Seismic Analysis and Design of R.C.C. Building with Soft Storey At Different Level in Different Zones

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Abstract- *Now a day's growth of Multi-story building is very high because of rapid urbanization all over the world. Availability of land is minimum due to population, so people tends to construct the multi-story building in earthquake prone area also. In soft-story buildings the relative stiffness of the soft-story, typically the bottom story, is significantly less than upper stories due to the presence of large openings which reduce the available space for lateral force resisting system components such as shear walls. Soft story is generally provided for parking, concert hall, cinema theater, barn or any purpose in multi-story building. Though multi-storeyed buildings with soft storey floor are inherently vulnerable to collapse due to earthquake. This depends on various factors effects on the behavior of multi-story building i.e. irregularity in plan and elevations, uneven distribution of mass etc. To study of different location on the seismic behavior of multi-story building, linear dynamic analysis (Response spectrum analysis, Time history method) in STAAD-Pro software is carried out for all zones.*

In this paper an investigation has been made to study the seismic behavior of soft storey building with different arrangement in soft storey building. This analysis is with consideration of strength and stiffness in the upper storey and with and without consideration of braces in the ground storey. Different seismic parameters like time period, story shear, story displacement and story drift are checked out. . For that, G+6(Reinforced cement concrete) RCC model is selected.

Keywords- Earthquake & Wind effects, Response Spectrum analysis, Time History method, soft story

I. INTRODUCTION

Earthquake is basically a naturally phenomenon which causes the ground to shake. The earth's interior is hot and in a molten state. As the lava comes to the surface, it cools and new land is formed. The lands so formed have to continuously keep drafting to allow new material to surface. According to the theory of plate tectonics, the entire surface of the earth can be considered to be like several plates, constantly moving. These plates brush against each other or collide at their boundaries giving rise to earthquakes. Therefore regions close to the plate boundary are highly seismic and regions further from the boundaries exhibit less seismicity. Earthquakes may also be caused by other actions such as underground explosions.

An earthquake is the result of a sudden release of energy in the earth's crust that creates seismic waves. The seismic activity of an area refers to the frequency, type and size of earthquake experienced over a period of time. At the earth's surface, earthquake occurs itself by shaking and sometimes displacement of the ground. When the epicenter of a large earthquake is located offshore, the sea bed may be displaced sufficiently to cause a tsunami. Earthquakes can also trigger landslides and occasionally volcanic activities.

An earthquake is measured by seismometers. An earthquake having magnitude of less than 5 are generally measured by Richter magnitude scale & that of magnitude upto 9 or more then 9 is measured by modified Mercalli scale. In its most general sense, the word earthquake is used to describe any seismic event, whether natural or caused by humans that generate seismic waves. Earthquakes are caused mostly by rupture of geological faults, but also by other events such as volcanic activities, landslides, blasts and nuclear tests. An earthquake's pint of initial rupture is called its focus or hypocenter. The epicenter is the point at ground level directly above the hypocenter.

At the time of earthquake occurrence certain waves are generated which causes destruction of human life & property. Waves generated from earthquake are of two types body waves (P-waves & S-waves) & surface waves (Rayleigh waves, Love waves, Stoneley waves). As these waves are destructive in nature causing damages or destruction of structures, therefore it is necessary to provide effective provision to resist an earthquake waves.

In this study the 3D analytical model of G+6 storey building is to be generated for different zones and with soft storey at various locations Building models are analyzed and designed by STAAD.Pro software.

We are analyzing the these structures for seismic load i.e. equivalent static lateral for response spectrum method for all four zones and time history methods for two zone (zone 3 and zone 4) using STAAD.Pro.

SOFT STOREY CONCEPT

The soft story irregularity, refers to the existence of a building floor that presents a significantly lower stiffness than the others, hence it is also called soft story. Due to increasing population since the past few years car parking space for residential apartments in populated cities is a matter of major concern. Hence the trend has been to utilize the ground story of the building itself for parking. These types of buildings having no infill masonry walls in ground story, but in filled in all upper story, are called Open Ground Story (OGS) buildings. There is significant advantage of these category of buildings functionally but from a seismic performance point of view such buildings are considered to have increased vulnerability. Due to the presence of infill walls in the entire upper storey except for the ground storey makes the upper storeys much stiffer than the open ground storey. Thus, the upper storeys move almost together as a single block, and most of the horizontal displacement of the building occurs in the soft ground storey itself. In other words, these types of buildings sway back and forth like inverted pendulum. During earthquake shaking, and hence the columns and beams are heavily stressed. Therefore it is required that the ground storey columns must have sufficient strength and adequate ductility. The vulnerability of this type of building is attributed to the sudden lowering of lateral stiffness and strength in ground storey, compared to upper storeys with infill walls.

II. AIM AND SCOPE OF PROJECT

1. To study the optimum location of soft storey at various height of building
2. To obtain displacement, storey drift, storey shear, time factor, maximum movement, maximum shear force, maximum area of steel in columns at various locations of building for different configurations.
3. .To obtain maximum area of steel at top and bottom, maximum movement, maximum shear force in beams at various locations of building for different configurations.

PRESENT STUDY

Present study involves finding the optimum location of a single and a multi-soft story in a G+6 RCC tall building. The project is been carried out using the software STAAD –Pro, AutoCAD

In total, 16 models are created namely T1 to T16, out of which, T1, T2, T3, T4 are the models without soft story in different zones.T5, T6, T7, T8 are the models with soft story at bottom of building in different zones.T9, T10, T11, T12 are the models with soft story at G+3 of building in different zones.

T13, T14, T15, T16 are the models with soft story at top of building in different zones. Analysis of each of the models were done and the results were compared with each other and the respective graphs were been obtained.

SCOPE OF THE STUDY

The purpose of this hypothetical study is to evaluate the seismic properties and characteristics for multi storey residential building structures. The main aspect of this analysis is to obtain the sustainability of the building regarding the performance of the buildings by using STAAD-Pro and the demand of the structure for a designed strong motion earthquake characteristics using the response spectrum method in soft story building.

TYPES OF MODEL

T1: Modal without soft story in Zone 2.
T2: Modal without soft story in Zone 3.
T3: Modal without soft story in Zone 4.
T4: Modal without soft story in Zone 5.
T5: Model with soft story at bottom of building in Zone 2.
T6: Model with soft story at bottom of building in Zone 3.
T7: Model with soft story at bottom of building in Zone 4.
T8: Model with soft story at bottom of building in Zone 5.
T9: Model with soft story at G+3 of building in Zone 2.
T10: Model with soft story at G+3 of building in Zone 3.
T11: Model with soft story at G+3 of building in Zone 4.
T12: Model with soft story at G+3 of building in Zone 5.
T13: Model with soft story at Top of building in Zone 2.
T14: Model with soft story at Top of building in Zone 3.
T15: Model with soft story at Top of building in Zone 4.
T16: Model with soft story at Top of building in Zone 5.

MODELLING

A. Model Defination

In the this study we take a G+6-storey RC building the geometrical parameters of the multi-story frame are as follows:

Number of storey:-G+6
Floor Height:-3m

Soft story height:- 5m
No of bay in X direction:-4
No of bay in Z direction:-5
Spacing in X direction:-5m
Spacing in Y direction:-5m
Slab Thickness:-125mm
Live load:- 2kN/m² at typical floor
1 kN/m² at terrace floor
5 kN/m² at soft story floor
Floor finish Load:-1.5 kN/m²
Concrete grade:-M25
Steel:-Fe500

Earthquake parameters:-

Type of frame:-SMRF
Seismic zone:-II, III, IV, V
Response reduction factor:-5
Importance Factor:-1

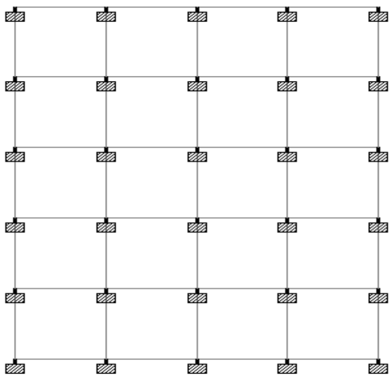


Fig. 3.1 Plan of the building

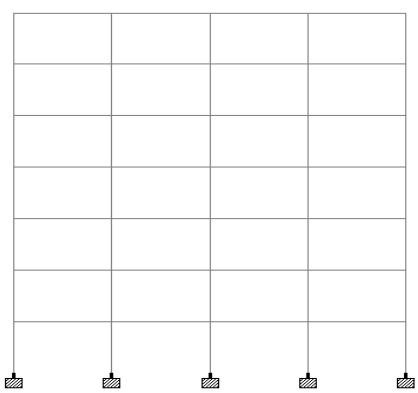


Fig. 3.2 elevation of view of building Without soft story in STAAD.Pro

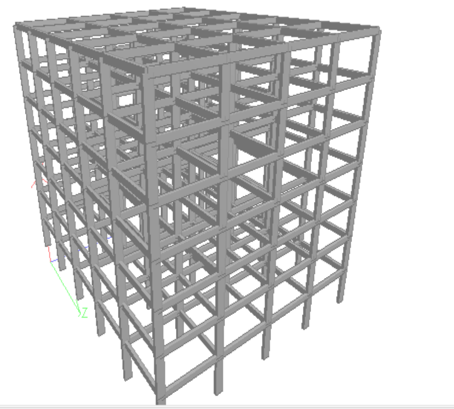


Fig. 3.3 3D rendering view building in STAAD.Pro

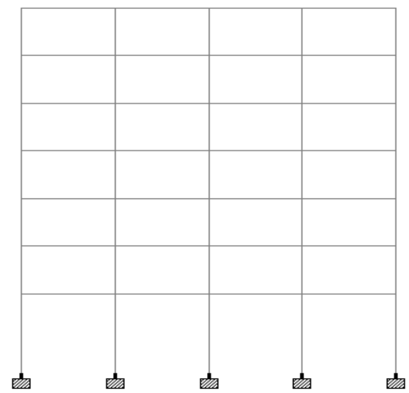


Fig. 3.4 elevation view of building with soft story at bottom in STAAD.Pro

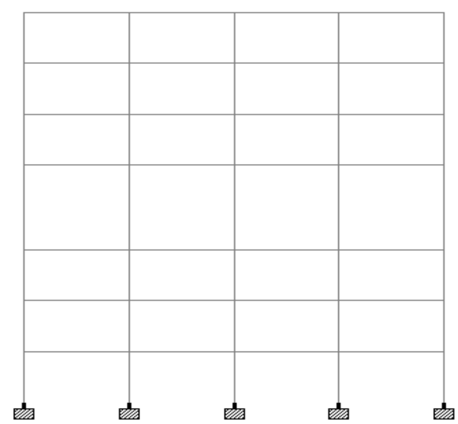


Fig. 3.5 elevation view of building with soft story at middle in STAAD.Pro

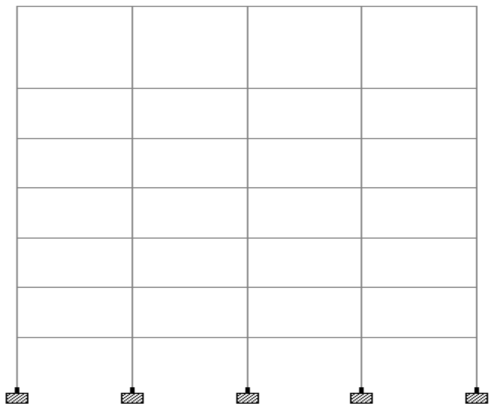


Fig. 3.6elevation view of building with soft story at top in STAAD.Pro

IV. ANALYTICAL ANALYSIS

Seismic Analysis of Buildings Using IS 1893(Part 1) – 2002

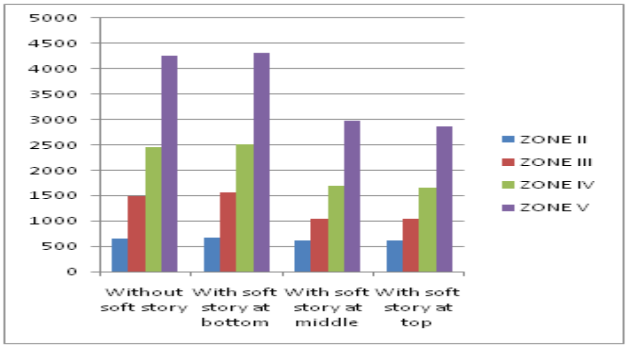
The analysis process can be categorized on three factors – 1. Externally applied loads 2. Structural behavior 3. Structural model type

A) Equivalent static method of analysis :-For the buildings having low to medium heights with a regular conformation.
B) Dynamic analysis:-The dynamic analysis is of two types

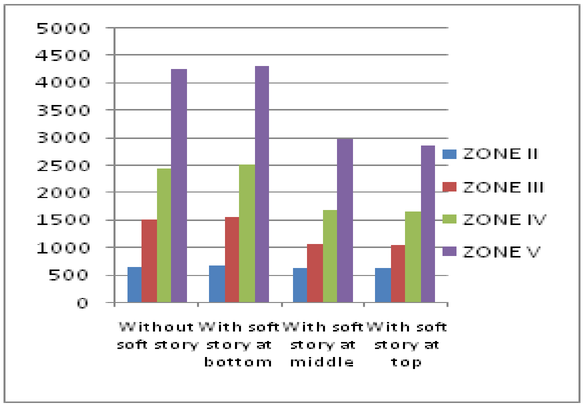
a) Response spectrum method – Using for irregular Bui. Having more height with non -linearity.
b) Time history analysis.

Following are the load combinations considered in this analysis

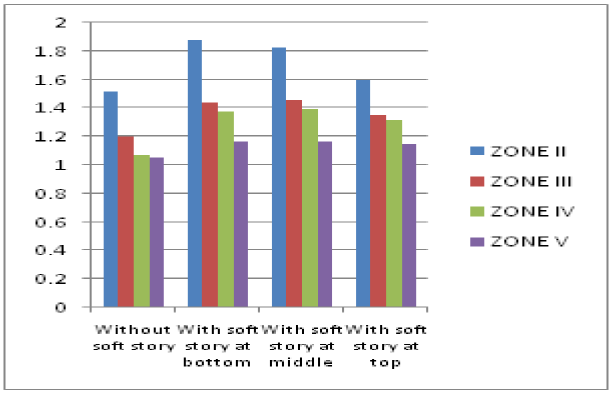
1)1.5(DL+LL)
2)1.2(DL+LL+EQX)
3)1.2(DL+LL-EQX)
4)1.2(DL+LL+EQY)
5)1.2(DL+LL-EQY)
6) DL+1.5EQX
7) DL-1.5EQX
8) DL+1.5EQY
9) DL-1.5EQY



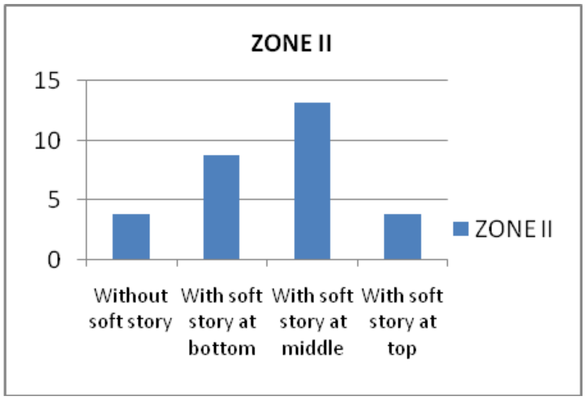
Graph: shows the variation of base shear in X direction for different configurations in different earthquake zones

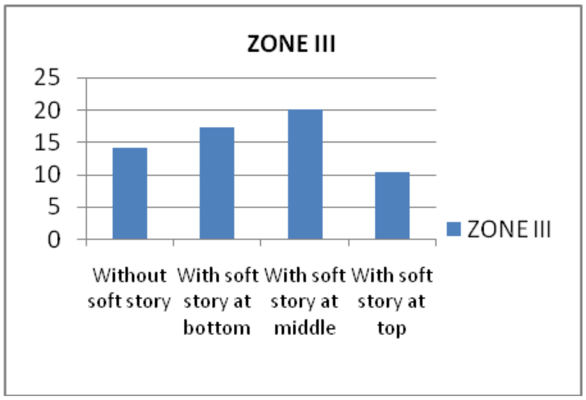


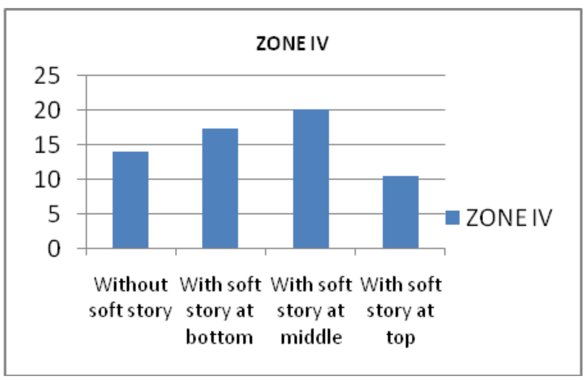
Graph: shows the variation of base shear in Z direction for different configurations in different earthquake zones

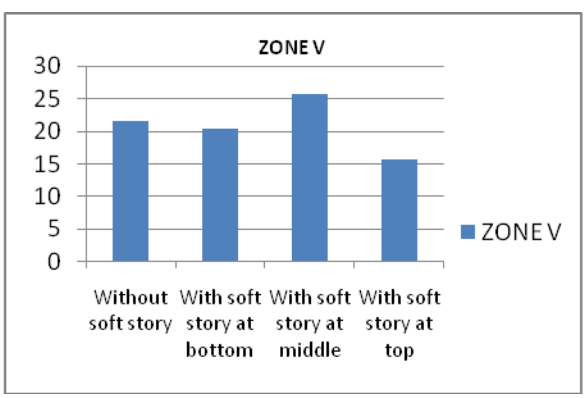


Graph: shows the variation of time periods for different configurations in different earthquake zones









Graph: shows the variation of story drift for different configurations in different earthquake zones

Fig. 3.7 columns considered for comparison (29, 31 ,218, 220)

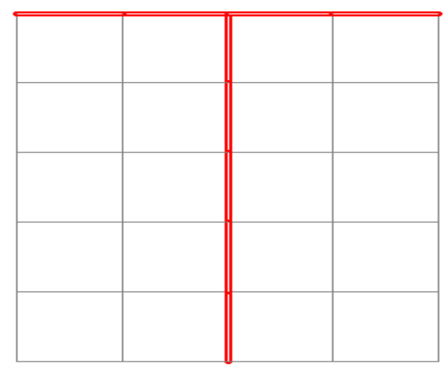
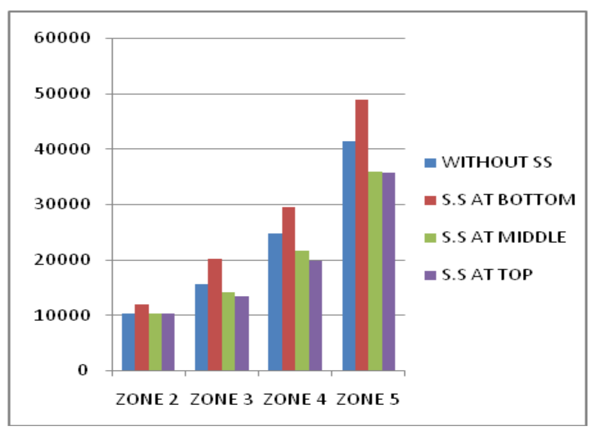
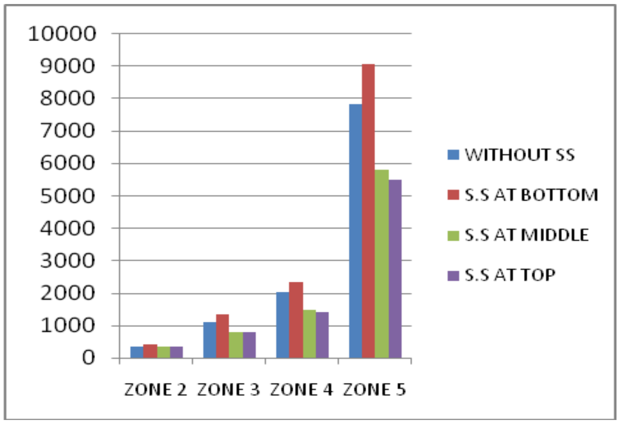
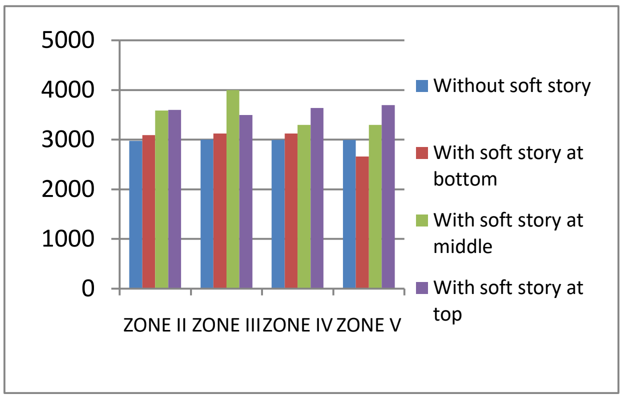


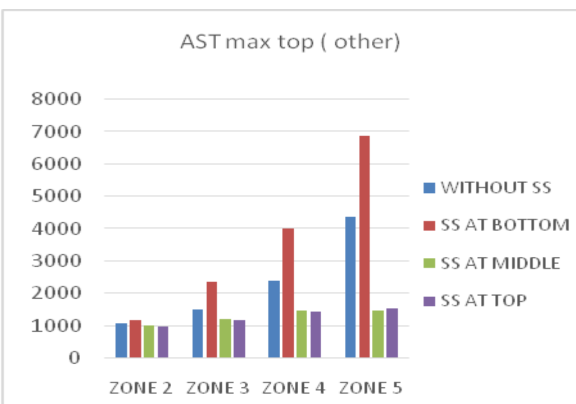
Fig. 3.8 beams considered for comparison (selected)

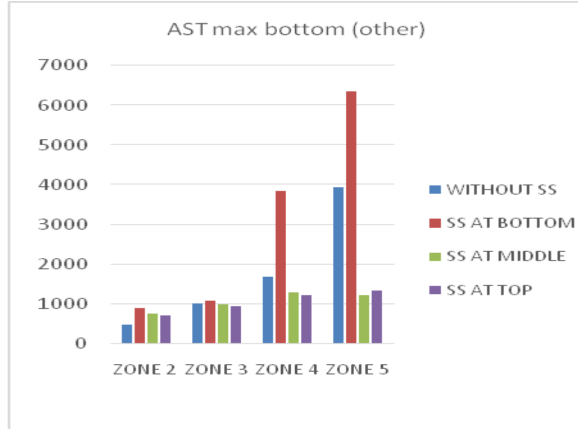


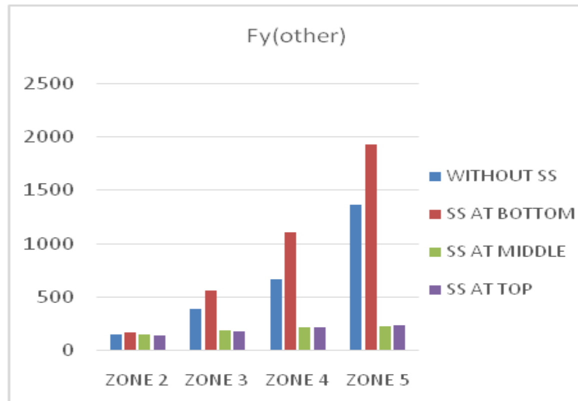


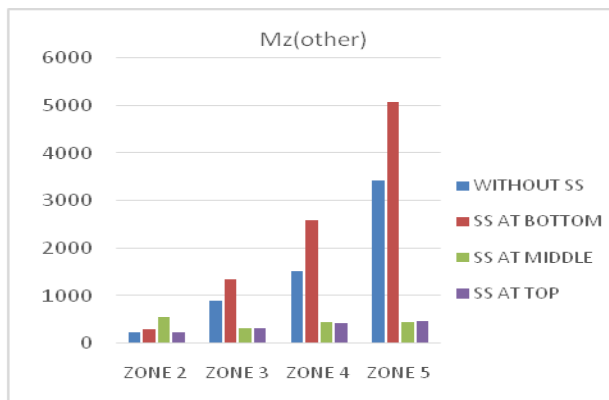


Graph: shows the variation of Ast, Mz, Fx for center column (220) different configurations in different earthquake zones









Graph: shows the variation of Ast, Mz, Fy for vertical beam (center) different configurations in different earthquake zones

V. DISCUSSION

i. The base shear for soft story at bottom is maximum as compared to other configurations i.e. EQX=4305 kN and EQY=9914kN for zone V case.

ii. As expected base shear for zone V is much more than in other zones, so use of earthquake resistant design and methods needs to be adopted to design buildings in zone V.

iii. The time period for soft story at bottom is maximum as compared to other configurations i.e. 1.87767 sec for zone II case.

iv. The time period for zone V configurations is less as compared to other zones, it is possible that time period of the building may lie in the range of short waves of earthquakes

v. The storey drift for soft story at middle case is maximum as compared to other configurations i.e. 38.2 mm in x direction and in case of Z direction story drift is maximum for soft story at bottom case i.e. 53.4 mm if or zone V case

vi. The storey drift for zone V is much more than allowed according to IS codes so need of shear walls is necessary for the design of RCC structures.

vii. Area of steel, bending moment (Mz), Axial force(Fx) for center columns are much more than corner columns, addition of shear walls is suggested

viii. Bending moment, shear force and area of steel for center beams are much more than corner beams.

VI. CONCLUSIONS

i. For base shear soft story at top is most effective as compared to other configurations.

ii. For time period soft at story at top gives equivalent results to without soft story.

iii. Storey drift in x direction is maximum for soft story at middle case and for z direction story drift is maximum for soft story at bottom case, thus soft story at top is preferable case.

iv. Forces in beams and columns are much more in soft story at bottom case as compared to other configurations.

v. Thus for basement parking and commercial structures at bottom stories, it is advisable to use shear walls to negotiate the effects of soft story at base.

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