PUSHOVER ANALYSIS OF RC FRAME STRUCTURE WITH FLOATING COLUMN ON SLOPING GROUND

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Abstract - Floating columns are typical feature in modern multi-storey construction. Floating column are considered due to the need of column free space, aesthetical view and functional requirement. The building located on sloping ground is irregular and unsymmetrical in both vertical and horizontal planes and torsionally coupled. In this present study fourteen number of ten storey RCC building frame models are considered, out of which seven models are step back building frames in which six models are step back building with floating columns at different location and one is step back building without floating column and remaining seven models are step back-set back in which six models are step back-set back building with floating columns at different location and one is step back –set back building without floating column are considered. The pushover analysis is performed for the considered fourteen models as per IS 1893:2002 & ATC 40, using ETABS version 9.7.4. From the pushover analysis the properties of the buildings such as time period, displacement, storey shear, storey drift, and performance point have been studied for different models.

Key Words: Floating column, sloping ground, pushover analysis

1.INTRODUCTION

Now a day, rapid construction is taking place in hilly areas due to scarcity of plain ground. As a result the hilly areas have marked effect on the buildings in terms of style, material and method of construction leading to popularity of multi-storeyed structures in hilly regions. Due to sloping profile, the various levels of such structures step back towards the hill slope and may also have set back also at the same time. The step-back structures usually have the number of story's decreasing successively at the bottom in each bay, in the direction of the slope maintaining same roof level, where as step back-set back buildings do not have same roof level. These structures become highly uneven and asymmetric, due to variation in mass and stiffness distributions on different vertical axis at each floor. Such construction in earthquake zone areas makes them to attract greater shear forces and torsion compared to normal construction.

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, especially above the base floor, so that added open space is accessible for assembly hall or parking purpose.

1.1 MODEL DESCRIPTION

Basically the model consist of 3 bays with 10 story building, each bay having a dimension of 5m in X direction 5m in Y direction. The story height is kept 3m .the beam size is of 0.3x0.45m and the column size is of 0.6x0.85m.The slab thickness is 0.125m. The building is to be situated in the seismic zone 5 with medium soil. The floor finish 1kN/m^2 and live load 3kN/m^2 are consider and concert grade of M25 and M30 and the grade of steel Fe-500 are assumed for study. These model were analyzed using pushover analysis method in ETABS

2.1 Models under Study

2.1.1 Set 1: Step Back Buildings on Sloping Ground

MODEL NO	DESCRIPATION
Model -1	Step back building without floating column as shown in fig 2
Model -2	Step back building with floating column at right side of the corner as shown in fig 3
Model -3	Step back building with floating column at left side of the corner as shown in fig 4
Model -4	Step back building with floating column at center of the floor as shown in fig 5
Model -5	Step back building with floating column at right side of the corner at 5th storey as shown in fig 6
Model -6	Step back building with floating column at left side of the corner at 5th storey as shown in fig 7
Model -7	Step back building with floating column at center of the floor at 5th storey as shown in fig 8

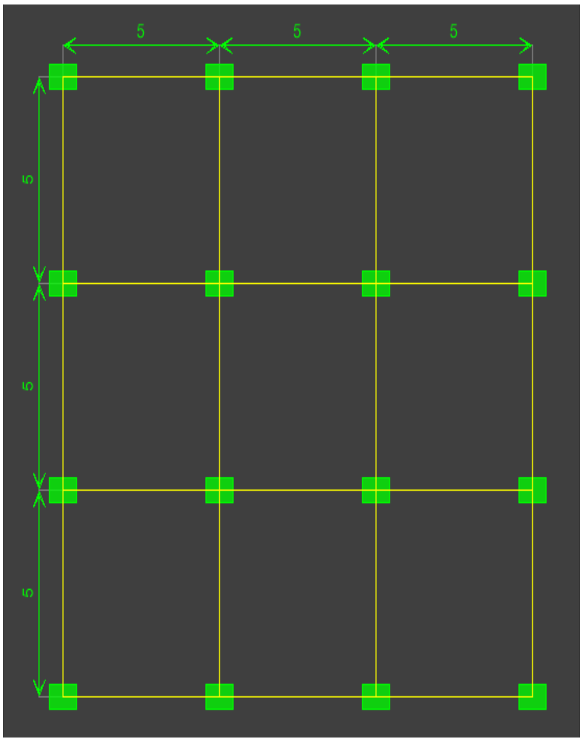


Fig: 1 Showing details of plan

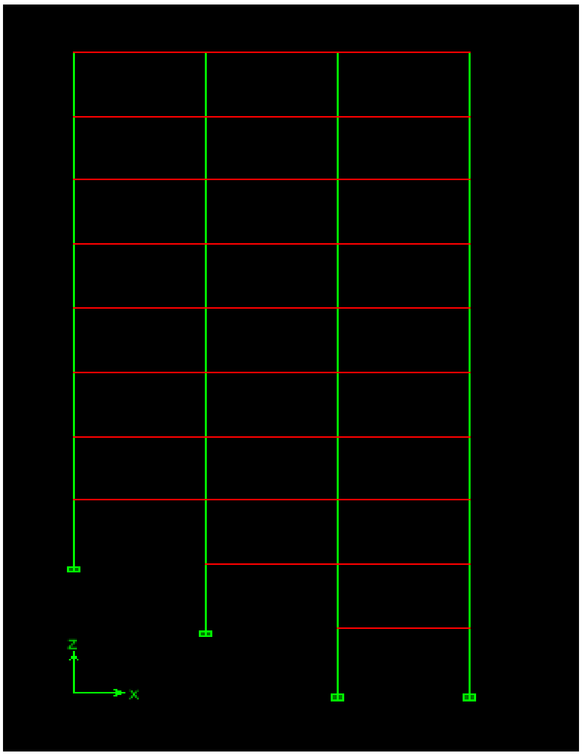


Fig : 2

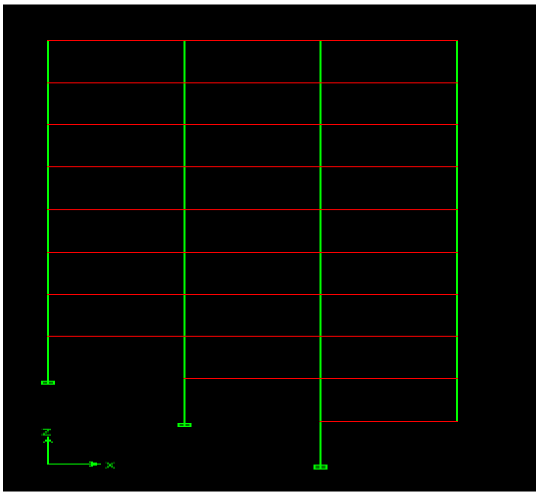


Fig: 3

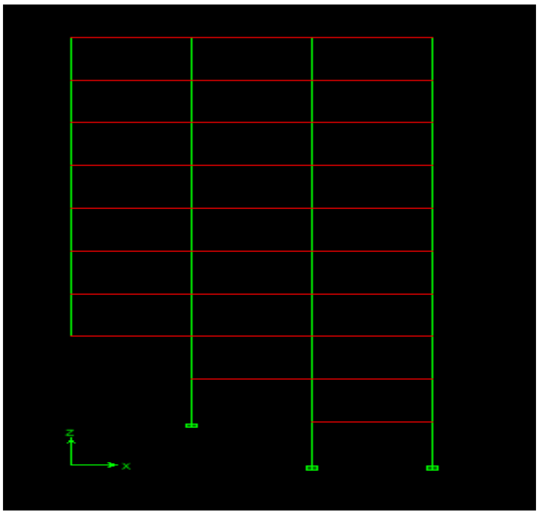


Fig:4

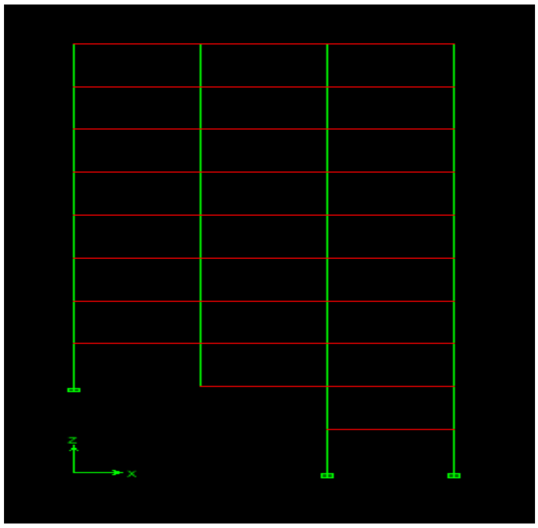


Fig: 5

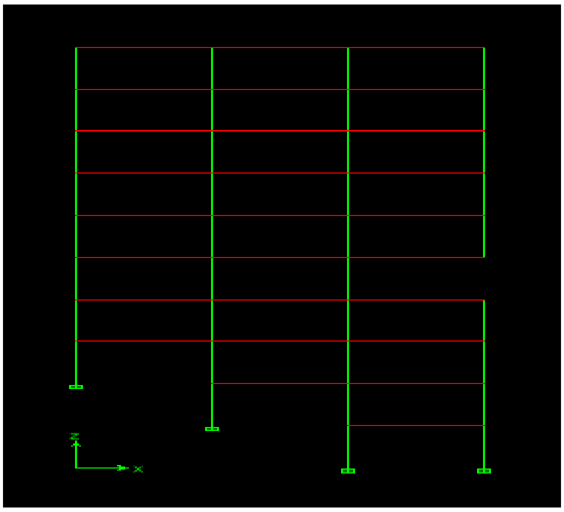


Fig: 6

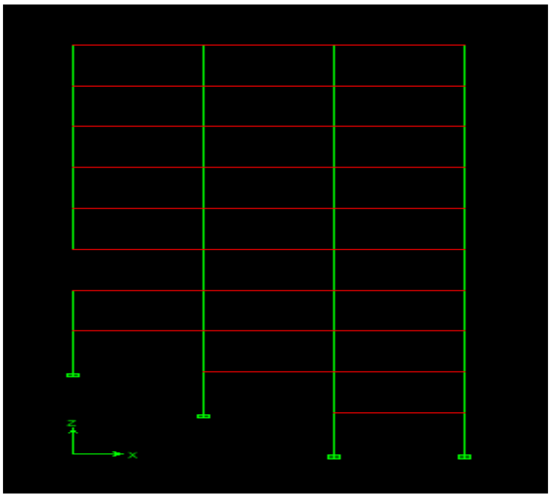


Fig: 7

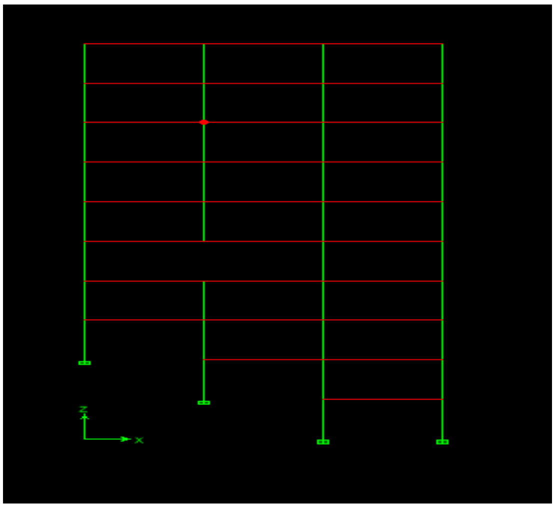


Fig: 8

2.1.2 Set2: Step back-setback Buildings on Sloping Ground

MODEL NO	DESCRIPATION
Model -8	Step back-set back building without floating column as shown in fig 9
Model -9	Step back-set back building with floating column at right side of the corner as shown in fig 10
Model -10	Step back-set back building with floating column at left side of the corner as shown in fig 11
Model -11	Step back-set back building with floating column at center of the floor as shown in fig 12
Model -12	Step back-set back building with floating column at right side of the corner at 5th storey as shown in fig 13
Model -13	Step back-set back building with floating column at left side of the corner at 5th storey shown in fig 14
Model -14	Step back-set back building with floating column at center of the floor at 5th storey as shown in fig 15

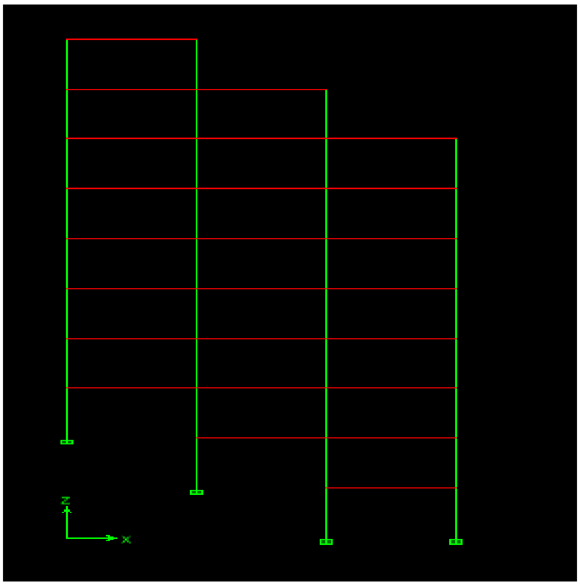


Fig: 9

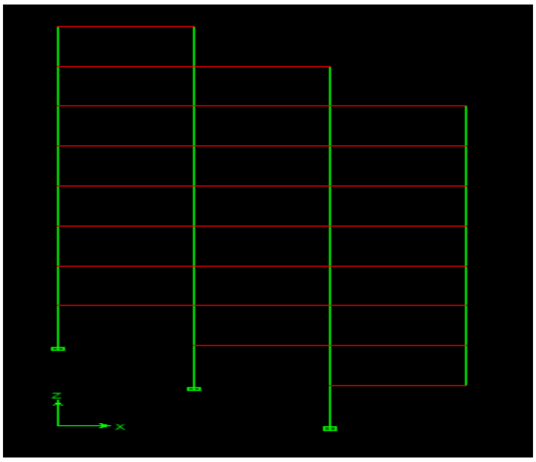


Fig: 10

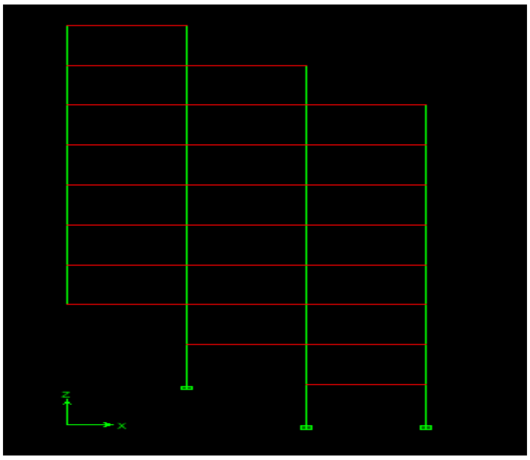
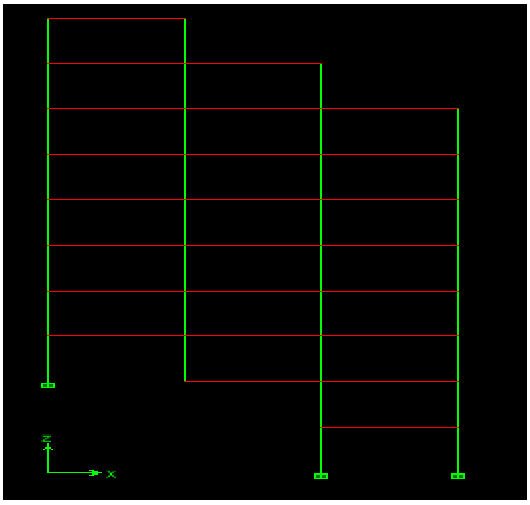


Fig: 11



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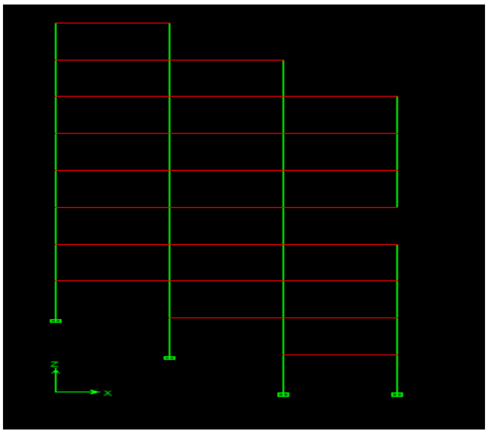

Fig 13

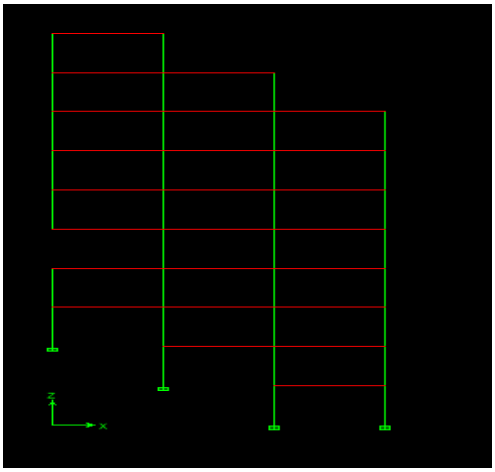

Fig 14

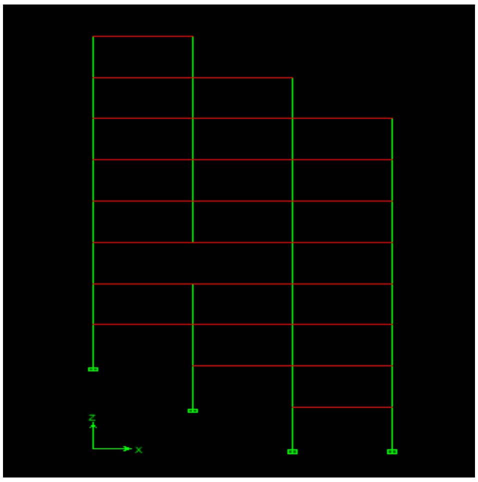

Fig 15

3. PUSHOVER ANALYSIS

The pushover curve obtained by the analysis of building on a sloping ground with and without floating column

Table-1 Fundamental time period for (model-1 to model-7 for step back) by pushover analysis

MODEL NO	TIME PERIOD (IN SEC)
M1	1.357
M2	1.38
M3	1.421
M4	1.361
M5	1.371
M6	1.371
M7	1.359

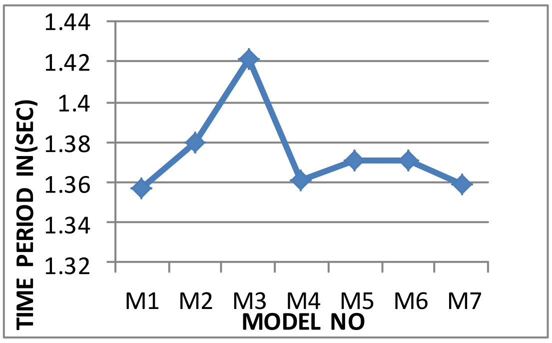

Fig-16 Fundamental time period for (model-1 to model-7 for step back) by pushover analysis

Table-2 Fundamental time period for (model-8 to model-14 for step back-set back) by pushover analysis

MODEL NO	TIME PERIOD (IN SEC)
M8	1.193
M9	1.211
M10	1.245
M11	1.195
M12	1.205
M13	1.205
M14	1.194

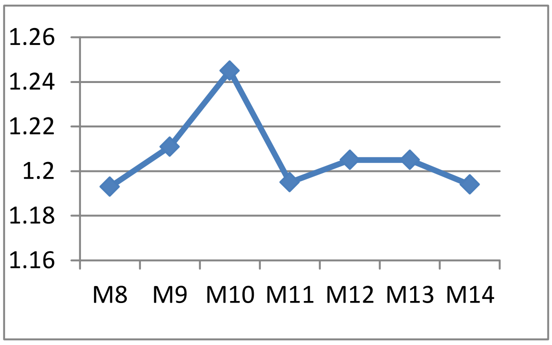

Fig-17 Fundamental time period for (model-8 to model-14 for step back) by pushover analysis

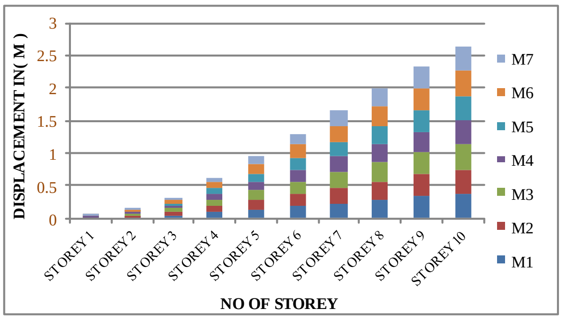

Fig-18 lateral displacement in longitudinal direction for step back

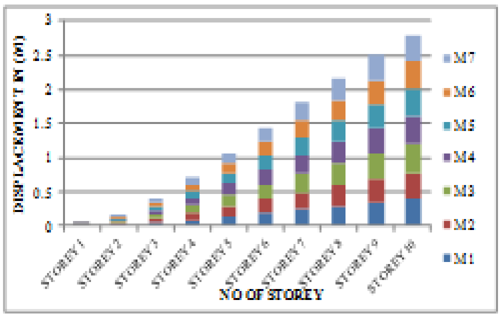

Fig-19 lateral displacement in transverse direction for step back-set back

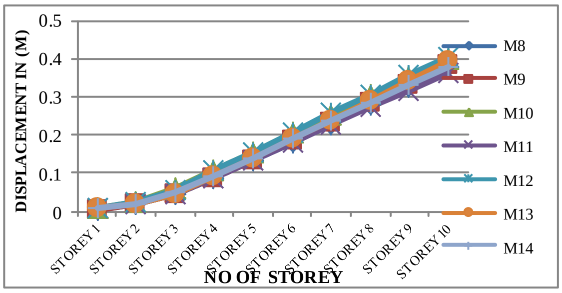

Fig-20 lateral displacement in longitudinal direction

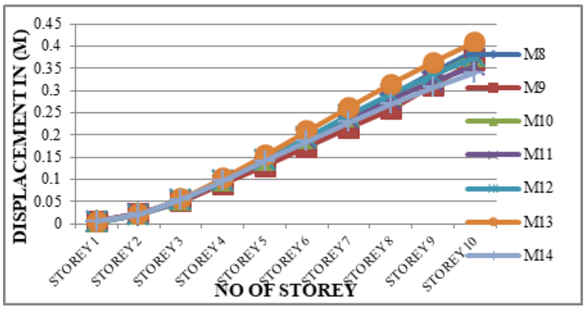

Fig-21 lateral displacement in transverse direction

Set 1:lateral displacement for step back

It is seen that by pushover analysis the displacement along longitudinal direction are increased by 5.8%, 5.6%, 2.7%, 5.3%, 5.5%, 1.2% for model 2,3,4,5,6,7 respectively compared to model-1.

It is seen that by pushover analysis the displacement along transverse direction are increased by 1.01%, 6.08%, 3.6%, 4.6%, 4.2%, 1.2%, for models 2,3,4,5,6,7 respectively compared to model-1

Set 2: lateral displacement for step back-set back

It is seen that by pushover analysis the displacement along longitudinal direction are increased by 8.4%, 12.5%, 3.8%, 13.5%, 10.9%, 7.1% for models 9,10,11,121,13,14, respectively compared to model-8.

It is seen that by pushover analysis the displacement along transverse direction are increased by 2.1%, 4.5%, 1.5%, 1.05%, 12.06%, 5.12%, models 9,10,11,12,13,14 respectively compared to model-8

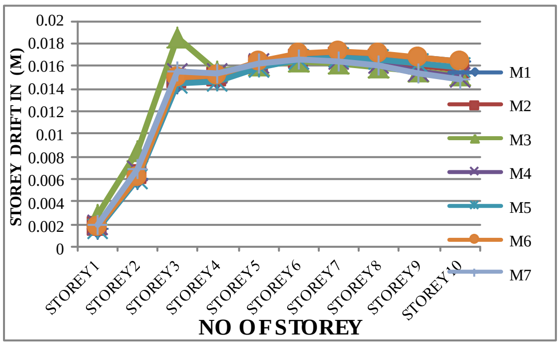

Fig 22 Showing storey drift in x-direction for step back

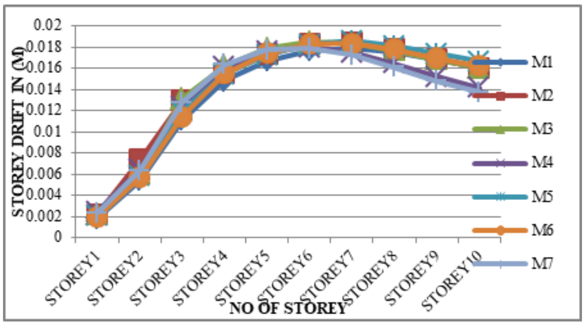

Fig 23 Showing storey drift in Y-direction for step back

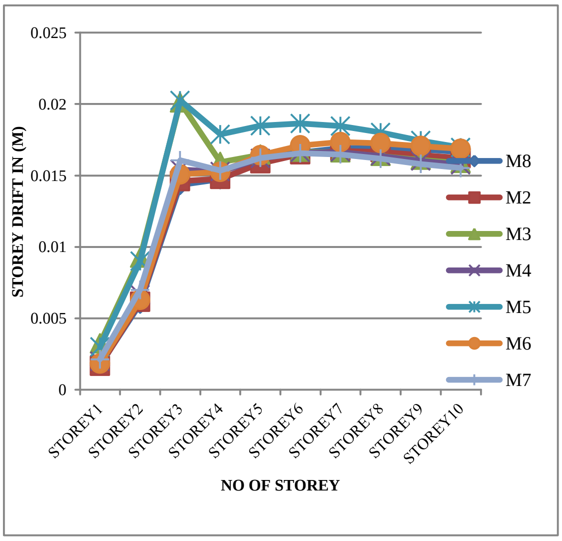

Fig 24 Showing storey drift in x-direction for step back-set back

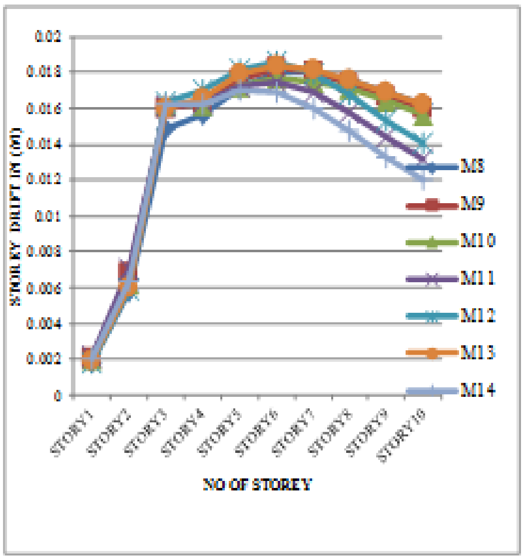

Fig 25 Showing storey drift in Y-direction for step back-set back

3.1 PERFORMANCE POINT

Performance point is the point on graph where capacity meets the demand of the structure. Depending upon this point only we can decide whether the structure is vulnerable or safe. Performance point is obtained by capacity spectrum method. Capacity spectra plotted, demand spectra plotted together and demand displacement coordinates computed. Where these two meet called performance point. As shown in fig 26

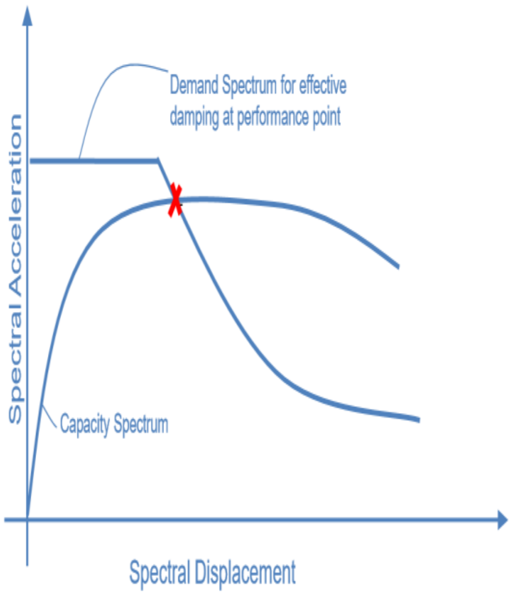

Fig 26

Table 3: Performance parameter for step back building for longitudinal direction

MODEL NO	BASE SHEAR (kN)	DISPLACEMENT (m)	SPECTARL ACCELERATION (m/s²)	SPECTRAL DISPLACEMENT (m)
M1	1964.24	0.207	0.095	0.142
M2	1554.29	0.232	0.081	0.166
M3	1566.27	0.283	0.072	0.191
M4	1945.55	0.212	0.093	0.145
M5	1536.95	0.240	0.79	0.170
M6	1549.85	0.259	0.075	0.177
M7	1737.83	0.239	0.084	0.165

Table 4: Performance parameter for step back building for transverse direction

MODEL NO	BASE SHEAR (kN)	DISPLACEMENT (m)	SPECTRAL ACCELERATION (m/s²)	SPECTRAL DISPLACEMENT (m)
M1	1797.00	0.224	0.85	0.163
M2	1506.76	0.267	0.075	0.183
M3	1467.60	0.289	0.068	0.207
M4	1774.19	0.224	0.083	0.163
M5	1449.31	0.275	0.072	0.189
M6	1464.17	0.275	0.070	0.196
M7	1669.65	0.250	0.079	0.165

Set 1: Displacement at performance point for step back building

It is seen that by pushover analysis the displacement along longitudinal direction are increased by 10.77%, 26.85%, 20.36%, 13.75%, 20%, 13.3% for model 2, 3, 4, 5, 6, 7 respectively compared to model-1.

It is seen that by pushover analysis the displacement along transverse direction are increased by 16.10%, 22.49%, 16.10%, 22.49%, 18.54%, 10.5%, for model 2, 3, 4, 5, 6, 7 respectively compared to model-1.

Set 1: Base shear at performance point for step back building It is seen that by pushover analysis the base shear along longitudinal direction are decreased by 20.87%, 20.26%, 1%, 21.75%, 21.09%, 11.52% for model 2, 3, 4, 5, 6, 7 respectively compared to model-1.

It is seen that by pushover analysis the base shear along transverse direction are decreased by 16.19%, 18.3%, 1.27%, 19.36%, 18.52%, 7%, for model 2, 3, 4, 5, 6, 7 respectively compared to model-1.

Table 5: Performance Parameter for step back-set back building for longitudinal direction

MODEL NO	BASE SHEAR (kN)	DISPLACEMENT (m)	SPECTRAL ACCELERATION (m/s^2)	SPECTRAL DISPLACEMENT (m)
M8	1965.79	0.201	0.108	0.125
M9	1534.19	0.232	0.090	0.148
M10	1604.82	0.273	0.082	0.169
M11	1826.45	0.224	0.100	0.142
M12	1961.31	0.210	0.110	0.133
M13	1583.15	0.248	0.086	0.155
M14	1752.28	0.230	0.096	0.145

Table 6: Performance Parameter for step back-set back building for transverse direction

MODEL NO	BASE SHEAR (KN)	DISPLACEMENT (m)	SPECTRAL ACCELERATION (m/s^2)	SPECTRAL DISPLACEMENT (m)
M8	1771.39	0.227	0.093	0.144
M9	1445.55	0.273	0.082	0.164
M10	1457.66	0.295	0.076	0.182
M11	1720.87	0.248	0.090	0.158
M12	1755.27	0.223	0.094	0.142
M13	1454.27	0.284	0.077	0.175
M14	1660.13	0.255	0.080	0.164

Set 2: Displacement at performance point for step back-set back building

Pushover analysis results shows that the displacements along longitudinal directon are increased by 13.3%, 26.37%, 10.26%, 4.28%, 18.95%, 12.60%, for model 9, 10, 11, 12, 13, 14 respectively compared to model-8.

Pushover analysis results shows that the displacements along transverse directon are increased by 16.84%, 23.05%, 8.46%, 5.46%, 20.07%, 10.98%, for model 9, 10, 11, 12, 13, 14, respectively compared to model-8.

Set 2: **Base** shear at performance point for step back-set back building

Pushover analysis results shows that the base shear along longitudinal directon are decreased by 21.95%, 18.36%, 7.08%, 0.22%, 19.46%, 10.86%, for model 9, 10, 11, 12, 13, 14, respectively compared to model-8.

Pushover analysis results shows that the base shear along transverse directon are decreased by 18.39%, 17.71%, 2.85%, 0.21%, 17.89%, 6.2%, for model 9, 10, 11, 12, 13, 14, respectively compared to model-8.

4. Conclusions

From this present study the following conclusions are drawn

1. It is concluded that building with provision of floating column at corner on any floor shows the poor performance compared to other cases. Hence provision of floating columns at corner should be considered as critical case, hence special attention is needed.

2. The analyzed result shows that storey shear, displacement and storey drift increases in building with floating column as compared with building without floating column.
3. Step back building frames gives greater values of time period as compared with step back-set back building frame with floating column located on sloping ground.
4. In case of step back building maximum storey displacement increases as compared to step back-set back building frames with floating column on sloping ground.
5. It is observed that in step back-set back building on sloping ground maximum displacement decreases when compared to step back building on sloping ground without floating column.
6. The performance of step back frames during seismic excitation prove to be more vulnerable in comparison with step back-set back building frames, hence step back-set back building frames are desirable then the step back frames.
7. The displacement at performance point of a building with floating column is more compared to building frame without floating column located on sloping ground.
8. The base shear at performance point of building without floating column is more as compared to building with floating column on sloping ground.

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