EFFECT OF FLOATING COLUMNS AND SOFT STOREY ON SEISMIC RESPONSE OF MULTI-STOREYED RC FRAMED BUILDINGS

Avinash Biradar[1], Shivanand C. G[2]

P. G. Student[1], Assistant professor[2]

M. Tech, Structural Engineering[1]

The Oxford College of Engineering, Bengaluru, India[1]

Abstract-Various factors which govern in contributing damage to the structure during an earthquake are vertical irregularities, irregularity in stiffness and strength, mass irregularity, torsional irregularity, etc... One such irregularity is a floating column. In this study the influence of floating columns in different storey levels in multi-storey building is studied. It is basically a stubbed column which is stopped at a particular storey and don't have any continuity to the lower adjacent storey. They use in building for parking space and aesthetics, but when such column become active member in resisting and dissipating the lateral forces due to seismicity, a hindrance is created in the clear load path and thereby generating a weak link in the structure.

The soft storey is also undesirable in building built in seismically active areas. In this study infill walls have considered to reduce the lateral load on the structure. For floating column bending moment parameter studied and for soft storey Lateral Displacement and Storey drift, Storey stiffness, time period considered. It is observed that by introducing floating column and soft storey at different storey locations in the building the criticality of the structure increases in terms of bending moment, storey drift, and Storey displacement. Conclusions drawn from the study stipulates that introducing Floating Columns and Soft storey increases the criticality of the structure under seismic forces.

Keywords—Soft Storey, Floating column, dynamic analysis, response spectrum analysis.

1. INTRODUCTION

Earthquake is a characteristic associated with violent shaking of the ground. It relies large strain energy when an earthquake travels s seismic waves any way through the earth layer reflecting & refracting at each interface.

A column is vertical member which has no foundation and rest on a beam is called floating column, It acts as a point load which transfer load from beam to columns below it. But in higher seismic zone providing floating column is very difficult, the below fig shows the floating column in building.

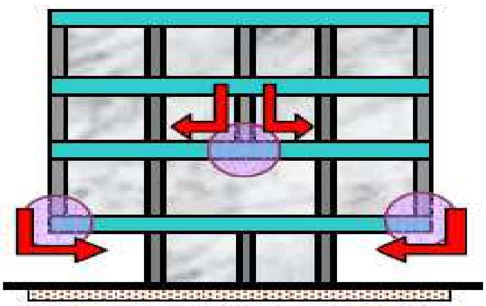

Fig1.1 floating column in building

Soft Storey:

The lateral stiffness of the storey is less than 70 percent of the above storey or less than 80 percent of above three storey's average stiffness.

Masonry infill's in RC frame structure:

In reinforced concrete building with masonry infill walls are widely constructed for industrial, commercial and multi-storey residential uses in seismic zones. Masonry infill consists of concrete or brick block, which is constructed in between column and beam of RC frame.

The use of infill walls has more impact on seismic response of RC framed structure which increases stiffness and building strength. And an infill wall reduces the bending moment and lateral deflection of the buildings reducing the collapse of the building.

Fig1.2 ground floor is open

2. OBJECTIVES

My research project aims at doing a seismic evaluation on the effect of floating column and soft storey in a building.

(1) To study the impacts of Floating column & Soft storey in structural behavior of high rise building.

(2) To Model the multi-storey structure with & without floating columns at different storey levels using ETABS 13.

(3) Model building with soft storey and infill walls at different floors.

(4) To do Dynamic analyses (RSA) for different cases of an unsymmetrical building.

(5) Comparison will be done for multi-storey building with and without floating columns, and same for soft storey when they set at different locations.

(6) All the structural models are carried out in seismic zones (Zone 5).

(7) For different building models the following parameters have been studied storey displacement, bending moment, time period, storey drift, storey stiffness, bending moment.

3. METHODOLOGY AND PROBLEM DESCRIPTION

An RCC building of 25mX35m is considered having a special moment resisting frame of 15 storeys. ETABS V13 is the software used for analyzing the frame. Inputs are mentioned below.

Table3.1 Model Details

Sl. No	Description	Floors	Details
1	Storey height		Base- 4.5m
			Typical- 3.5m
2	Materials		Concrete , Brick masonry
3	Column size	Base to 10th floors	500X500mm
		11th to 15th floors	400X400mm
4	Beam Size	Base	230X400mm
		1st to 10th floors	230X400mm
		11th to 15th floor	230X300mm
5	Slab thickness	For all floors	125mm
6	Live Load	Typical floor	3kN/m²
		Terrace Floor	2kN/m²
7	Super Dead Load (SDL)	Typical floor	1.8kN/m²
		Terrace Floor	1.2kN/m²

a) PLANS AND MODELS ON FLOATING COLUMN

- **Case 1:** Bare Frame Model (BFM)
- **Case 2**: Building with Floating columns at different floors.
  - Model 1: Floating column at 1st/ Ground Floor. (M1)
  - Model 2: Floating column at 5th storey. (M2)
  - Model 3: Floating column at 10th storey. (M3)

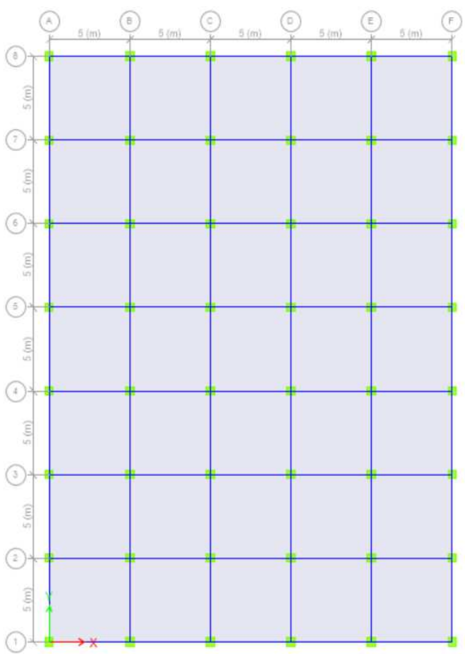

Fig3.1 plan view of regular building

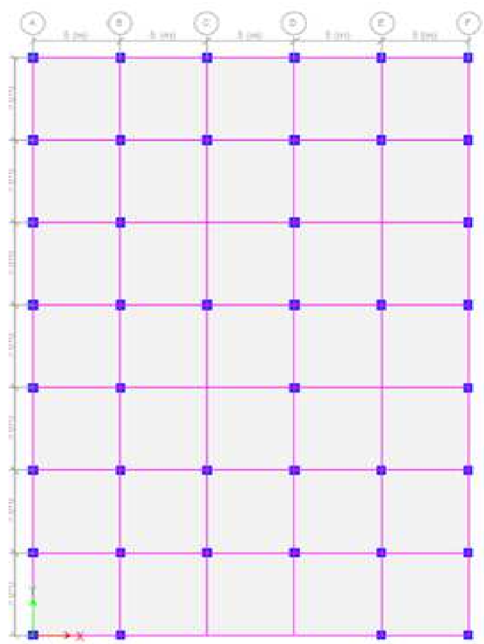

Fig3.2 plan with floating column at 1st floor

b) PLAN AND MODEL OF SOFT STOREY HAVING INFILL WALLS AND WITHOUT INFILL WALL.

For these models the above data is same as shown in Table3.1.

- **Case 3:** Regular Building.
- **Case 4:** Building with Infill walls and soft storey effect at different floors.
  - Model 4: Soft Storey in 5th floor and other floors having infill walls. (M4)
  - Model 5: In this Soft Storey will be at 10th floor and other floors having infill walls. (M5)
  - Model 6: Building with soft storey effect at 15th floor and remaining floor are infill walls. (M6)

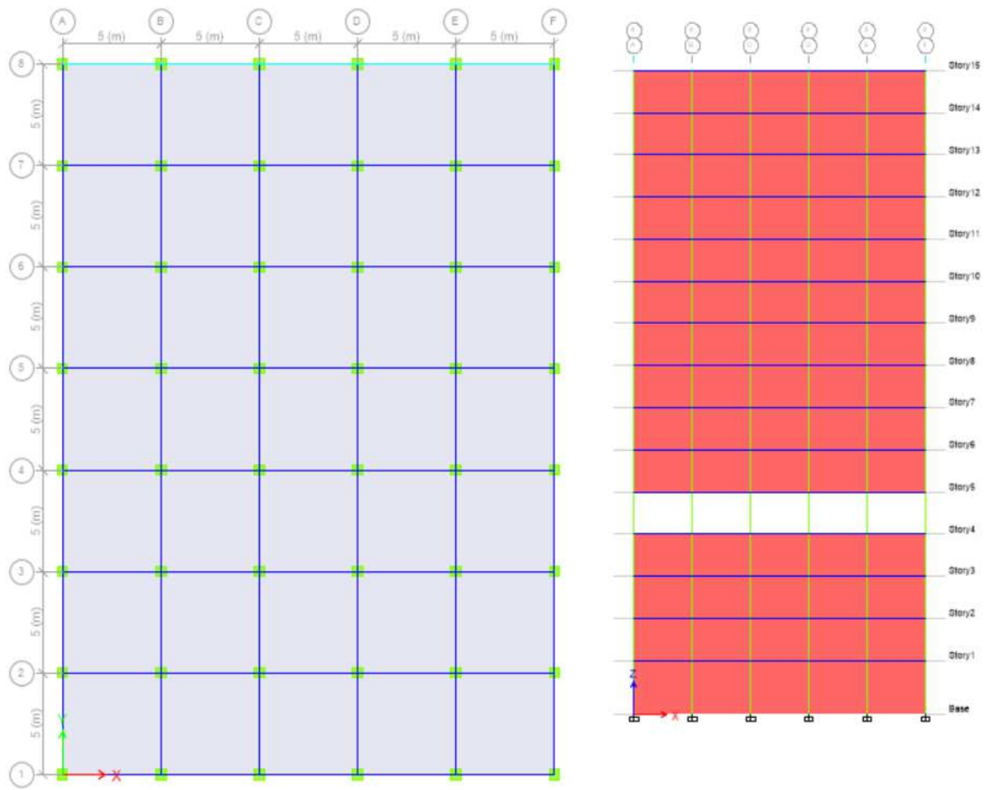

Fig3.3 Plan and elevation view of the soft storey in 5th floor

4. RESULT AND DISCUSSION

a) Comparison will be done with and without floating column.

In this the bending moment values seen surrounding the columns which have been removed from different floors.

Table4.1 bending moment values for beams

BENDING MOMENT (kN-m)				
	BARE FRAME	GF FC	5th FC	1Oth FC
BEAMS	BFM	M1	M2	M3
B69	9.4681	95.1366	92.1362	98.5059
B32	9.377	13.3594	13.2591	20.5733
B33	9.2894	100.2092	96.5708	99.6748
B41	15.5321	80.9592	71.202	73.224
B75	15.7116	78.126	71.586	70.6844
B42	15.5844	85.6433	74.071	73.885

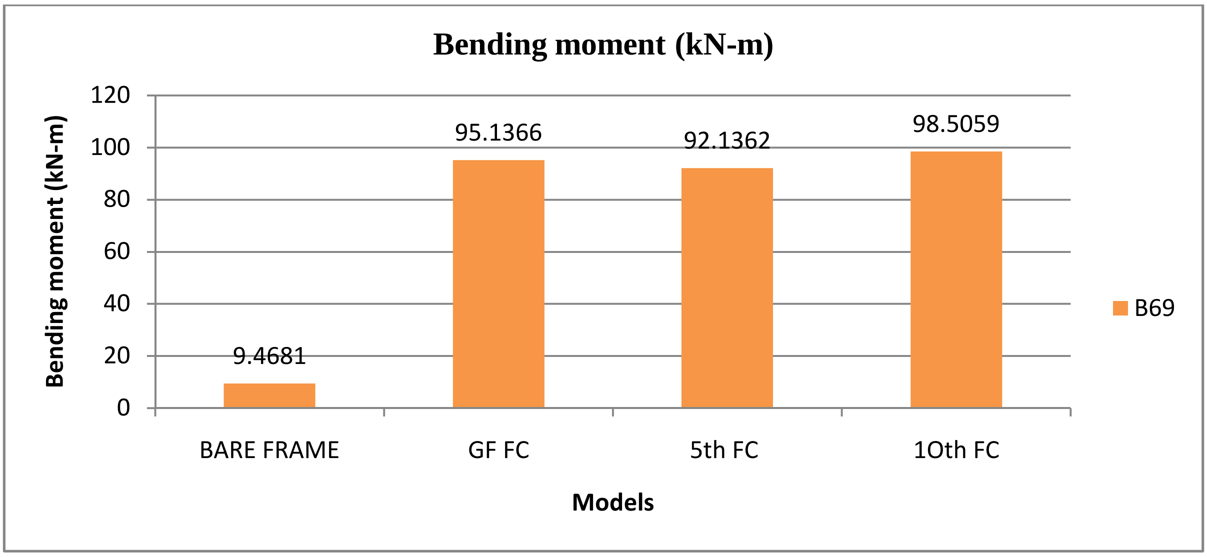

Fig4.1 bending moment to beam (B69)

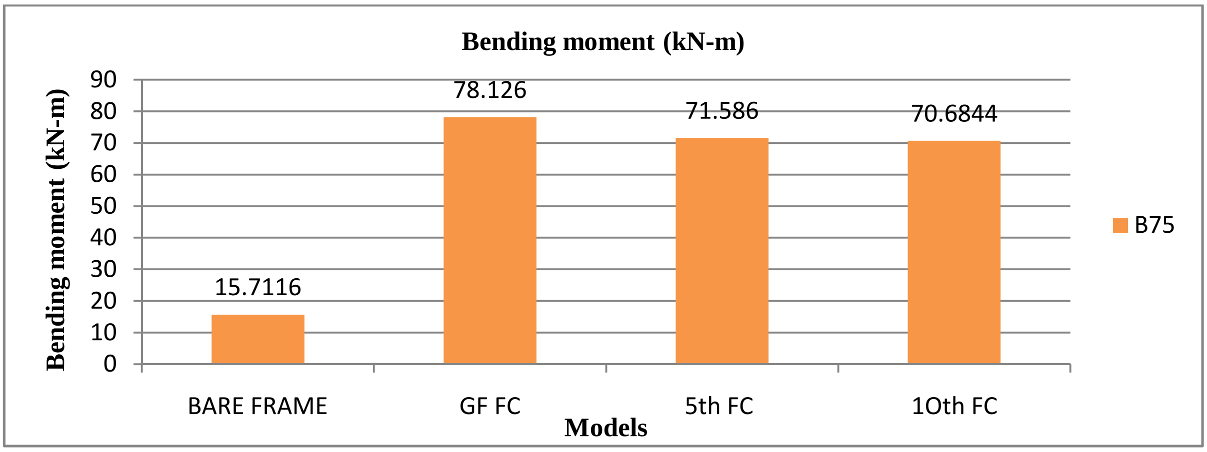

Fig4.2 bending moment to beam (B75)

Discussion on Bending moment Values

In this floating column has been placed at different floors and there bending moment behaviors studied.

- From the above graph it is found out that more bending moment will be in floating column buildings than normal building.
- It is seen that more bending moment in model M1 compared to (M2 and M3). Due to presence of floating column in ground floor.
- However it is seen that use of floating column at top storey's safer than ground storey.
- The bending moment value increases in 80% to 90% in model (M1) compared to bare frame model.

b) Comparison done between the models of Case 4 and Case 3 for soft storey effect.

Storey Displacement

Table4.2: Storey Displacement of all floors in RSX

STOREY DISPLACEMENT (mm)				
	Bare frame	5th SS	10th SS	15th SS
Storey	BFM	M4	M5	M6
15	407.3	20.3	15.9	11.1
14	396.5	20	15.8	6.7
13	379.2	19.7	15.5	6.6
12	355.8	19.3	15.2	6.4
11	328.2	18.8	14.8	6.1
10	301.1	18.3	14.2	5.8
9	279	17.7	5.5	5.4

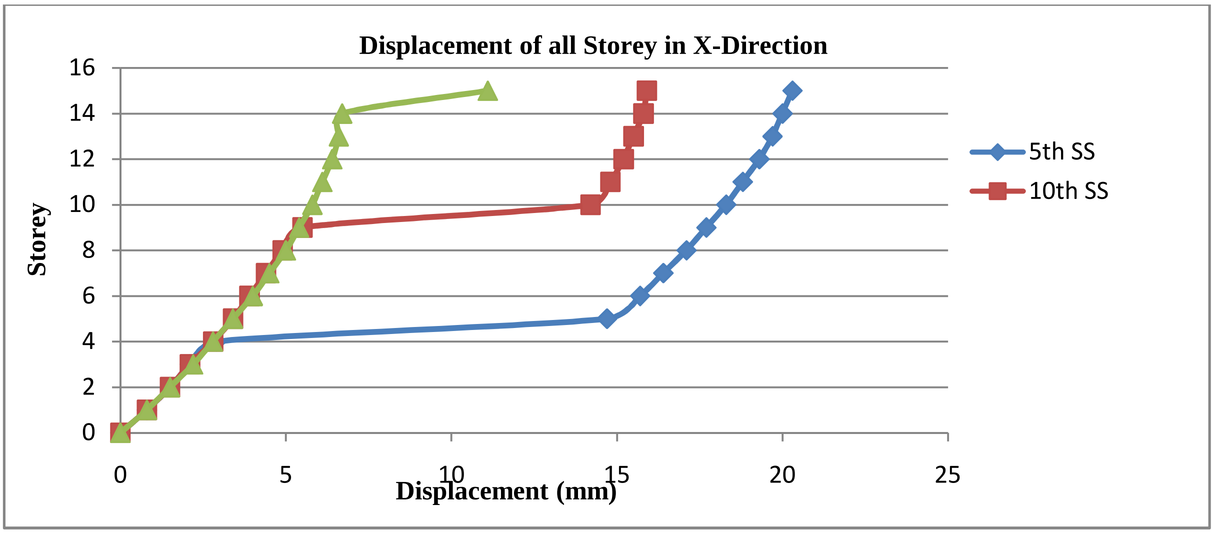

Fig 4.3: Displacement for different Soft Storey levels in X-Direction

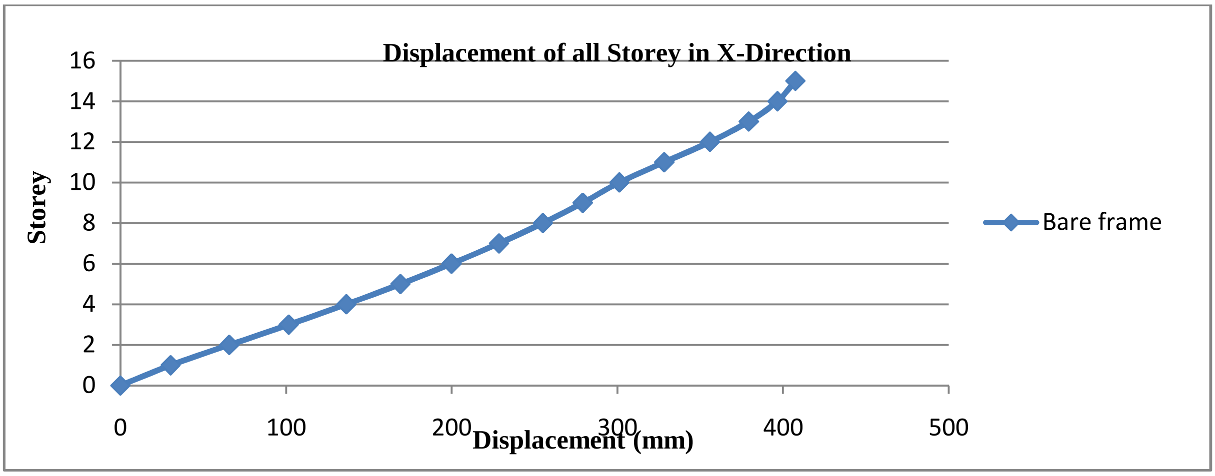

Fig 4.4: Displacement for bare frame model in X-Direction

Discussion on Displacement Values

- The maximum displacement is at the 15th floor in all the models.
- From above fig. 4.3 and fig 4.4, it is found that, in case of infill walls, there will be sudden change in the displacement at a floor where infill walls are absent and varies linearly.
- In bare frame model (BFM) displacement is too high compared with models having brick masonry infill walls. Hence, an infill wall plays an important role in displacement values during earthquakes.
- The displacement is more in model (M4) compare to other models (M5 and M6) having soft storey effect in different levels.

Storey Stiffness

Table4.3: Storey Stiffness of all floors in RSX

STIFFNESS (10^3) (kN/m)				
	Bare frame	5th SS	10th SS	15th SS
Storey	BFM	M4	M5	M6
15	117.4459	3627.56616	7409.4196	318.42294
14	137.47379	6666.76472	11384.128	14657.886
13	137.43519	8643.6957	13191.368	18524.167
12	141.14936	10021.866	14928.938	18451.532
11	169.45284	10951.944	13543.807	18464.694
10	241.91135	12046.791	969.140903	19299.379

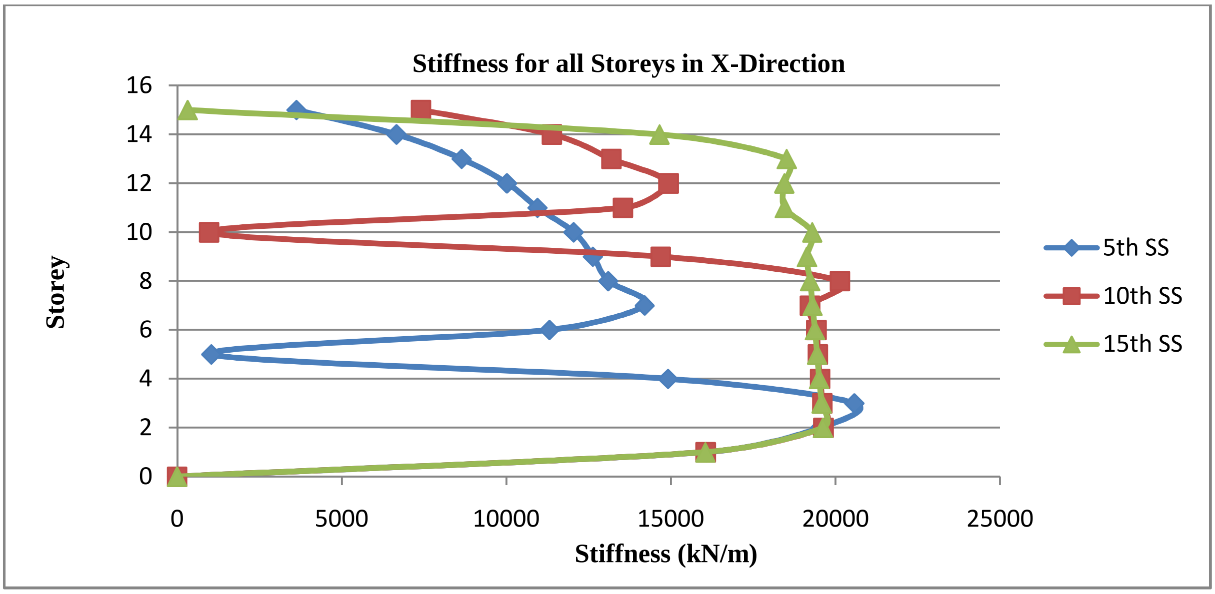

Fig 4.5: Stiffness for different Soft Storey levels in X-Direction

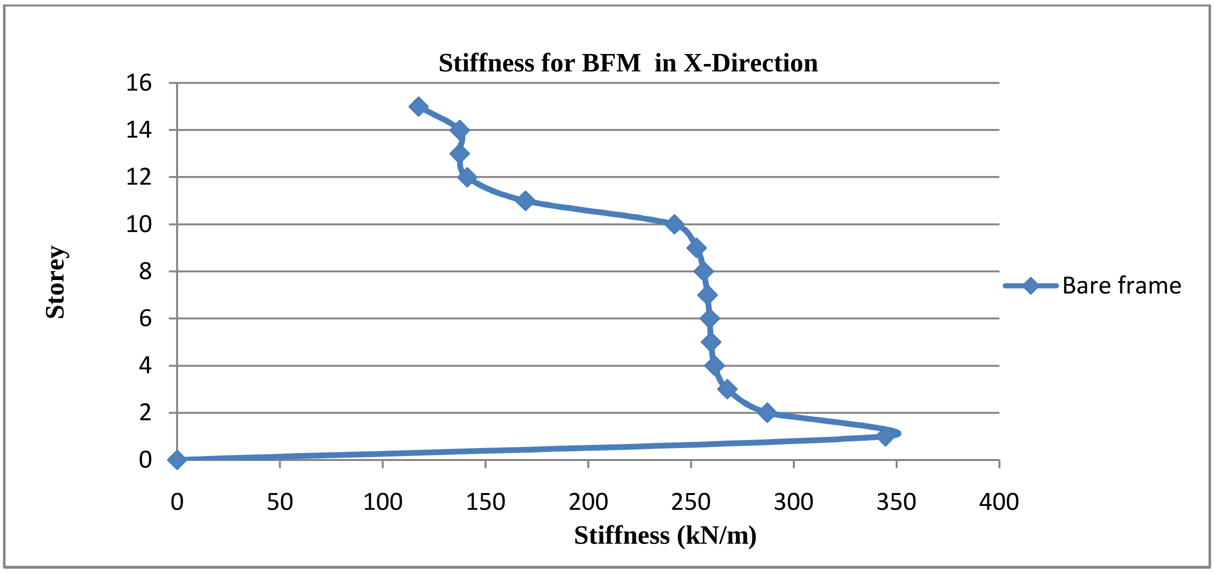

Fig 4.6: Stiffness for bare frame model in X-Direction

Discussion on Stiffness Values

It is seen that more the stiffer the structure is, more can resist them from failure due to lateral loads. The building without any lateral resisting unit is less stiff and failure will be more in that structure.

- From the Table 4.3 it is seen that bare frame model has very less values for stiffness due to absence of infill walls. The Stiffness is more in ground floor and reduces as it moves to upper floors.
- To maintain the stiffness of the building masonry infill walls or any other lateral load resisting element should be provided.

MODE PERIOD OF ALL MODELS

Table4.4: Mode Period Values

MODEL PERIODS (sec)				
	Bare frame	5th SS	10th SS	15th SS
MODES	BFM	M4	M5	M6
1	4.047	0.954	0.744	0.543
2	3.857	0.868	0.669	0.465
3	3.616	0.724	0.547	0.344
4	1.501	0.218	0.287	0.322

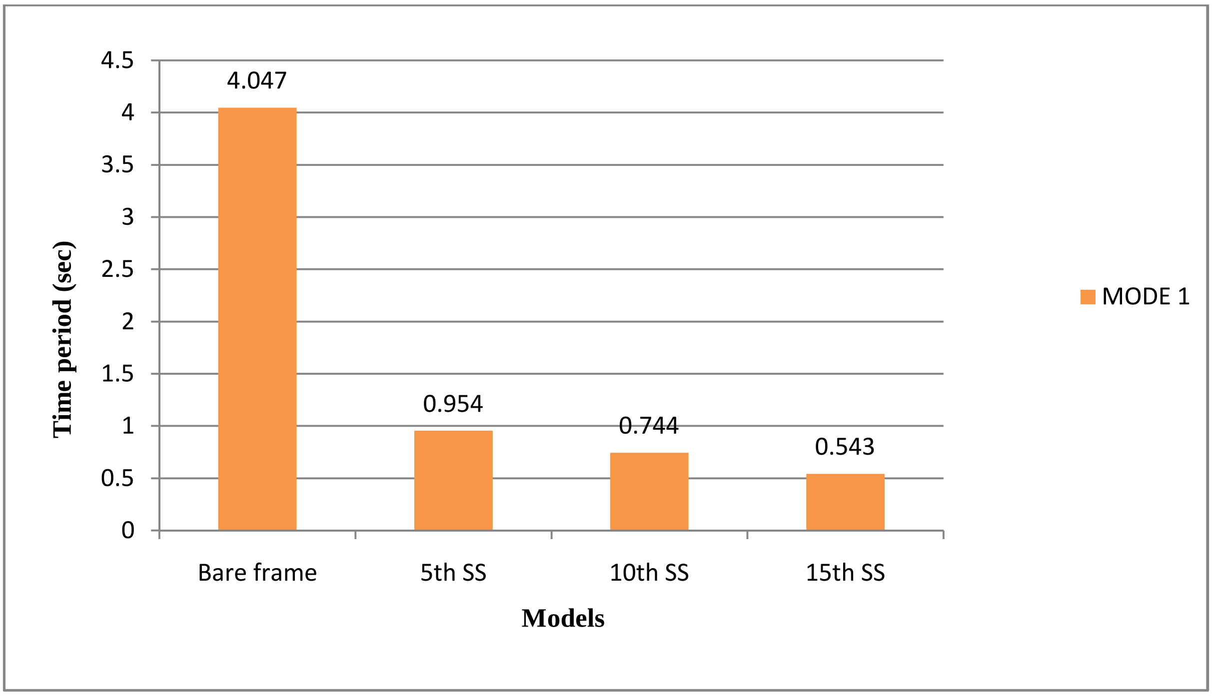

Fig4.7: Time Period for all the Models

Discussion on Modes period Values

Time period of the building for particular mode shape is the time taken to complete the oscillation for corresponding mode shape. After giving a unit displacement to the structure and when releasing the displacement suddenly the building moves in back and forth motion having some time period which is called fundamental time period of the structure.

- The vibration is more in regular frame model because there is no lateral load resisting elements and stiffness is also weak in it.
- From the chart it is found out that less time period in model M6 compare to (M4 and M5). Because it depends on soft storey effect in different storey levels.

5. CONCLUSION

From the analysis results, it is found that use of floating column and soft storey in the building increases the collapse of building under earthquake forces as compared to conventional buildings.

- It is evident from dynamic analysis that introduction of Floating Column in a building increases the bending moment of beams with respect to its regular counterpart and thereby increasing the criticality of structure when seismic forces are considered.
- It is observed that the bending moment tends to be maximum when Floating Columns exist at the bottom most storey for all the models under consideration hence, it can be deduced that the critical location for floating columns to exist in a building is at its bottom storey.
- Storey displacement has shown highest value at top storey and least value at bottom storey, both in bare frame and infill frame.
- The Fundamental natural period of bare frame model has higher magnitude than the infill frame model.
- The bare frame gives high displacement and the risk of deflection during earthquake is high. Hence providing the lateral load resisting elements is important to minimize the risk of failure.
- Because of soft storey, sudden increase in the drift can be seen in that floor. Stiffness will be more for the storey having infill walls and bare frame is weak in stiffness.
- The arrangement and placing of infill walls is very important to minimize the soft storey effect.
- Displacement resistance and controlling the drift can be done by the addition of infill walls in turn, improves the stiffness of the building.

6. REFERENCES

[1] Abhishek Arora, " Alternative Approach to Soft Storey in Seismic Analysis of R.C.C Building Structures" SSRG International Journal of Civil Engineering (SSRG-IJCE) – EFES April 2015

[2] A.S.Kasnale,Dr. S S Jamkar, "Study Of Seismic Performance For Soft Basement of RC Frame" International Journal of Engineering Science & Research Technology"

[3] Bhavya B S1,Jisha P, **"**Seismic Evaluation of RC Unsymmetrical Building with Floating Columns and Soft storey Considering Different Configuration", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, Issue 8, August 2016.

[4] Dande P. S, Kodag P. B. "Influence of Provision of Soft Storey in RC Frame Building for Earthquake Resistance Design" International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 3, Issue 2, March -April 2013, pp.461-468

[5] Dr. Saraswati Setia and Vineet Sharma " Seismic Response of R.C.C Building with Soft Storey" International Journal of Applied Engineering Research, ISSN 0973-4562 Vol.7 No.11 (2012)

[6] IS-875 (Part-1)-1987 code of practice for design loads (other than earthquake loads) for buildings and structures: part-1 for dead loads.

[7] IS: 1893 (Part 1): 2002. "Criteria for Earthquake Resistant Design of Structures", Bureau of Indian Standards, New Delhi.