International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 05, May-2019

Seismic Analysis of open Soft Storey Building for Different Models

Pravesh Gairola
Faculty of Technology,
Structural Engineering Department
UTU, Dehradun

Mrs. Sangeeta Dhyani
Faculty of Technology,
Structural Engineering Department
UTU, Dehradun

***Abstract*— Soft first storey is a typical feature in the modern multi-storey constructions in urban India. Though multi-storeyed buildings with soft storey floor are inherently vulnerable to collapse due to earthquake, their construction is still widespread in the developing like India. Functional and Social need to provide car parking space at ground level and for offices open stories at different level of structure far out-weighs the warning against such buildings from engineering community. With the availability of fast computers, so that software usage in civil engineering has greatly reduced the complexities of different aspects in the analysis and design of projects. In this paper an investigation has been made to study the seismic behaviour of soft storey building with different models (Bare frame, Infill frame, Bracing Frame, Shear wall frame) in soft storey building when subjected to earthquake loading. It is observed that, providing different models improves resistant behaviour of the structure when compared to soft storey provided.**

Keywords—Soft Storey, Etabs, Storey drift.

I. INTRODUCTION

Many building structure having parking or commercial areas in their first stories, suffered major structural damages and collapsed in the recent earthquakes. Large open areas with less infill and exterior walls and higher floor levels at the ground level result in soft stories and hence damage. In such buildings, the stiffness of the lateral load resisting systems at those stories is quite less than the stories above or below. During an earthquake, if abnormal inter-story drifts between adjacent stories occur, the lateral forces cannot be well distributed along the height of the structure. This situation causes the lateral forces to concentrate on the storey (or stories) having large displacement(s). In addition, if the local ductility demands are not met in the design of such a building structure for that storey and the inter-storey drifts are not limited, a local failure mechanism or, even worse, a storey failure mechanism, which may lead to the collapse of the system, may be formed due to the high level of load deformation (P-Δ).

If the P-Δ impact is considered to be the primary purpose for the dynamic fall apart of building structures throughout earthquakes, as it should be determined lateral displacements calculated inside the elastic design process can also offer very critical information approximately the structural behavior of the device codes outline smooth storey irregularity by stiffness contrast of adjoining floors, displacement primarily based criteria for such irregularity determination is greater green, distribution concepts optimum solution where size, cost, effectiveness every aspect counts.

The Indian seismic code IS 1893 (Part1): 2002 classifies a soft storey as one where in the lateral stiffness is less than 70 percentage of that within the storey above or less than 80 percentage of the common lateral stiffness of the three storeys above.

Etabs is an engineering software product that caters to multi-story building analysis and design, modeling tools and templates, code-based load prescriptions, analysis methods and solution techniques, all coordinate with the grid-like geometry unique to this class of structure. Basic or advanced systems under static or dynamic conditions may be evaluated using ETABS. For a sophisticated assessment of seismic performance this is considered to be one of the most widely used software. Intuitive and integrated features of this software makes it user friendly. Interoperability with a series of design and documentation platforms makes ETABS a coordinated and productive tool for designs which range from simple 2D frames to elaborate modern high-rises.

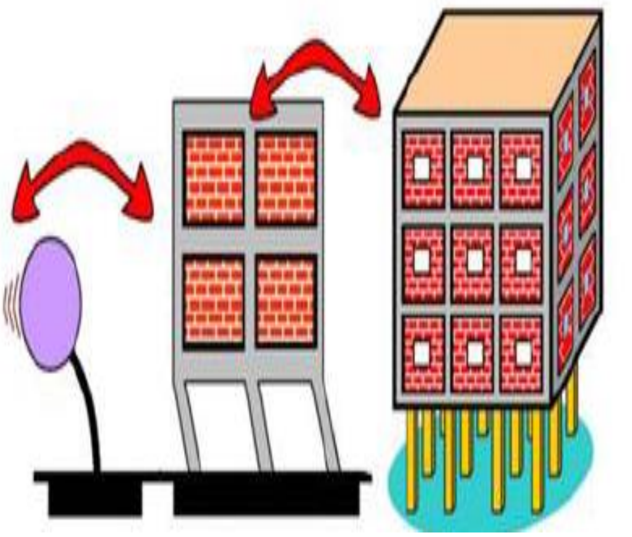

Fig 1- Behaviour of soft storey building as inverted pendulum

Objective of study

1. To study the behaviour of ground and first storey as open storey building with different models in high seismic zones.
2. To create 3D G+9 storey Ordinary Moment Resisting Frame structure as per IS 1893:2002 with different configurations (Bare frame model, Infills model, Bracings frame model, Shear wall frame model).
3. Analyse the different model by using Etabs software.

4. Perform Equivalent Static Analysis Method.
5. Results are discussed in terms of lateral forces, storey displacements, storey drifts, storey shear, and overturning moment and storey stiffness.
6. Comparison of the parametric results of different types of models are done.

II. LITERATURE REVIEW

Ganga Tepugade and Suchita Hirde (2014), discussed performance of building analysis of soft storey building at different level of the building with at ground level.

1. They concluded the static pushover analysis of the structure and carried out that plastic hinge developed in ground level soft storey.
2. This remark is not acceptable and not consideration for design safe criteria.
3. They also conclude that displacement has been reduce when soft storey is provided at higher level goes up increase upward form ground level.

Anuj Chandiwala and Hiten Kheni (2014), has been investigated many buildings having destructed during past earthquake.

1. It shows behaviour that there has been strong beam and weak column which show opposite behaviour of the building.
2. Column section has been critical and fail before beam yielded, this adverse effect is due to soft storey failure mechanism.
3. They use software for analysis of different building stiffness.
4. They concluded that the displacement has been maximum for upper storeys and smaller for lower storey and independent for the total number of storeys in models as per codal lateral load patterns.

Dhadde Santosh (2014), has been analysed the nonlinear pushover is conduct on the building models.

1. He use ETABS software for analysis and evaluation has been carried out for non-retrofitted buildings.
2. Retrofitting methods has been used and suggested like shear wall (central core), ground storey column stiffness increases, and infill walls.
3. He concluded that drift value has maximum value as compare to other storeys and drift value decreases for the soft storey building gradually from lower to top.

Bhavani Shankar and Rakshith Gowda K.R (2014), investigated soft storeys have been provided at different levels for different load combinations.

1. They used ETABS software for modelling and analysing RCC building.
2. They concluded that interstorey drift has been maximum in irregular vertical structure as compare to the regular structure.

D.Dhandapany (2014), investigated the building(RCC) under seismic loading condition for different soil condition by taking with and without consideration of shear wall.

1. He analysed the above criteria by using ETABS software for soil conditions (soft, medium, hard).
2. Compared the different values of axial force, Base shear and Displacement (Lateral) between frames.
3. He concluded that the analysis design for STAAD and ETABS give same result for consideration of all structural members.

Praveena Rao, Sanjaya K Patro and Susanta Banerjee (2014), analysed response parameters as storey drift, base shear and floor displacement.

1. Model and analysis has been performed by program IDRAC(2D) having nonlinear analysis
2. They concluded that maximum storey drift and lateral roof displacement has been reduced by considered infill wall than bare frame.

D. B. Karwar and Dr. R.S. Londhe (2014), investigated the analysis behaviour of RCC framed structure by using pushover analysis and nonlinear static procedure.

1. They use SAP2000 software for analysis and study has been made for different models in terms of displacement, base shear, and performance point.
2. They concluded that base shear is maximum for frame (infill) whereas it calculated minimum for bare frame consider G+8 building.

Nikhil Aggarwal(2013), analyzed the system of in filled masonry RCC frames such that it including first storey as with or without opening.

1. The lateral stiffness decreases as the frames opening percentage increases of in filled frame.
2. He concluded that stiffness of structure can be increases by increase in infill panels.

A.S. Kasnale and Dr. S.S. Jamkar (2013), investigated the performance of RCC frames considering give frames.

1. They considered various arrangements of infill with held different location and dynamic earthquake has been subjected.
2. They concluded that as more infill wall has been provided to get more stiffness and more stable in all components in terms of drift and displacement.

Dande P.S. and Kodag P.B. (2013), investigated the behaviour frames with provide features of stiffness and strength of the building:

1. By provide stiff column
2. By provide infill wall with is adjacent wall panel arrangement at each corner of building frames
3. They concluded that as compare to upper storey is stiffer than ground storey.
4. In such cases there has been difficult to provide column in the first storey.

Narendra Pokar and Prof. B.J. Panchal (2013), investigated the behaviour of RCC model frames consisting with scaled models and tested it.

1. Testing has been done in such a way that it arrive at optimal model with special design for structures.

2. Structure has been analysed using software SAP with has included seismic effect.
3. They concluded that both RCC and steel models gives nearly result for scaling full method.

III. METHODOLOGY AND MODELLING

The characteristics like intensity, duration of seismic ground vibrations expected at any location depends upon the magnitude of earthquake, its depth of focus, distance from the epicenter, characteristics of the path through which the seismic waves travel, and the soil strata on which the structure stands. The random earthquake ground motions, which cause the structure to vibrate, can be resolved in any three mutually perpendicular directions. The predominant direction of ground vibration is usually horizontal. The response of a structure to ground vibrations is a function of the nature of foundation soil, materials, form, size and mode of construction of structures and the duration and characteristics of ground motion. This standard specifies design forces for structures standing on rocks or soils which do not settle, liquefies or slide due to loss of strength during ground vibrations. The design approach adopted is to ensure that structures possess at least a minimum strength to withstand minor earthquakes, which occur frequently, without damage, resist moderate earthquakes without significant structural damage though some non-structural damage may occur and aims those structures withstand a major earthquake without collapse. Actual forces that appear on structures during earthquakes are much greater than the design forces specified.

Methods of Seismic Analysis

Seismic analysis is a major tool in earthquake engineering which is used to understand the response of buildings due to seismic excitations in a simpler manner. In the past the buildings were designed just for gravity loads and seismic analysis is a recent development. It is a part of structural analysis and a part of structural design where earthquake is prevalent.

There are different types of earthquake analysis methods:

1) Equivalent Static Analysis.
2) Response Spectrum Analysis.
3) Time History Analysis.

Equivalent Static Analysis

All design against seismic loads must consider the equivalent linear static methods. It is to be done with an estimation of base shear load and its distribution on each story calculated by using formulas given in the code. Then the displacement demand of model must be checked with code limitation. Equivalent static analysis can therefore work well for low to medium-rise buildings. The equivalent static analysis procedure consists of the following steps:

1) Estimate the first mode response period of the building from the design response spectra.
2) Use the specific design response spectra to determine that the lateral base shear of the complete building is consistent with the level of post-elastic (ductility) response assumed.
3) Distribute the base shear between the various lumped mass levels usually based on an inverted triangular shear distribution of 90% of the base shear commonly, with 10% of the base shear being imposed at the top level to allow for higher mode effects.

Response Spectrum Analysis

The representation of the maximum response of idealized single degree freedom system having certain time period and damping, during past earthquake ground motions. The requirement that all significant modes be included in the response analysis may be satisfied by including sufficient modes to capture at least 90% of the participating mass of the building in each of the building's principal horizontal directions. Model damping ratios shall reflect the damping inherent in the building at deformation levels less than the yield deformation. The peak member forces, displacements, story forces, story shears, and base reactions for each mode of response shall be combined by recognized methods to estimate total response. The maximum response plotted against the un-damped natural period and for various damping factors, and can be expressed in terms of maximum absolute acceleration, maximum relative velocity or maximum relative displacement.

Time History Analysis

It is an analysis of the dynamic response of the structure at each increment of time, when its base is subjected to a specific ground motion time history. Recorded ground motion data base form past natural earthquakes can be a reliable source for time history analysis. The steps involved in time history analysis are as follows.

1. Calculation of Model matrix.
2. Calculation of effective force vector.
3. Obtaining of Displacement response in normal coordinate.
4. Obtaining of Displacement response in physical coordinate.
5. Calculation of effective earthquake response forces at each storey.
6. Calculation of maximum response.

Equivalent Static Analysis Assumptions

The following assumptions shall be made in the earthquake resistant design of structures:

1. Earthquake causes impulsive ground motions, which are complex and irregular in character, changing in period and amplitude each lasting for a small duration. Therefore, resonance of the type as visualized under steady-state sinusoidal excitations will not occur as it would need time to build up such amplitudes.
2. Earthquake is not likely to occur simultaneously with wind or maximum flood or maximum sea waves.
3. The value of elastic modulus of materials, wherever required, may be taken as for static analysis unless a more definite value is available for use in such condition.

Seismic Analysis Procedure in Etabs

Step 1 - Define the code (i.e. IS 1893: 2002) and geometry of structure.

1. The grids of the structure are created.
2. Numbers of Stories are formed.
3. Beams, columns and roofs are made.

Step 2 - Define Materials of Members.

1. Steel
2. Concrete
3. Masonry

Step 3 - Define section of Members

1. Beams and columns
2. Bracing
3. Shear Wall

Step 4 - Defining Load

1. Dead and Live Load
2. Earthquake Load
3. Load Combinations

Step 5 - Assign property to members

1. Columns
2. Beams
3. Roofs
4. Bracing
5. Shear Wall

Step 6 - Assign supports

1. Hinge
2. Fix

Step 7- Analysis of structure

1. Static analysis

Step 8 - Run Analysis

1. The software package Etabs-2016 is used throughout the course of research for the analysis of the building models. The building structures are directly modelled into the ETABS modelling screen. Then the buildings are subjected to the usual dead and live load as per the Indian standards (IS 1893: 2002). This is to be done in order to check the capacity of the preliminarily fixed dimensions of the structural members. If all the members pass the design check, then the next part of analysis i.e. seismic analysis is carried out otherwise the member sizes are revised and the procedure is taken forward. Then the equivalent static method is applied and load cases required for carrying out the analysis are defined for both X and Y directions. After the member sizes are fixed, all the columns and beams (frame members) are assigned based on the properties we proceed to next step. Analysis of the structure is done and the results are obtained.
2. Results are obtained in terms of storey displacements, storey drifts, storey shear, storey stiffness and base shear. Finally comparison of the results of analysis of different models is done.

Structural configuration of different models

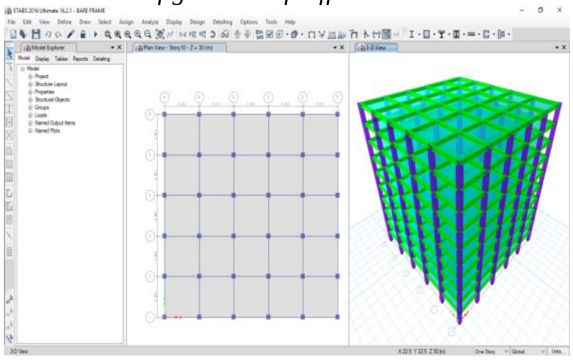

Fig 2- Plan and 3D view of Model 1(Bare Frame)

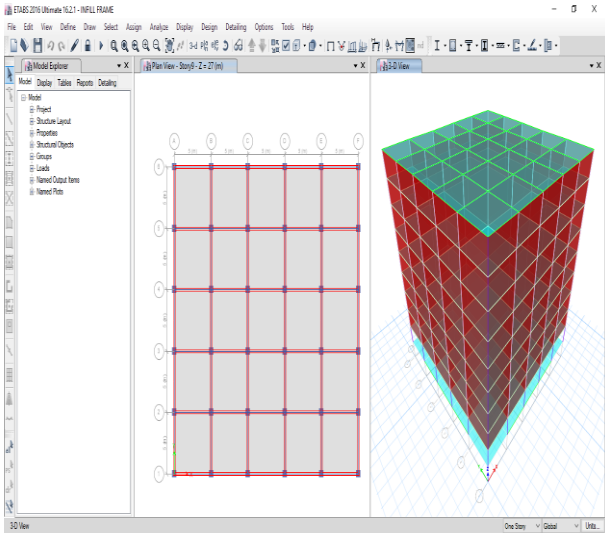

Fig 3- Plan and 3D view of Model 2(Infill Frame)

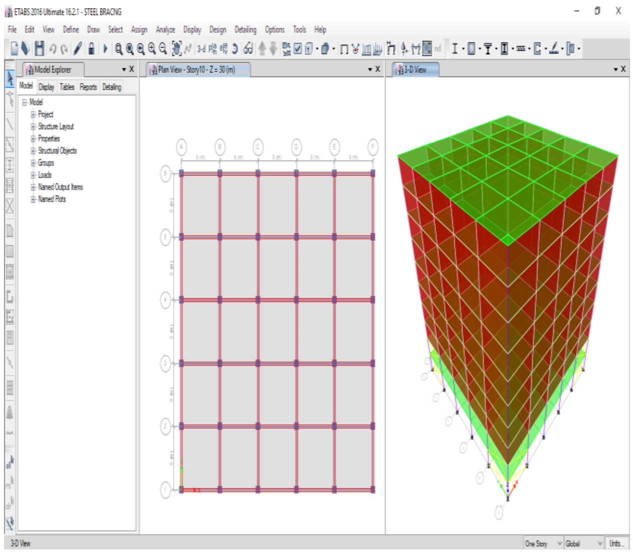

Fig 4- Plan and 3D view of Model 3 (Bracing X type Frame)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 05, May-2019

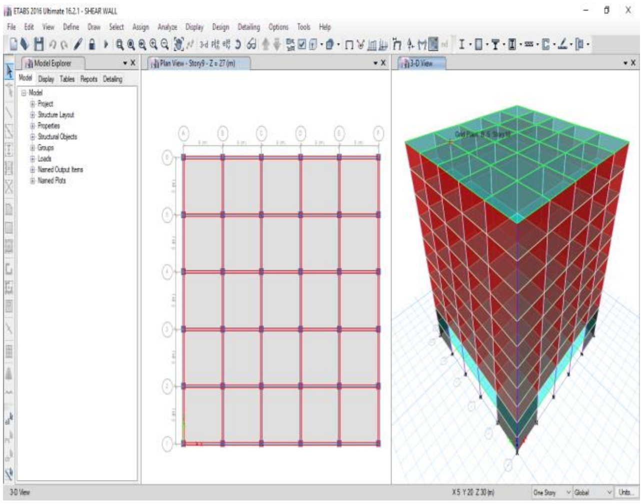

Fig 5- Plan and 3D view of Model 4 (Shear Wall Frame)

Table 1- Seismic Parameters for all Models

SEISMIC PROPERTIES	
Seismic Zone	V
Seismic Intensity	Very Severe
Zone Factor	0.36
Soil Type	Medium
Response Reduction Factor	3
Importance Factor	1.5
Damping Ratio	5%
Reduction Percentage Live Load	25%

Table 2- General Parameters for all Models

GENERAL PROPERTIES	
Type of Structure	3D G+9 RC Framed Structure
Moment Resisting frame	OMRF
Plan Dimension	25 * 25 m
Type of Building Use	Commercial Building
No. of Bay in X direction	5
Width of Bay in X direction	5m
No. of Bay in Y direction	5
Width of Bay in Y direction	5m
Height of each Floor	3m
MEMBER PROPERTIES	
Size of Beam	300*600 mm
Size of Column	600*600 mm
Bracing Section	ISLB 600
Thickness of Slab	125 mm
Thickness of Wall	230 mm
Thickness of Shear Wall	230 mm
MATERIAL PROPERTIES	
Grade of concrete	M-25, M-30
Grade of steel	Fe-415, Fe-250
Density of concrete	25 KN /m^3
Density of masonry	21.20 KN /m^3
Poisson's ratio of concrete	0.20
DEAD LOAD INTENSITY	
Roof finishes	0.75 KN/m^2
Floor finishes	0.75 KN/m^2
LIVE LOAD INTENSITY	
Roof	Nill
Floor	3.0 KN/m^2

IV. ANALYSIS

The behaviour of all different models of structure in high seismic zones has been analyzed using equivalent static method in ETABS software. The results of different models structure are obtained and finally results of all model of structure are compared.

The results obtained are in terms of following and the results of the study are being illustrated using the graphs of:

1) Base Shear
2) Storey Shear
3) Storey Displacements
4) Storey Drift
5) Overturning moment
6) Storey stiffness

The main point of consideration of all results is as follows:

1) Displacement should be minimum for best model for consideration.
2) Story Stiffness should be maximum for best model.
3) Storey Drift should be minimum for different stories.
4) Storey Shear should be maximum to restrained the structure against seismic analysis.
5) Base shear should be maximum for base and minimum for upward due to seismic variation.

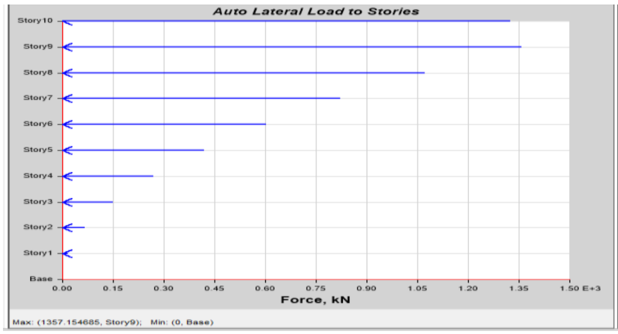

Fig 6.- Storey Lateral Loads for Model 2(Infill Frame)

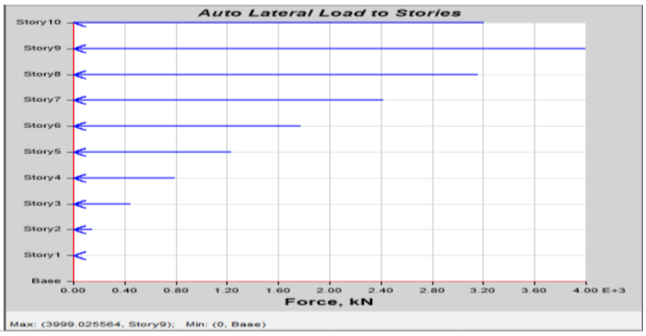

Fig 7- Storey Lateral Loads for Model 2(Infill Frame)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 05, May-2019

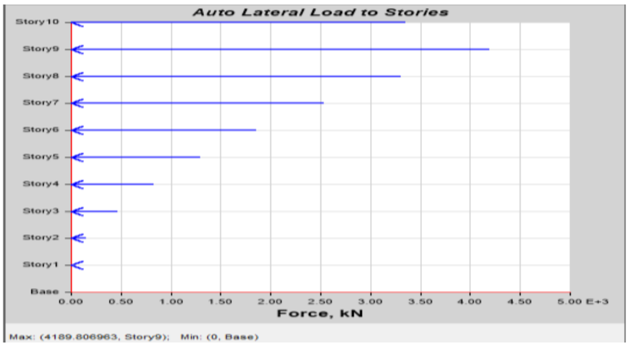

Fig 8- Storey Lateral Loads for Model 3(Bracing Frame)

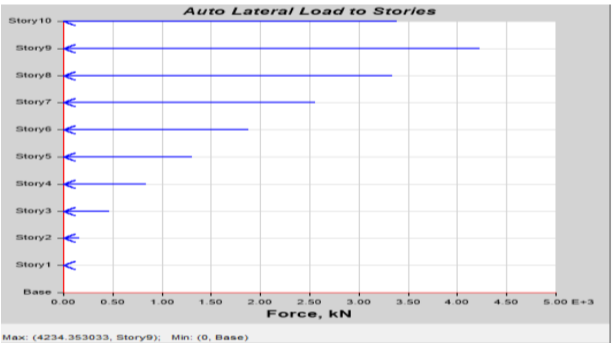

Fig 9- Storey Lateral Loads for Model 4(Shear Wall Frame)

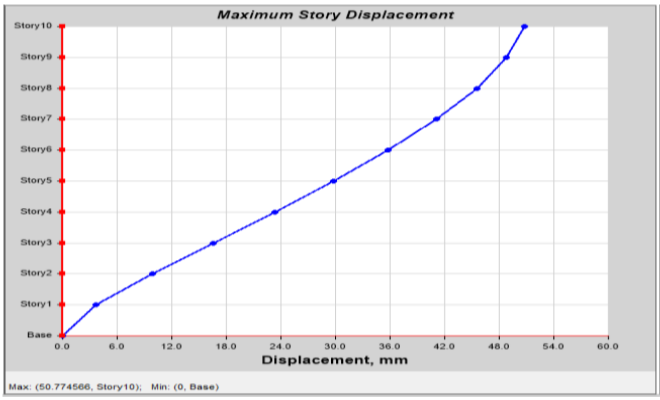

Fig 10- Storey Displacement for Model 1(Bare Frame)

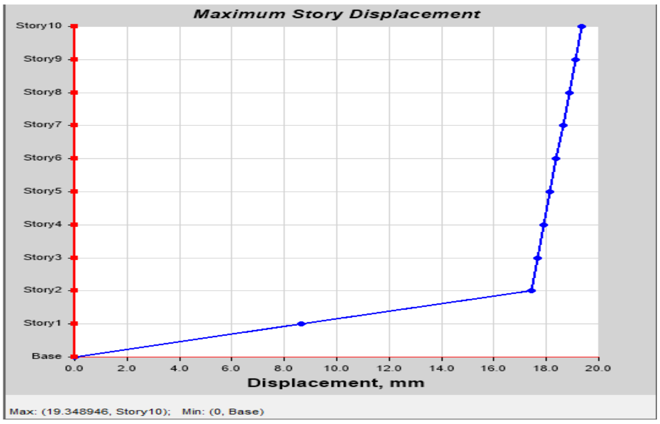

Fig 11- Storey Displacement for Model 2(Infill Frame)

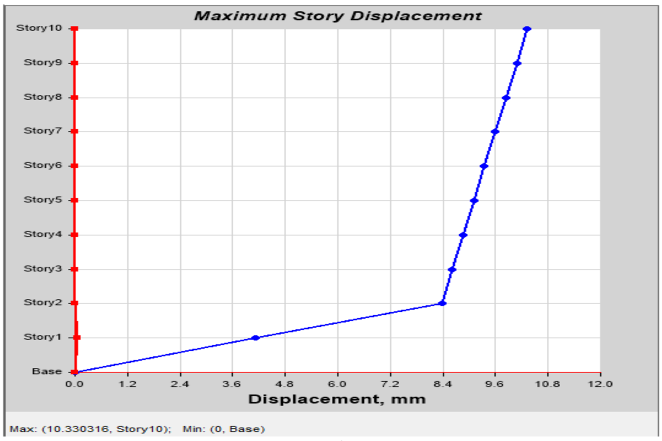

Fig 12- Storey Displacement for Model 3(Bracing Frame)

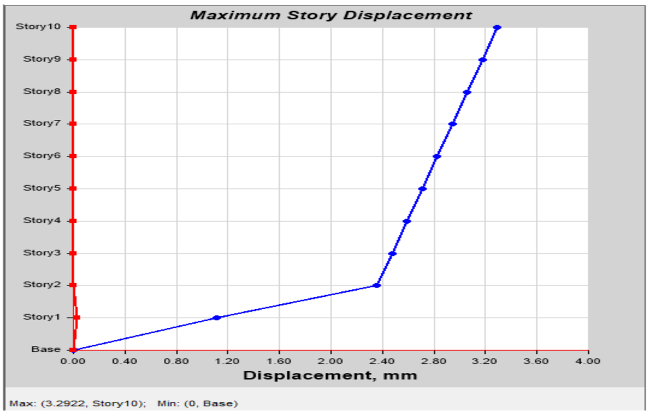

Fig 13- Storey Displacement for Model 4(Shear Wall Frame)

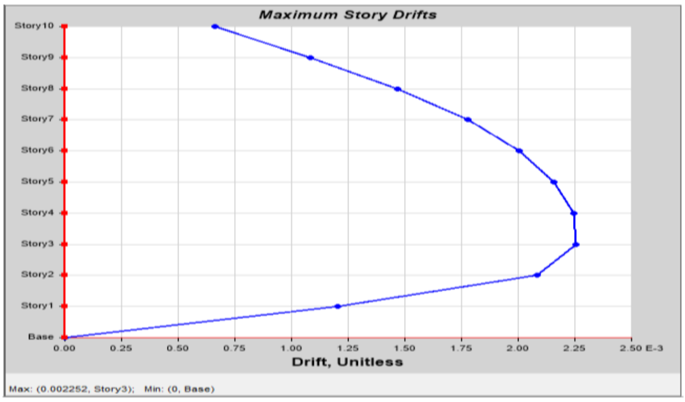

Fig 14- Storey Drifts for Model 1(Bare Frame)

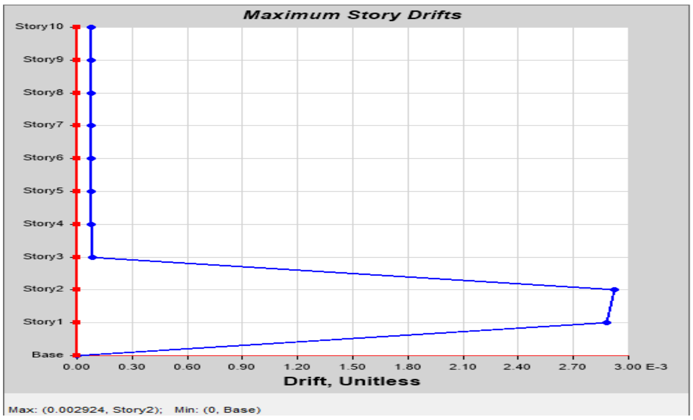

Fig 15- Storey Drifts for Model 2(Infill Frame)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 05, May-2019

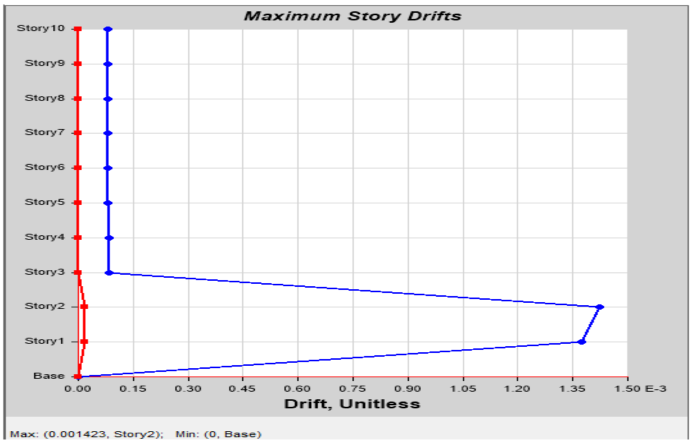

Fig 16- Storey Drifts for Model 3(Bracing Frame)

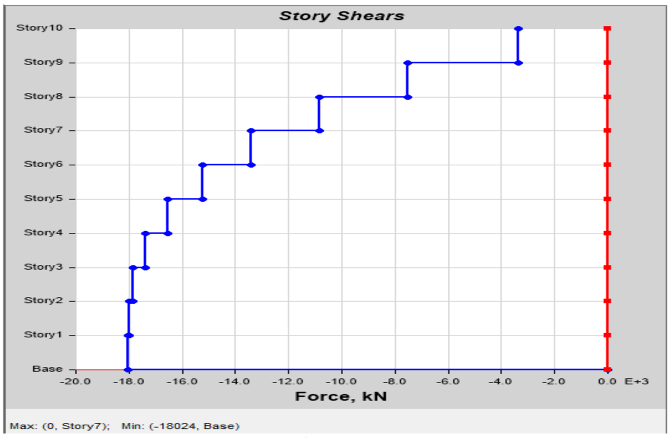

Fig 20- Storey Shear for Model 3(Bracing Frame)

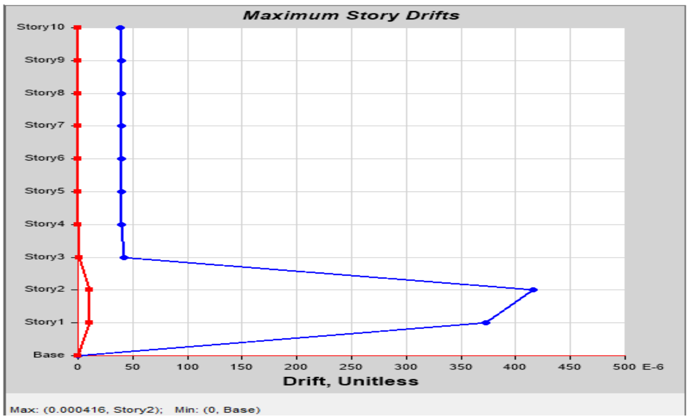

Fig 17- Storey Drifts for Model 4(Shear Wall Frame)

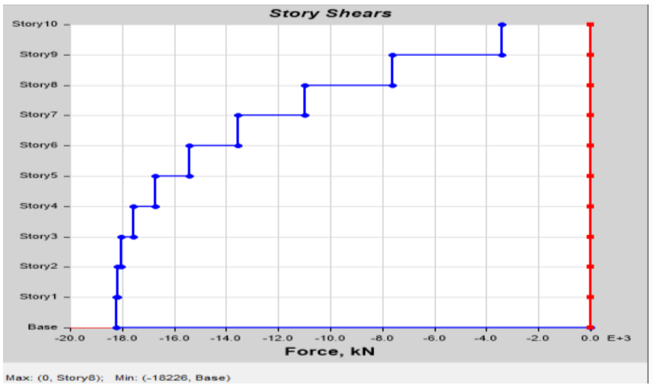

Fig 21- Storey Shear for Model 4(Shear Wall Frame)

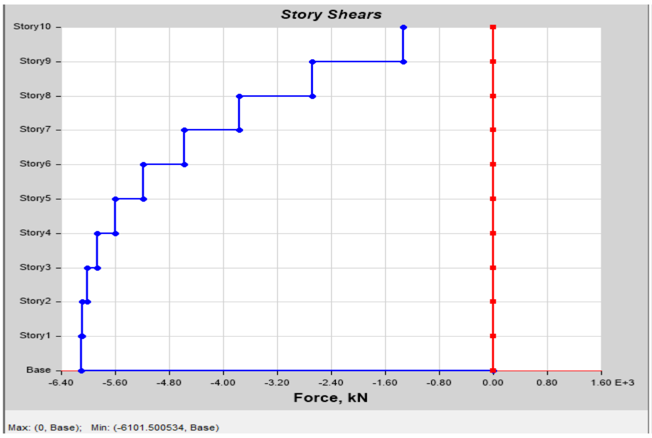

Fig 18- Storey Shear for Model 1(Bare Frame)

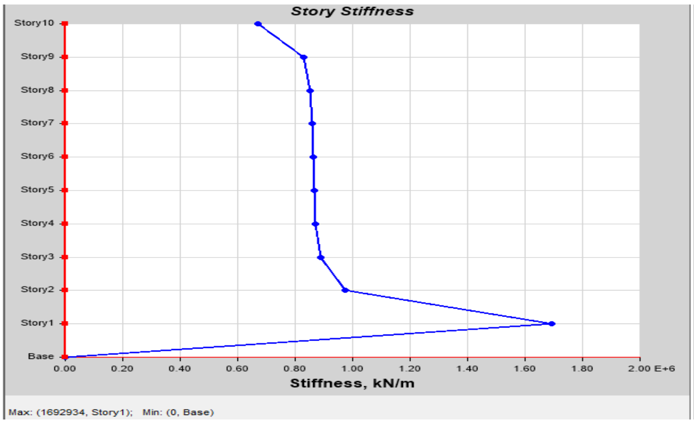

Fig 22- Storey Stiffness for Model 1(Bare Frame)

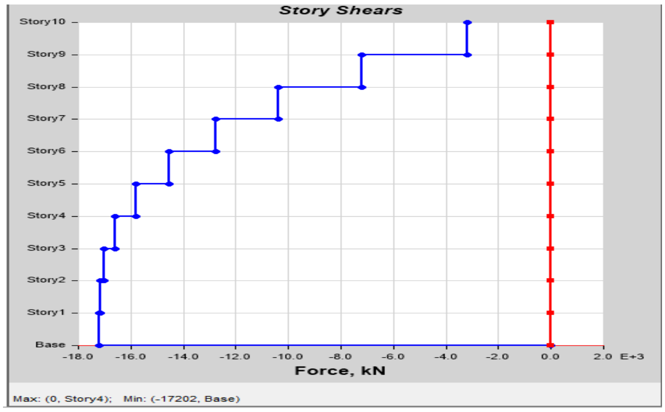

Fig 19- Storey Shear for Model 2(Infill Frame)

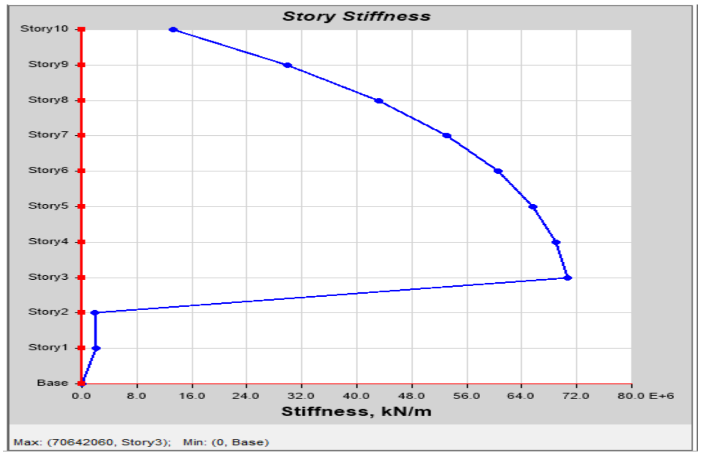

Fig 23- Storey Stiffness for Model 2(Infill Frame)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 05, May-2019

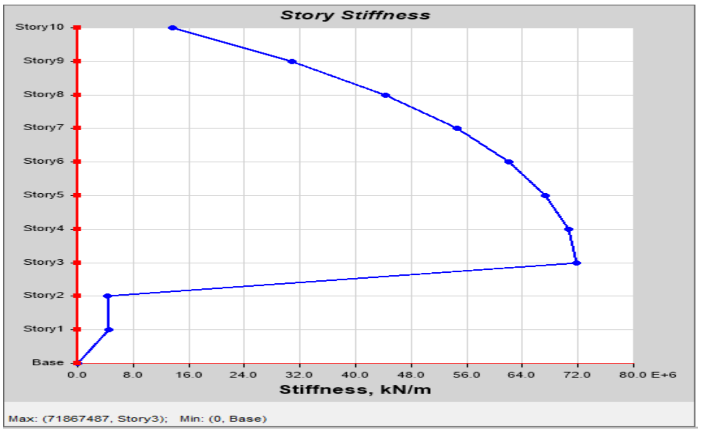

Fig 24- Storey Stiffness for Model 3(Bracing Frame)

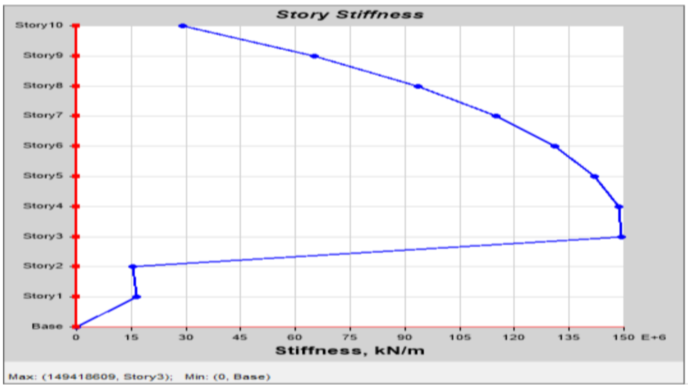

Fig 25- Storey Stiffness for Model 4(Shear Wall Frame)

V. RESULTS AND CONCLUSIONS

From the past earthquakes it has been noticed that the buildings have performed poorly as open storey building. Hence to understand the behavior of the structure, performance based analysis is very useful. In this project equivalent static analysis is done for both the structures. All the structures are influenced by dead, live and seismic loads. Out of these three loads, a seismic load proves to be major concern. Dead load mostly includes self-weight of the building, while the live load is something we can easily predict that will come on the structure in its entire lifetime. When it comes to seismic analysis it is very difficult to predict seismic load or rather say that, the seismic load or earthquake load comes to the structure is highly unpredictable. So to understand the nature of these types of loads seismic analysis is done using the code recommended i.e. IS 1893:2002.

The values are adopted from the code such that the structure should remain stable during its lifetime against the maximum considered earthquake on that particular zone. In this project the study is done to achieve an acceptable limit of safety for all structure so that the structure should not fail to that particular limit. The safety of the structure has always been considered most important by structural engineer.

RESULTS

The results of the study are being illustrated using the graphs which explain the structural behaviour of all the structures modals in terms of Lateral Forces, Storey Shear, Storey Displacements, Storey Drift, Storey stiffness, Over-turning moment. The study concluded with the following points:

1. According to the results using equivalent static method, the lateral load is zero at the ground and maximum at the top storey for all the structures.
2. The storey shear force was found to be maximum for the first storey and it decreased to a minimum in the top storey in all cases.
3. Large displacement was observed in the bare frame building compared to others. It indicates that building with bare frame structure in high seismic zones can also show higher displacement than a rest of the structure.
4. Since Shear wall model show less displacement it indicates that it is more economical and safe among all the models.
5. It is observed that the storey drift is much higher in bare frame model.
6. Storey drift is maximum for storey 6 i.e., intermediate storey.
7. The storey drift for all the stories are found to be within the permissible limits as per code
8. As a result of comparison of storey stiffness it is maximum for shear wall model. This result indicates that the shear wall system provide better restrained and feasibility against seismic variation and have good model among all.

DESIGN CHECK

Design for all members has been check and the following result has been concluded:

1. For common sectional properties of all structural members only modal 2 has been failed due to maximum seismic forces occurs on ground and first storey.
2. Model 4 gives best result from all the models.

FUTURE SCOPE

1. Different bracing system will be adopt to get more feasible result.
2. Different Shear wall system will be adopt to get different results.
3. For open storey consideration different location of soft storey will be adopt for future reference.

REFERENCES

[1] Dr. S. Setia and V. Sharma, Seismic Response of RCC Building with Soft Storey, International Journal of Applied Engineering and Research vol. 7 no. 11, 2012.

[2] Misam.A and M. N. Mangulkar, Structural Response of Soft Storey-High Rise Buildings under different Shear Wall locations, International Journal of Civil Engineering and Technology (IJCIET) Vol. 3, Issue. 2, July - December 2012.

[3] S. Arunkumar and Dr. G. N. Devi, Seismic demand study of Soft Storey building and its strengthening for Seismic Response, International Journal of Emerging Trends and Technology in Computer Science Vol. 5, Issue 2, March – April 2016.

[4] Prof. S. S. Patil and Mr. S. D. Sagare, Dynamic analysis of Soft Storey-High Rise Buildings with Shear Walls, International Journal of Civil Engineering Research and Application Vol. 1, Issue 4, August 2013.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 05, May-2019

[5] S. Kasnale and Dr. S. S. Jamkar, Study of Seismic performance for Soft basement of RC Framed Buildings, International Journal of Engineering Science and Research Technology, 2013.
[6] J. N. Arlekar, S. K. Jain and C. V. R. Murty, Seismic Response of RC Frame Buildings with Soft First Stories, Proceedings of the CBRI Golden Jubilee Conference on Natural Hazards in Urban Habitat, New Delhi 1997.
[7] P. Tiwari, P. J. Salunke and N. G. Gore, Earthquake Resistant Design of Open Ground Storey Building, International Research Journal of Engineering and Technology Vol. 2, Issue 7, October 2015.
[8] P. B. Lamb, Dr. R. S. Londhe, Seismic behavior of Soft First Storey, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) Vol. 4, December 2012.
[9] I.S. 1893 (Part 1): 2002, Criteria for Earthquake Resistant Design of Structures, Bureau of Indian Standards, New Delhi.
[10] IS: 875 (Part 1and 2) -1987 Code of practice for design loads (other than earthquake) for buildings and structures.
[11] Dande P. S. and, Kodag P. B.(2013), Influence of Provision of Soft Storey in RC Frame Building for Earthquake Resistance Design International Journal of Engineering Research and Applications
[12] Narendra Pokar and Prof. B. J. Panchal(2013),Small Scale Modelling on Effect of Soft Storey, International Journal of Advanced Engineering Technology
[13] N. Sivakumar and S. Karthik (2013), Seismic Vulnerability of Open Ground Floor Columns in Multi Storey Buildings, International Journal of Scientific Engineering and Research (IJSER)
[14] 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).
[15] P.B.Lamb and Dr R.S. Londhe(2012), Seismic Behaviour of Soft First Storey, IOSR Journal of Mechanical and Civil Engineering (IOSRJMCE) ISSN: 2278-1684 Volume 4, Issue 5 (Nov. - Dec. 2012)