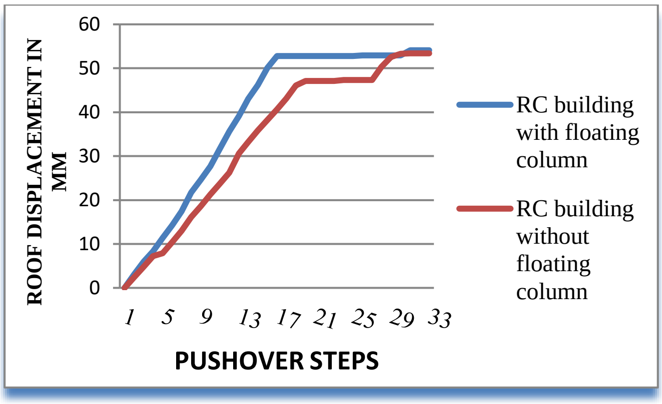
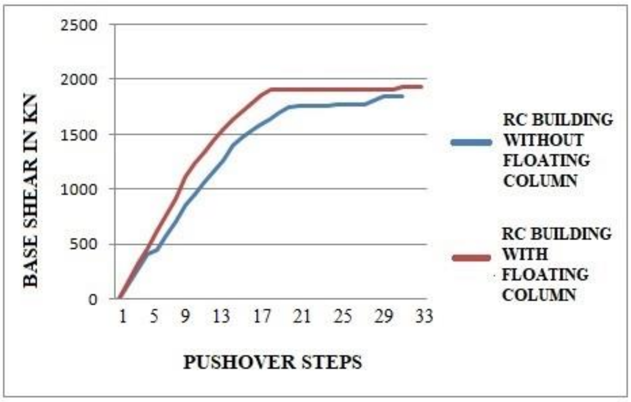


Fig. Comparison of Base Shear



Hinge Formation of Buildings:

(Model-1 - 1st Hinge Formation on RC Building without floating column & Model-2 - 1st Hinge Formation in Building with Floating Column)

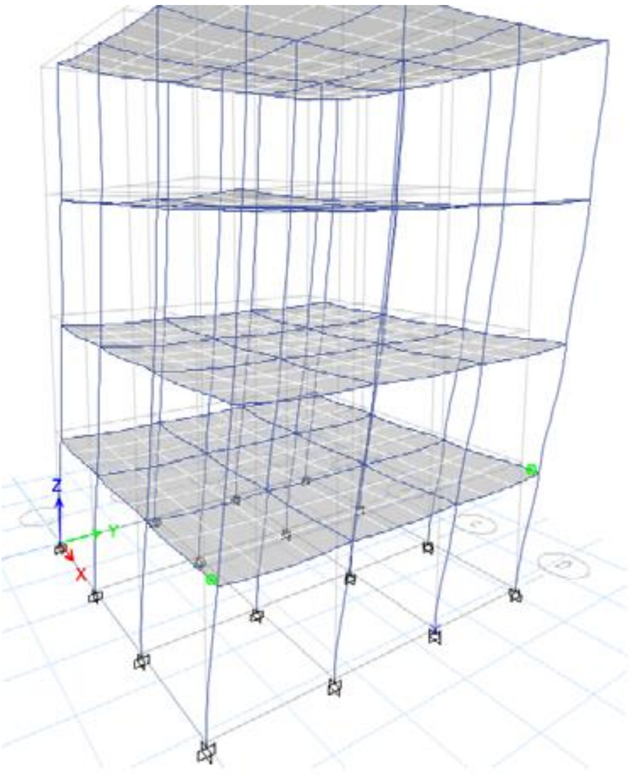


Fig. 1st hinge formations in Model-1

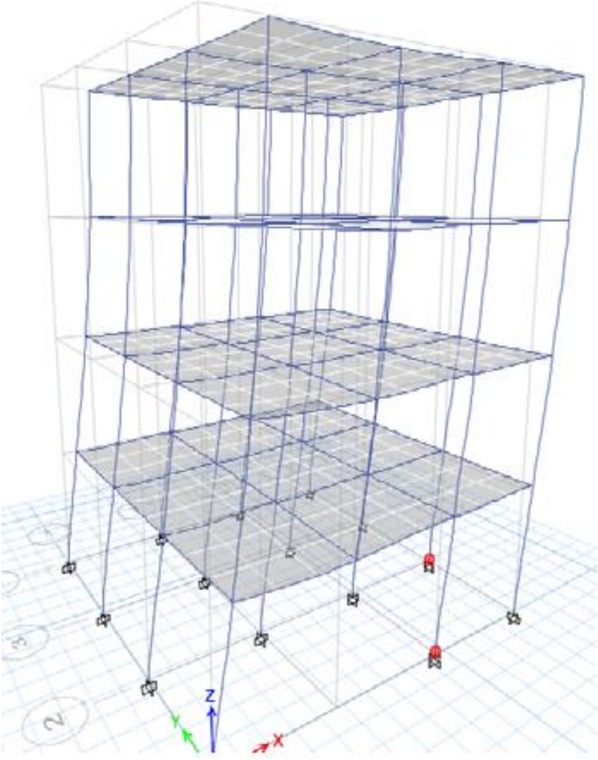


Fig. 1st hinge formation in Model-2

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IV. CONCLUSION

The behaviour of multistorey building with and without floating column is studied under earthquake excitation. Structural models have been developed to study the dynamic behaviour by using ETABS 2015 software. After studying all the results following conclusions can be made:

1. There is significant increase in roof displacement for RC building with floating column as compared to RC building without floating column. That means incorporation of floating column in RC building leads to increase in roof displacement.
2. When base shear of both the buildings are taken into consideration it is observed that base shear in building with floating column increases slightly.
3. Pushover analysis helps in finding the weak points in the structure. The weak points in Building with floating columns are the columns supporting the beam girder on which floating column is resting. Even though the size of beam girder is increased the column forces and moment on column below girders increases drastically. Performance wise these columns are giving the worst behaviour. Columns C1, C9, C13, and C14 are found to be weak according to the performance level of their hinges.
4. When we compare the performance level of hinges of both the building, in building with floating column most of the hinges forms are directly exceeding the Collapse prevention level, which should not be the case, which clearly shows that the capacity of building is not up to the mark of what the demand is.

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