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SEISMIC ANALYSIS OF R C BUILDINGS WITH FLOATING COLUMNS USING NON-LINEAR STATIC ANALYSIS

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Abstract - *A column is meant to be an upright member ranging from footing level and conveying the load to the lowest. The term floating-column is additionally an upright member that ends (due to subject field design/ web site situation) at its lower level (termination Level) rests on a beam that may be a horizontal member. The beams successively transfer the load to alternative columns below it. Such columns in structures will be analyzed and designed. In follow, actuality columns below the termination level [usually the stilt level] aren't created with care and a lot of risk of failure. Hypothetically, there's no would like for such floating columns – the spans of all beams need not be nearly identical and a few spans will be considerably longer than others. This way, the columns supporting beams with larger spans would be designed and created with immense care.*

Key Words: Floating column, Monitor displacement, Pushover analysis, Elastic behavior, Plastic behavior.

1. INTRODUCTION

An earthquake (volcanic activity) is a chain of throbs induced within the layer by the abrupt rupture and rebound of rocks during which elastic strain has been slowly accruing. An earthquake is that the results of a sharp unharness of energy within the Earth's prime 700 kilometer that makes unstable waves. These waves are sensed with seismo-meters and strengthened electronically so that they will be displayed and operated by a measuring instrument named seismogram. At the external, earthquakes manifest themselves by throbbing and generally translation of the core. Once the epicenter of an oversized earthquake is found offshore, the core generally is elated enough to cause a moving ridge. The throbbing in earthquake may trigger landslides and sometimes devastating activity.

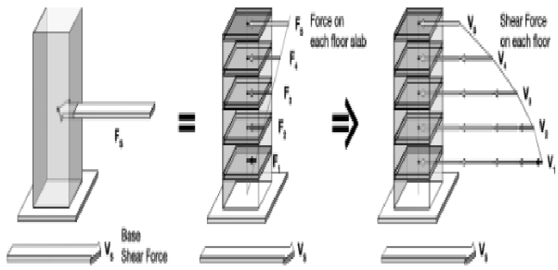


Fig.1: Lateral forces and Shear forces generated in buildings due to ground motion

Conventional Civil Engineering structures are designed on the basis of strength and stiffness criteria. The strength is related to ultimate limit state, which assures that the forces developed in the structure remain in elastic range. The stiffness is related to serviceability limit states which assures that the structural displacement remains with the permissible limits. In case of earthquake forces the demand is for ductility. Ductility is an essential attribute of a structure that must respond to strong ground motions. Ductility is the ability of the structure to undergo distortion or deformation without damage or failure which results in dissipation of energy. Larger is the capacity of the structure to deform plastically without collapse, more is the resulting ductility and the energy dissipation. This causes reduction in effective earthquake forces.

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 in turn 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 in the ground floor. These open spaces may be required for assembly hall or parking purpose. The transfer girders have to be designed and detailed properly, especially in earth quake zones.

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. . However, this need not be done at the cost of poor behavior and earthquake safety of buildings. 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 are 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 the columns can be increased by retrofitting or these may be provided with bracing to decrease the lateral deformation.

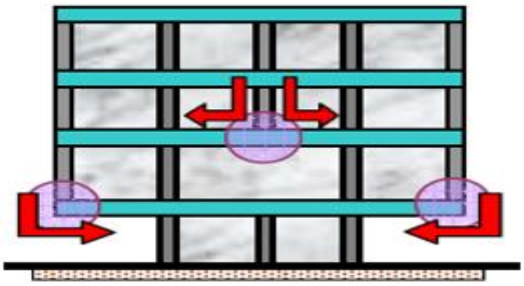


Fig.2: Example of Floating column

1.1 Advantages and disadvantages of floating columns

Advantages

i) By using floating columns large functional space can be provided which can be utilize for storage and parking.
ii) In some situations floating columns may prove to be economical in some cases.
iii) The floating column is important for dividing the rooms and some portion can raise without whole area.

Disadvantages

i) Not suitable in high seismic zone since abrupt change in stiffness was observed.
ii) Required large size of girder beam to support floating column.
iii) Floating columns leads to stiffness irregularities in building.
iv) Flow of load path increases by providing floating columns. The load from structural members shall be transfer to the foundation by the shortest possible path.

2. OBJECTIVES

The project work is focused on the following objectives

i) To study the elastic behaviour, plastic (inelastic) behaviour and change of state from elastic to plastic state behaviour of the RC framed SMRF building model under consideration.
ii) To perform non-linear static displacement controlled analysis and obtain load-displacement curve (pushover curve) for the building models under consideration.
iii) To study the performance response of the RC framed SMRF building models situated in seismic zone IV, on hard soil (Type-I) using linear static and non-linear static displacement controlled analysis by considering the effect of floating columns.
iv) To attain and compare various results such as storey shear, storey drifts, storey displacement, with and without considering the idea of floating columns for the considered building models under consideration using both linear and non- linear static displacement controlled analysis under DCON-2 load combinations as per IS 1893:2002 (part-1) using FEM based analytical software ETABS- 15 version.
v) To find the overall capacity of the building having floating columns at 3rd and 7th floors at corner base under DCON-2 load combinations as per IS 1893:2002 (part-1) for the models under consideration.
vi) To identify the point of performance for the RC framed SMRF building models under consideration by overlapping the demand curve and capacity curve.
vii) To recognize the performance levels of the RC framed SMRF building models under consideration by inelastic analysis.
viii) To attain the inelastic formation of hinges and their status for the RC framed SMRF building models under consideration.

2.1 ANALYTICAL PROCEDURES

METHODS OF ANALYSIS:

1. Linear Static: Linear analysis techniques give a good suggestion of elastic capability of the structures and indicate where first yielding will arise. The linear static method of analysis is limited to undersized, reliable buildings.

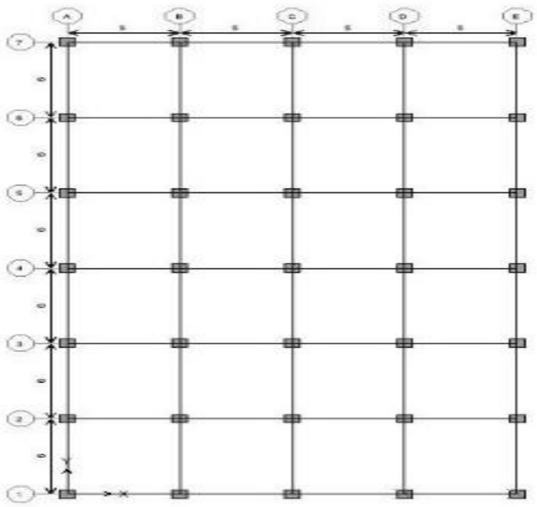
2. Linear Dynamic: In IS:1893,2002 (Part 1) two methods, one Seismic factor and other Response Spectrum method is described to carry out the analysis for Earthquake forces. One Table (in Clause 4.2.1) is also provided to decide upon the method to be used, depending upon structure elevation and seismic zone. At the lowermost of this table, it is evidently mentioned that structures with irregular shape and/or irregular dissemination of mass and stiffness in x and/or y plane, shall be analyzed as per Response Spectrum approach. For all practical reasons, no structure is uniform in all the respects (i.e. mass/stiffness, shape distribution in x and y plane). This means that for no structures, the Seismic Co-efficient method shall be helpful. Response Spectrum approach, being time elapsing and tiresome process, mostly, computer applications are possible.

3. Non-linear Static: In a nonlinear static analysis technique the building model integrates directly the nonlinear force-deformation features of individual components and elements due to inelastic physical response. Several methods (ATC40, FEMA273) existing and all have in common that the nonlinear force–deformation features of the building is characterized by a Pushover curve, PO curve of base shear vs. top translation, obtained by subjecting the building model to monotonically augmenting lateral forces or augmenting translations, distributed over the peak of the building in correspondence to the first mode of vibration until the building disintegrates. The maximum translation likely to be experienced during a given earthquake is determined using either highly damped or inelastic response spectra.

2.2 MODEL DESCRIPTION

Various models considered for the study are as follows and are shown in Fig.3 and Fig.4

i) MODEL I: G+9 storey bare frame.
ii) MODEL II: G+9 storey building with one floating column in 3rd floor.



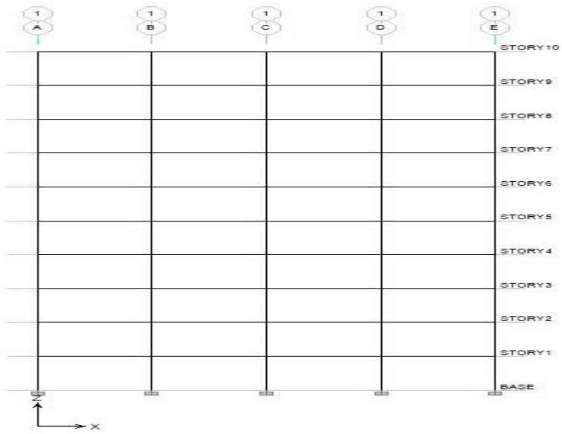
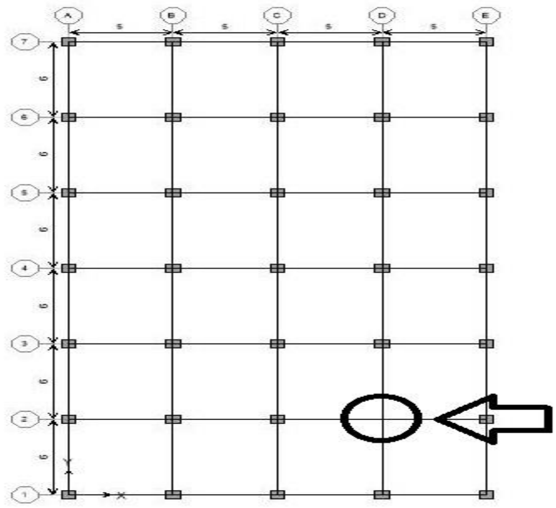


Fig.3: Plan and elevation of Model 1



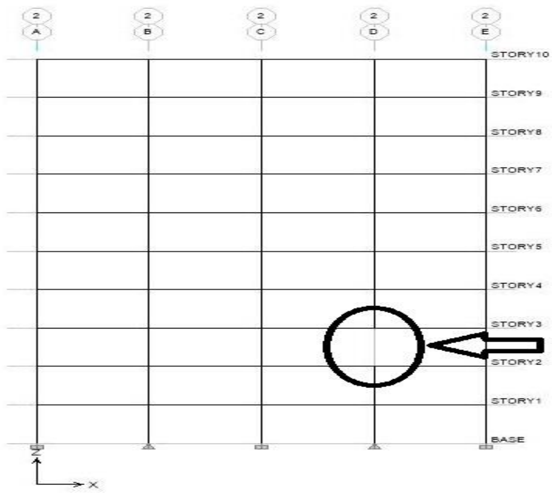


Fig.4: Plan and elevation of Model II

3.RESULTS AND DISCUSSIONS

Below table gives the various data considered for the building model.

Table.1: Building model data

PARAMETERS	MODEL-1	MODEL-2
Soil type	Hard(type I)	Hard(type I)
Seismic zone	IV	IV
Response reduction factor	5	5
Importance factor	1	1
Height of building	33.2m	33.2m
Floor height	3m	3m
Basement height	3.2m	3.2m
Slab thickness	140mm	140mm
Floating column	-	3rd floor
Live load	4 kN/m^2	4 kN/m^2
Floor finish	0.75 kN/m2	0.75 kN/m^2
Terrace load	2kN/m^2	2kN/m^2
Spacing of column	5m c/c	5m c/c
Column size	650X650mm	650X650mm
Beam size	400X500mm	400X500mm
Material property	M30, Fe500	M30, Fe500

3.1 STOREY SHEAR: Storey Shear in kN for G+9 storey model for both Linear and Non-linear analysis in longitudinal X Direction as shown in Table2 and Fig.5, where in Fig.5 shows the graph of storey shear.

Table.2: Storey Shear in kN for G+9 storey model for both Linear and Non-linear analysis in longitudinal X Direction

Storey levels	M1		M2	
	Linear X	Non-linear X	Linear X	Non-linear X
10	482.93	774.99	97.18	183.62
9	938.37	1505.88	187.68	354.62
8	1298.22	2083.37	259.19	489.74
7	1573.74	2525.51	313.94	593.19
6	1776.15	2850.35	354.17	669.19
5	1916.72	3075.93	382.10	721.97
4	2006.69	3220.31	399.98	755.75
3	2057.29	3301.52	410.02	774.73
2	2079.78	3337.61	414.48	783.15
1	2085.41	3346.63	415.60	785.26

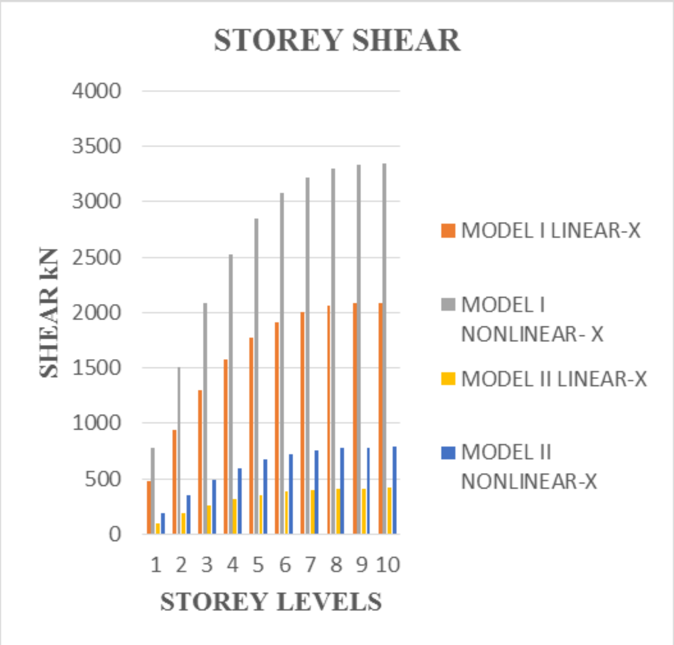


Fig.5: Storey shear for both linear and non-linear analysis

3.2 STOREY DRIFT: Storey Drift for G+9 storey model for both Linear and Non-linear analysis in longitudinal X

Direction as shown in Table3 and Fig.6, where in Fig.6 shows the graph of storey drift.

Storey levels	Table.3: Storey Drift for G+9 storey model for both Linear and Non-linear analysis in longitudinal X Direction			
	M1		M2	
	Linear X	Non-linear X	Linear X	Non-linear X
10	0.31	0.49	0.06	0.12
9	0.47	0.75	0.09	0.18
8	0.62	0.99	0.12	0.23
7	0.75	1.20	0.15	0.28
6	0.84	1.35	0.17	0.32
5	0.90	1.45	0.18	0.34
4	0.93	1.50	0.19	0.35
3	0.92	1.47	0.19	0.36
2	0.81	1.30	0.17	0.32
1	0.42	0.68	0.11	0.22

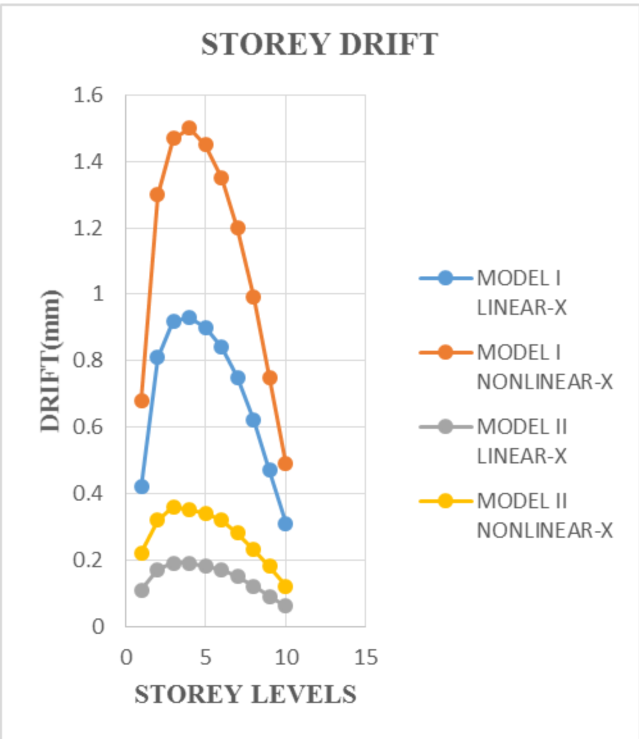


Fig.6: Storey drift for both linear and non-linear analysis

3.3 Non-linear Base shear verses Displacement curve (PO-Curves): Table4, Fig7 and Table5, Fig8 shows the PO-Curve results and curves for Model1and Model2.

Table.4: Pushover Curve results for Model I		
STEP	BASE FORCE	DISPLACEMENT
0	0	0
1	3.35	334.75
2	6.7	669.51
3	10.05	1004.27
4	13.4	1339.03
5	16.75	1673.78
6	20.1	2008.54
7	23.45	2343.3
8	26.8	2678.06
9	30.15	3012.82
10	31.91	3189.58
11	33.5	3346.63

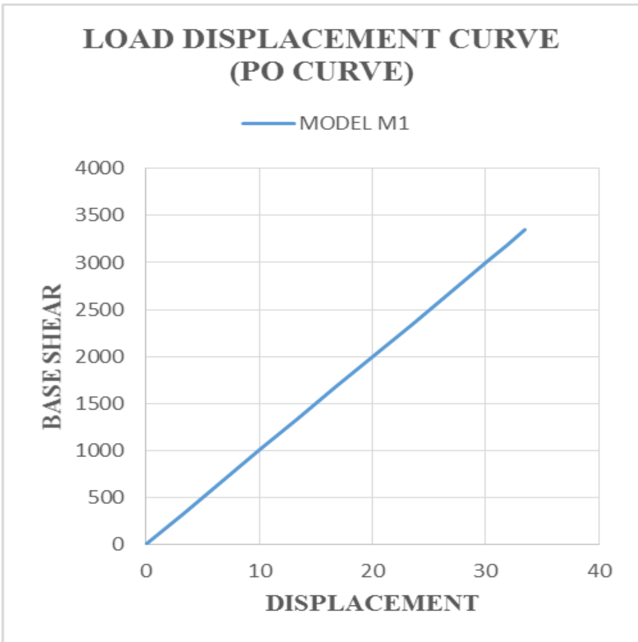


Fig.7: PO Curve for Model I

Table.5: Pushover Curve results for Model II

STEP	BASE FORCE	DISPLACEMENT
0	0	0
1	0.815	78.5295
2	1.63	157.0591
3	2.445	235.5886
4	3.26	314.1181
5	4.075	392.6476
6	4.89	471.1772
7	5.705	549.7067
8	6.52	628.2362
9	7.2215	695.8313
10	8.15	785.2633

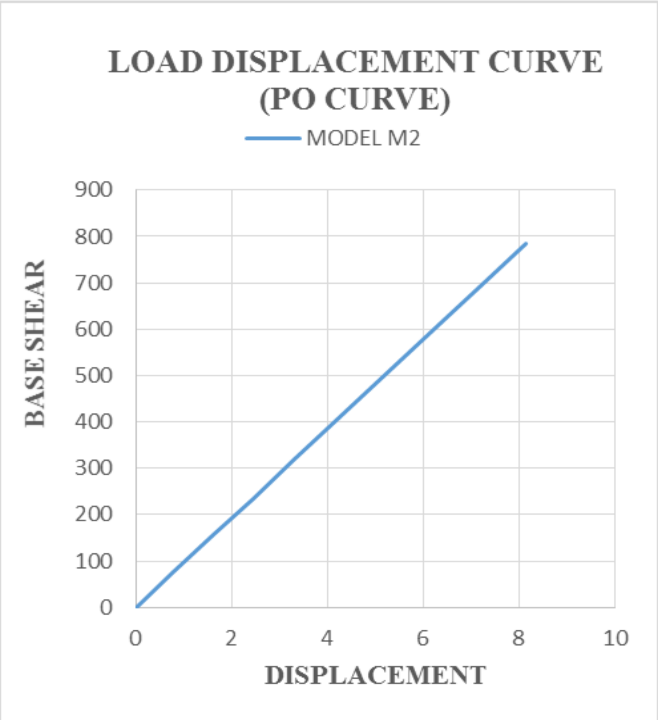


Fig.8: PO Curve for Model II

4.CONCLUSION

- The Storey shear obtained from non-linear pushover analysis seems to be about 37.68% greater than storey shear obtained by linear equivalent static analysis. Also storey shear depends on the mass of the building model considered.
- Storey drift and storey shear values are also extracted, tabulated and graphed for both linear and nonlinear static analysis for the models load combinations considered.
- Base shear verses monitored displacement pushover curves are attained for all the building models considered by performing nonlinear static pushover analysis.
- Overall capacity of the building depends on the applied loads and the base shear capacity for the model M1 which can withstand is 3346.63 kN beyond which the building model tends to move in plastic state.

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