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# Pushover Analysis of RC Building with and without Floating Column

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***Abstract*— RC structure and Floating column structure are typical features in the modern multi-storey constructions in urban India. Such features are highly undesirable in buildings built in seismically active areas; this has been verified in numerous experiences of strong shaking during the past earthquakes like Bhuj 2001. In this study an attempt is made to reveal the effects of floating column in RC building effected with seismic forces. For this purpose 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 determination of actual performance of the structure. To achieve this objective, two RC structures with G+3 stories will be analyzed and compared the base force and displacement of RC structure for earthquake forces by using ETABS 2015 analysis software.**
**Keywords: floating column, RC structure, pushover analysis, earthquake forces, ETAB2015**

## I. INTRODUCTION

Many urban multistorey buildings in India today have open first storey as an unavoidable feature. This is primarily being adopted 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.

## II. FLOATING CLOUMNS

Floating column is also a vertical member, The Columns Float or move in above stories such that to provide more open space is known as Floating columns. Floating columns are implemented, specially above the base floor, so that added open space is accessible for assembly hall or parking purpose. For the study of the floating column many projects have been undertaken where the transfer of load is through the girders. Floating columns are usually adopted above the ground storey level. So that maximum space is made available in the ground floor which is essentially required in apartments, mall or other commercial buildings where parking is a major problem.

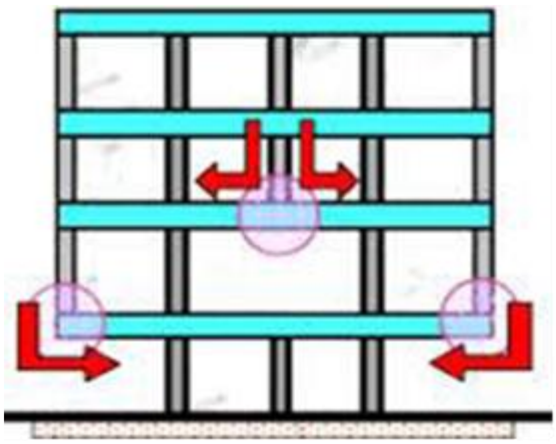


Figure 1. Building with Floating

But those structures cannot be demolished; rather study can be done to strengthen the structure. The stiffness of these columns can be increased by retrofitting or these may be provided by bracing to decrease the lateral deformation. Many high rise buildings are planned and constructed with architectural complexities. The complexities are nothing but soft storey, floating column, heavy load, the reduction in stiffness, etc.

### A. Methodology

In the of case structures to avoid earth quake damages, special arrangement needs to be made to increase the lateral strength and stiffness of the members. As per IS 1893 (part-1): 2002, 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.

### B. CALCULATION OF BASE SHEAR

The total design lateral force or design seismic base shear (VB) is calculated according to clause 7.5.3 of IS 1893:2002 (IS 1893:2002 is referred to as the Code subsequently).

The total Base shear=

$V_b = A_h \times W$

Where Ah is the design horizontal seismic coefficient.

Ah = (Z/2) x (Sa/g) x (I/R)
Here
Z = Zone Factor
I = Importance Factor
R = Response Reduction Factor
The values of Z, I, R are given in Tables 2, 6, 7 respectively in IS 1893 (part-1):2002.
Sa/g = Spectral acceleration coefficient. 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 = 0.0075x h0.75
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

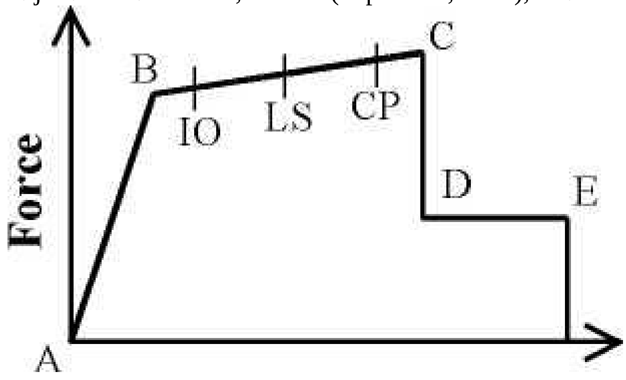
C. PUSHOVER ANALYSIS

Pushover analysis is a static, nonlinear procedure in which the magnitude of the lateral loads is incrementally increased, maintaining a predefined distribution pattern along the height of the building. Pushover analysis can determine the behavior of a building, including the ultimate load and the maximum inelastic deflection. Local nonlinear effects are modeled 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.

NON-LINEAR STATIC ANALYSIS

The existing building can become seismically deficient since seismic design code requirements are constantly upgraded and advancement in engineering knowledge. Further, Indian buildings built over past two decades are seismically deficient because of lack of awareness regarding seismic behaviour of structures. 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 colors 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)




III. BUILDING DETAILS

The basic planning and the loading conditions are considered same for RC Structure with Floating Column and without Floating Column. For present work Pushover analysis is carried out for reinforced concrete moment resisting building frame having (G+3) storeys situated in zone IV. The analysis is carried out using ETABS 2015.

Two types of buildings considered in the study, which are
1) RC Buildings without Floating Column.
2) RC Buildings with Floating Column.

Table 1: Design Basis

| | |
|---|---|
| Type of building | Residential Building |
| Type of frame | Moment Resisting Frame |
| Total height of building | 12 m |
| Plan of the building | 9m × 9m |
| Thickness of external walls | 230mm |
| Live load | 4.0kN/sq.m |
| Grade of Concrete | M20 |
| Grade of reinforcing Steel | Fe415 |
| Density of Concrete | 25 kN/m3 |
| Density of brick masonry | 20 kN/m3 |
| Zone | IV |
| Soil type | Rock |
| Importance factor | 1.0 |
| Response reduction | 5.0 |
| Seismic zone factor | 0.24 for zone IV |
| Damping ratio | 5% (For RCC& Composite structure) |

Table 2: Structural Member Sizes

| **Member** | **Model 1** | **Model2** |
|---|---|---|
| Columns | 230mmX450mm | 230mmX450mm |
| Beams Below Floating Column | | 230mmX600mm |
| Beam | 230mmX450mm | 230mmX450mm |
| Slab | 150mm slab | 150mm Deck |

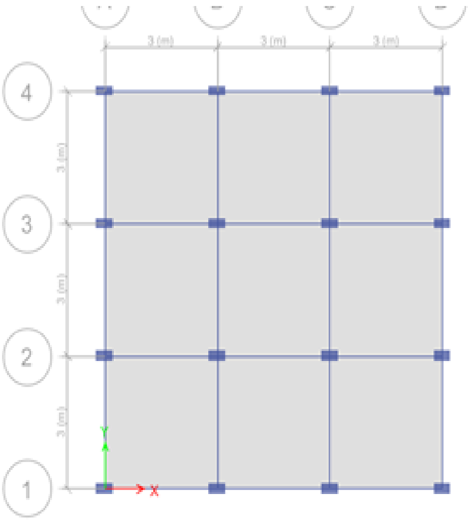


Figure 2. Plan of Model 1

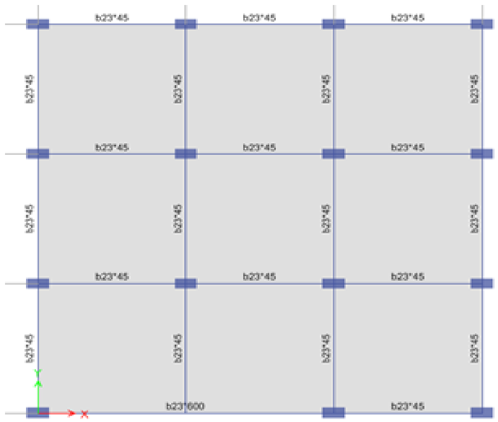


Figure 3. Plan of Model 2

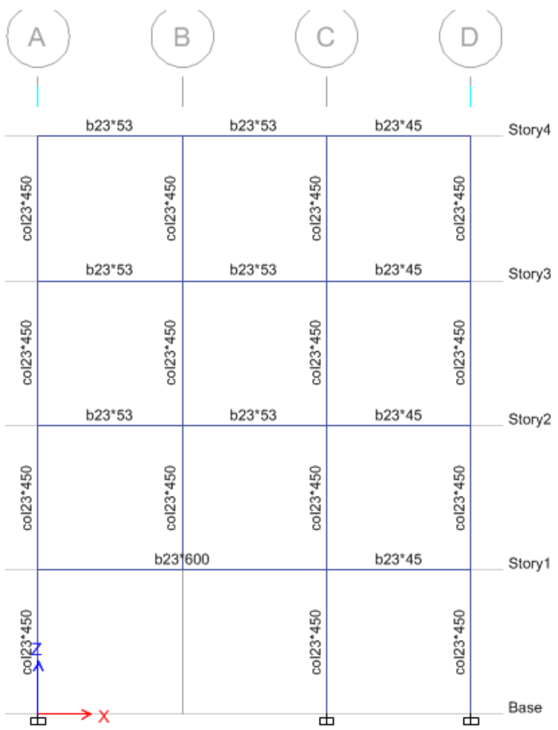



Figure 4. Elevation of model 2

## IV. RESULTS AND DISCUSSION

A. *1.* Pushover Curve

1. For model 1


**Figure 5. base shear vs Displacement**

**2. For Model 2**

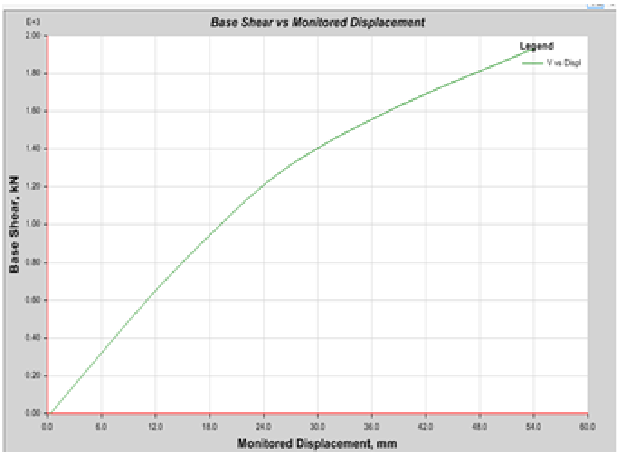



**Figure 6. Base shear vs Displacement**

**3. Stepwise Performance of Model 1**

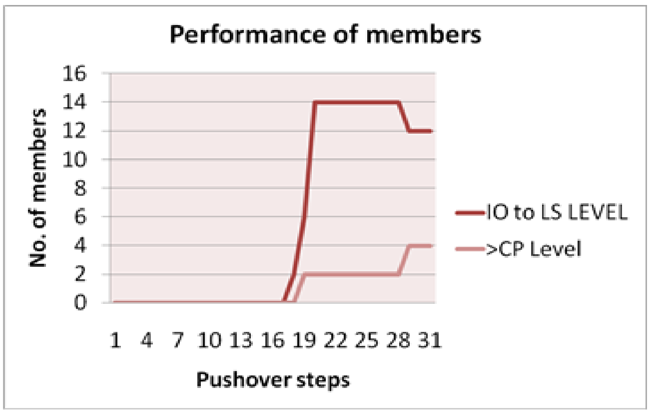



Figure 7. Pushover steps Vs No. of Members

1. Stepwise Performance of Model2

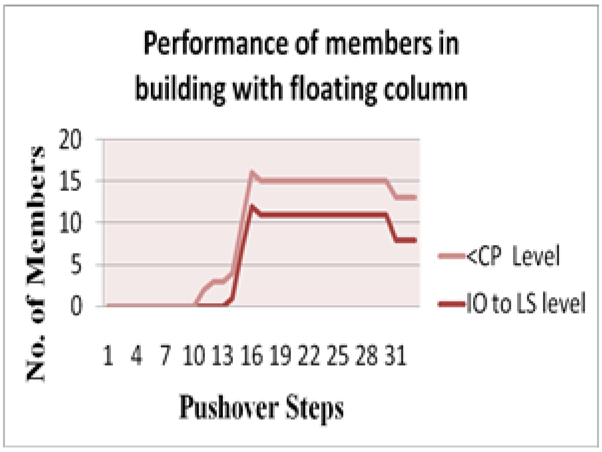



Figure 8 . Pushover steps Vs No. of Members

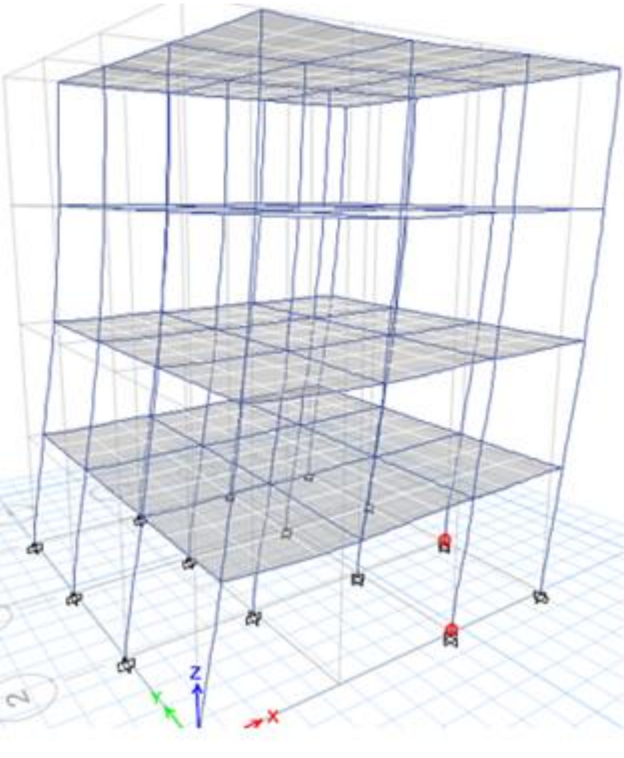


Figure 9 .1st hinge Formation in Model 2

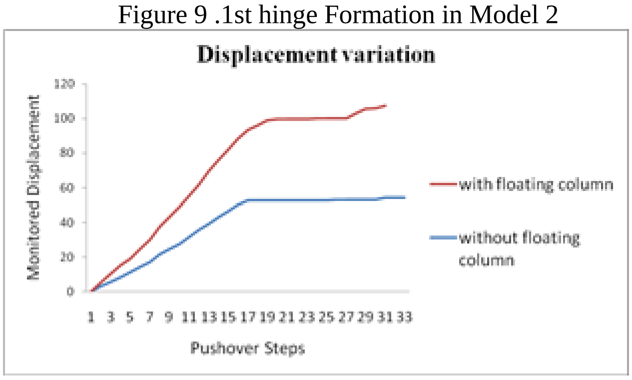



Fig. 10 Stepwise Displacement variation in both the models

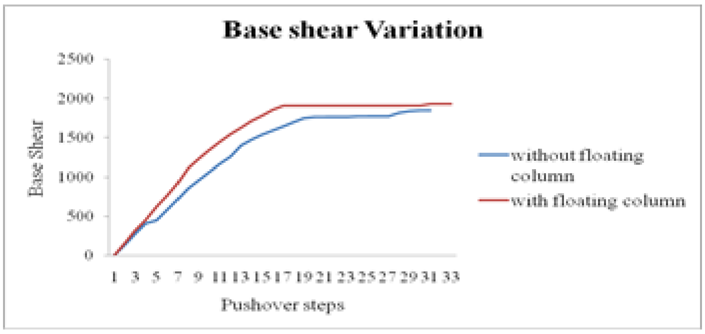



Fig. 11 Stepwise Base shear variation in both the models

2. Column force

For model 1

| Story | Column | Load Case | P |
|---|---|---|---|
| Story1 | C1 | PUSHX | -54.7033 |
| Story1 | C9 | PUSHX | -457.574 |
| Story1 | C13 | PUSHX | -323.494 |
| Story1 | C14 | PUSHX | -511.585 |

For model 2

| Story | Column | Load Case | P |
|---|---|---|---|
| Story1 | C1 | PUSHX | -155.7344 |
| Story1 | C9 | PUSHX | -640.2032 |
| Story1 | C13 | PUSHX | -319.7163 |
| Story1 | C14 | PUSHX | -508.6969 |

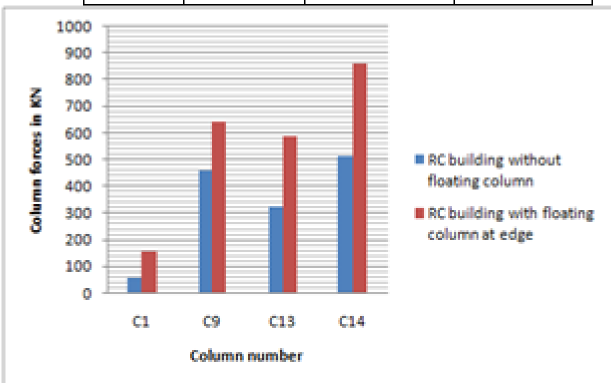



Figure 12.Comparison of Critical Column Forces of model-1 and model-2

3. Column Moments

For model 1

| Story | Column | Load Case | M3 |
|---|---|---|---|
| Story1 | C1 | PUSHX | 97.9298 |
| Story1 | C9 | PUSHX | 169.2933 |
| Story1 | C13 | PUSHX | 139.6387 |
| Story1 | C14 | PUSHX | 173.5334 |

For model 2

| Story | Column | Load Case | M3 |
|---|---|---|---|
| Story1 | C1 | PUSHX | 148.1602 |
| Story1 | C9 | PUSHX | 223.9871 |
| Story1 | C13 | PUSHX | 143.5654 |
| Story1 | C14 | PUSHX | 176.0143 |

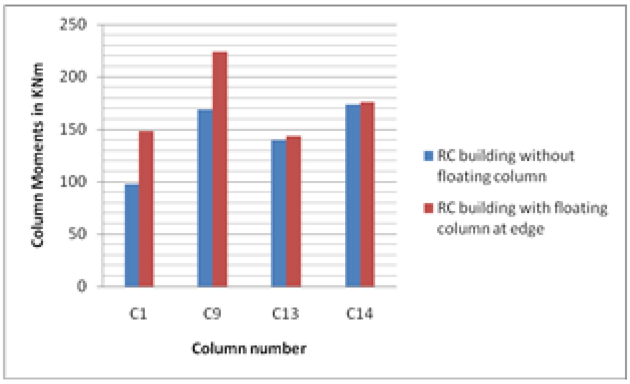



Figure 13.Comparison of Critical Bending Moments in Column of model-1 and model-2

## V. DISCUSSIONS

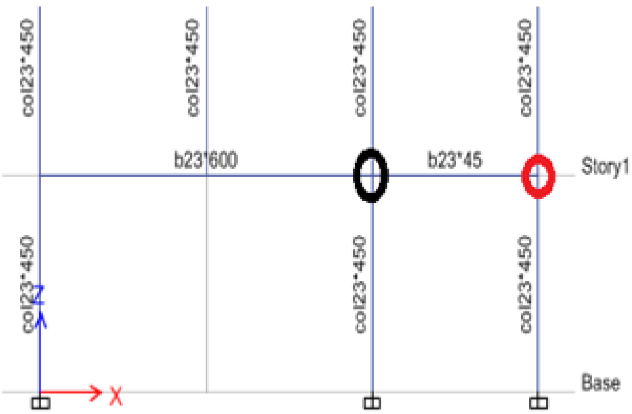



Figure 14. Columns directly Exceeding the CP level

The circle Marked columns are the weakest part in building with floating column(Model 2). It is obvious that the Section of beam Below floating column has to be increased to fulfill the demand of safety. But as per as results of analysis, By increasing the section of this girder we cannot say that structure will give the proper response during Ground Shaking Though it is found safe for the vertical load cases. When Pushover analysis is performed on the building with floating column The columns below floating are found to be critical and exceeds the acceptance criteria CP (Collapse prevention).

## CONCLUSION

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. If column forces of columns C1, C9, C13, C14(columns below an around girder supporting floating column) are compared with column force in building without floating column ,it is seen that about minimum 50% of increase is observed in column forces with floating column than in building without floating column. The sections of these column should be appropriately increase to with stand safely.

4. Moments in column C1, C9, C13, C14 are drastically increased in Building with floating column.

5. Base shear, displacement, drift increases in building with floating column as compared to building without floating column.

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## References

[1] Applied Technology Council, ATC 40: Seismic Evaluation and Retrofit of Concrete Buildings (USA,1996).

[2] Federal Emergency Management Agency, FEMA 356: Pre-standard and Commentary for the Seismic Rehabilitation of Buildings (Washington, 2000).

[3] Federal Emergency Management Agency, FEMA 440: Improvement of Nonlinear Static Seismic Analysis Procedures (Washington, 2005).

[4] IS 1893-2002 (Part I) Indian Standard Criteria for Earthquake Resistant Design of Structures (New Delhi, 2002)

[5] IS 13920 : 1993 Ductile Detailing of Reinforced Concrete Structures Subjected To Seismic Forces. -(1993, Reaffirmed 2008), Code of Practice -Indian Standards.

[6] IS 456:2000 Plain and Reinforced Concrete - Code of Practice-Indian standards

[7] D. Satish and RaghavaRao, "Push Over Analysis For Rc Building With And Without Floating Columns", international Journal of Advancements in Research & Technology, Volume 4, Issue 11, November -2015 ISSN 2278-7763

[8] Hardik Bhensdadia1, Siddharth Shah , "Pushover Analysis Of RC Frame Structure With Floating Column And Soft Story In Different Earthquake Zones" International Journal of Research in Engineering and Technology , Volume: 04 Issue: 04 | Apr-2015

[9] Martino R and Kingsley G.,"Pushover Analysis of Reinforced Concrete Frame Structures", Asian Journal of Civil Engineering (Building and Housing) Vol. 9, No. 1(2004) Pages 75-83.

[10] Prerna Nautiyal, Saleem Akhtar and Geeta Batham, “Seismic Response Evaluation ofRC Frame Building with Floating Column Considering Different Soil Conditions”,International Journal of Current Engineering and Technology, Vol.4, Issue 1, 2012, pp.132-138.

[11] Tufan Cakir, “Evaluation of The Effect of Earthquake Frequency Content on Seismic Behaviour of Cantilever Retaining Wall Including Soil–Structure Interaction”, Soil Dynamics and Earthquake Engineering,Vol.45, pp. 96–111, 2012.

[12] Kavya N, Dr. K.Manjunatha, Sachin.P.Dyavappanavar, “Seismic Analysis of RCMulti-Storied Structures with Shear Walls at Different Locations”,International Research Journal of Engineering and Technology (IRJET), Vol. 02, Issue 06,2015 , pp. 214-219.

[13] Maison Bruce F. and Neuss Carl F., “Dynamic Analysis of A Forty Four Storey Building”, Journal of Structural Engineering, Vol. 111,Issue 7,July 1985, pp.1559- 572.

[14] Pradeep Kumar Ramancharla , “Seismic Analysis of A Normal Building and

[15] Floating Column Building”International Journal of Engineering Research & Technology (IJERT), Vol.3, Issue 9, pp. 981-987.

[16] ArlekarJaswant N, Jain Sudhir K. and Murty C.V.R, “Seismic Response of RC Frame Buildings with Soft First Storeys”, Proceedings of the CBRI Golden Jubilee Conference on Natural Hazards in Urban Habitat, 1997, New Delhi.

[17] Awkar J. C. and Lui E.M, “Seismic Analysis And Response of Multi-Storey Semi Rigid Frames”, Journal of Engineering Structures, Vol. 21, Issue 5, pp. 425-442, 1997.