

Behavior of Soft Storey And Weak Storey in RC Framed Structures Under Three Seismic Zones

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Abstract- RC structure in the recent time has got a special feature i.e. ground storey is left open for the purpose of social and functional needs like vehicle parking, shops, reception lobbies, a large space for meeting room or a banking hall etc. Such buildings are often called soft storey or open ground storey buildings. During earthquake the major effect to the buildings are due to soft storey and weak storey. Because of less stiffness in soft and weak storey, they cannot withstand the effect of earthquake which results in the collapse of the building. Many studies have shown that there is a sudden collapse of the building if soft or weak storey is present in the ground floor of the building. Increase in the stiffness of the building which have soft or weak storey will reduce the effect of earthquake to the building.

Keywords- Soft storey, Weak storey, Seismic Coefficient method, Mode superposition method

I. INTRODUCTION

An earthquake can be defined as a wave like motion which is generated by forces in constant convulsion, may be below the earth surface or travelling through the crust of earth. It can also be defined as the violent vibration due to the energy released in the earth's crust. These wave like motions or elastic waves are generated mainly by abrupt disorganization of the crust's segments, or it may also be caused by explosions created by humans. About 90% of the earthquakes are caused due to the movement of tectonic plates, especially the faults movement. Other 10% are due to volcanic eruptions, collapse of subterranean cavities, manmade explosions.

During earthquake the major disasters that may occur are due to collapse of the structures like buildings, bridges etc. According to the past earthquake studies, it is very much important to consider the parameters which are developed do design a building safely against the earthquake. For structures which are already built, they must be strengthened in order to resist the earthquake

II. LITERATURE REVIEW

Abhishek Arora [1], has given two ways of controlling the effect of soft storey in RC framed building. The first method is that by providing stiff column, which increases the load carrying capacity of the building. The second method is that by providing adjacent infill wall in the soft storey structure. He has taken two buildings namely MODEL NO.1 and MODEL NO.2 for his work. For the first model he has provided full infill masonry wall in all storeys except ground storey with column size of 300 mm x 600 mm. In second model he has provided column with masonry wall i.e. shear wall in ground storey and one full infill masonry wall in all other storeys. The conclusion was that when the first model was subjected to lateral force, each floor was drifted with respect to the adjacent floors. This is because each floor mass acts independently. But in the second model due the presence of shear wall all the upper floor act as a single mass and relative drift between adjacent floors was restricted.

M.R Amin, P Hasan, B.K.M.A Islam [2], have analyzed four types of building models. They are 3 storeys, 6 storeys, 9 storeys and 12 storeys with identical plan. In order to generate infill effect they have provided Equivalent Diagonal Strut. They kept the building symmetric in order to avoid the torsion effect and provided square column to keep the discussion focused only on soft storey effects and not distracting by the issues like orientation of the column. They have altered the soft storey level for every storey level. To produce the effect of soft storey they have not given any infill in that particular storey. Linear elastic analysis was performed using E-TABS 9.6.0. They found that irrespective of the storey height and location of the soft storey a similar pattern was generated. Initially the drift decreases till the middle portion. In the middle portion it increases and again it decreases from middle to top portion. This indicates that there is maximum lateral deflection in the middle portion of the building. The inter storey drift ratio was also observed to be maximum in the middle portion of the buildings. This pattern was independent of the location of the soft storey and also the height of the building.

III. SOFT STOREY AND WEAK STOREY

Soft storey can be defined as the one in which lateral stiffness is less than 70 percent of that in the storey above or less than 80 percent of the average lateral stiffness of the three stories above. The weak storey can be defined as the one in which the storey lateral strength is less than 80 percent of that in the storey above. The storey strength is defined as the total strength of all seismic force resisting elements sharing the storey shear in the considered direction. Many RC framed buildings having soft stories, suffered major structural damage and collapsed in recent earthquakes. The major causes for the damage are large open areas with less infill and exterior walls in ground floor compared to upper floors. In such type of structures, the stiffness of lateral load resisting systems at those stories is quite less when compared to the stories above or below.



Figure 1. Soft and weak storey failure due to large lateral displacement

a) DETAILS OF THE MODELS

Major three models are done. For these models variation of ground floor and introducing equivalent diagonal strut is done. A new concept called double height column is introduced, that is in particular floor slabs, beams (except periphery) and columns (except periphery) are removed. The modeling and analysis was done for zone III and the same building is used for zone II and V. Hence it can be observed that there is huge amount of displacement in bare frame buildings in zone V, The three models are as follows

- Regular building
- Irregular building with symmetry in both directions.
- Irregular building with asymmetry in both directions.

b) EQUIVALENT DIAGONAL STRUT

The material and geometrical properties of the equivalent diagonal strut are required to increase the stiffness of the RC frame building with bare frame. The effective width and thickness of the strut are the required geometrical

properties. The thickness and thickness of the strut are similar to that of the masonry infill wall of the building.

Many researchers have studied the interaction of the between masonry infill and RC frames. They have reported significant findings regarding the panel's greater mechanical strength, lower displacement and higher ductility. However, there are wide variety of techniques to evaluate the strength and stiffness of the infill frames.

IV. OBJECTIVES OF THE WORK

The objectives to be carried out are as follows:

- Behaviour of high raised buildings having silt floors.
- Analysis to be done using.
 - Seismic coefficient method
 - Mode superposition method
- Behaviour of regular structure in different seismic zones.
- Behaviour of irregular building which is symmetrical in both directions in different seismic zones.
- Behaviour of irregular building which is unsymmetrical in both directions in different seismic zones.
- Comparison of regular and irregular buildings under different seismic zones.
- Effect of soft storey and weak storey in all the building models considered. Effect of infill in the buildings considered

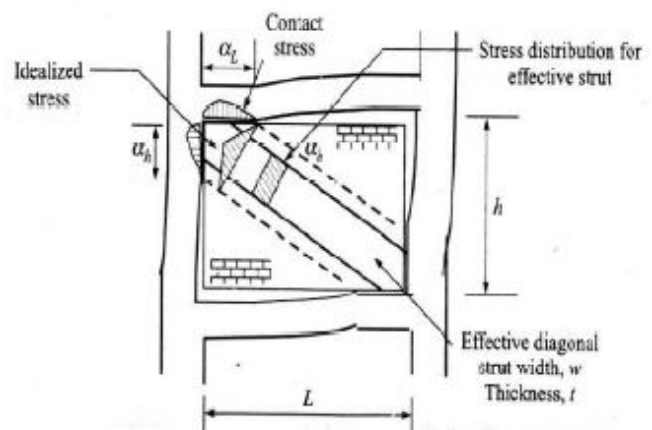


Figure 2. Typical equivalent diagonal strut (Drydale, et al, 1994)

V. SEISMIC COEFFICIENT METHOD

For most of the structures seismic analysis is carried out on the basic assumption that lateral force is equivalent to dynamic loading. Less effort is required for this method because, other than fundamental period, the periods and shapes of higher natural modes of vibration are not required. The total horizontal force on the structure, that is base shear, is

calculated on the basis of the mass of the structure, its fundamental period of vibration, and corresponding shapes. The base shear is always distributed along the height of the structure, in the form of lateral forces. This method is usually preferred to low and medium raised buildings.

VI. MODE SUPERPOSITION METHOD

This method is applicable for those types of structures where modes other than fundamental mode is significantly affect the response of the structure. Mode superposition is based on the fact that the certain types of damping, the response in each natural mode of vibration can be computed independently of the others, and the modal responses can be combined to determine the total response. Each mode responds with its own definite pattern of deformation that is mode shape, with its own frequency that is modal frequency and with its own modal damping. For each modal response time history can be computed by analysis of a single degree of freedom oscillator with properties chosen to be representative of the particular mode and the degree to which it is excited by the earthquake motion. The responses are needed to be found only for first few modes because response to earthquake is primarily due to lower modes of vibration.

Generally this method is used for the analysis of dynamic response of the structures, which are not symmetrical or have areas of irregularity or discontinuity. In particular, this method is applicable for the analysis of forces and deformations in multi storey buildings due to medium intensity ground shaking. This causes a moderately large but essentially linear response in the structure. The design Base shears VB' calculated using mode superposition method is compared with the Base shear VB calculated using seismic coefficient method. We can observe that VB is greater than VB' . We should multiply scale factor VB/ VB' for all response quantities, for example member forces, displacements, storey forces, storey shears and base reactions. The value of damping can be taken as 5 percent of critical value, for the purpose of dynamic of RCC buildings.

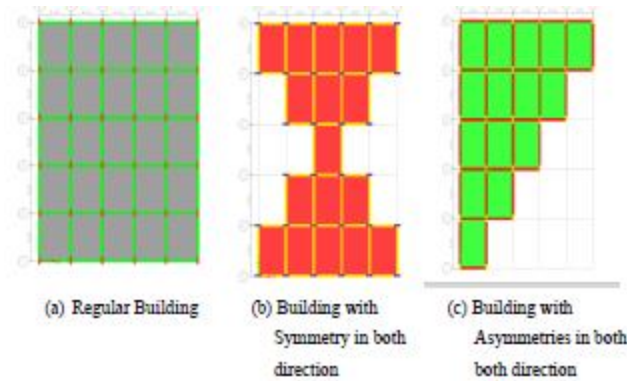


Figure 3. Plans of different types of models considered

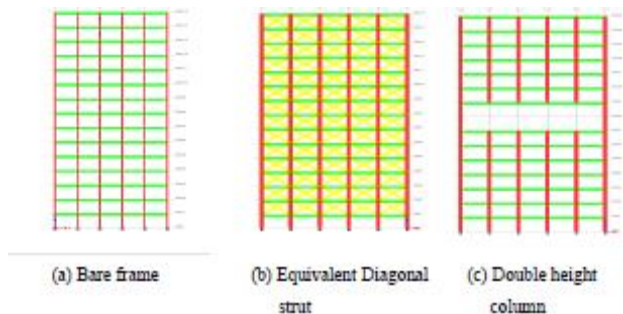


Figure 4. Elevations of buildings considered for the project work

VII. RESULTS AND DISCUSSIONS

Maximum storey displacement and Maximum storey drift are considered as parameters for results and discussions. Graphs are plotted from the result obtained from E – TABS 2015. These graphs are merged according to their Zones are related according to the models prepared.

a. TYPES OF COMPARISONS

TYPE A:

In this type of comparison major parameters considered is Seismic Coefficient method and Mode Superposition Method. In both the methods displacement and drift are considered. Here displacement and drift of all models for all zones are compared. For example regular building with bare frame having varying story height for all zone are compared considering displacement and drift as parameters for both the methods

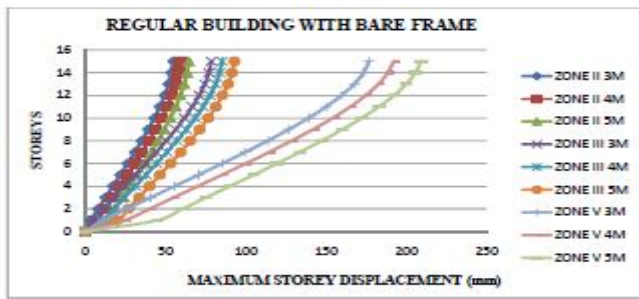


Figure 5. Regular building with bare frame (SCM, Displacement)

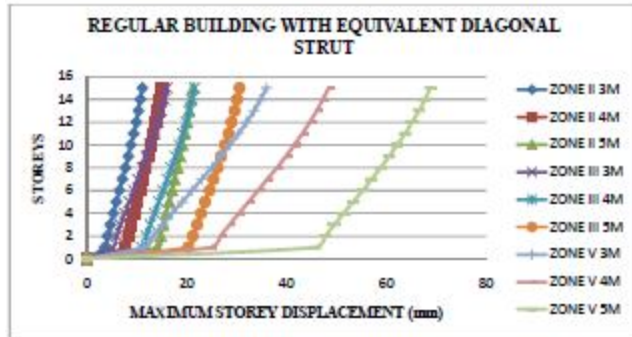


Figure 6. Regular building with Equivalent Diagonal strut (MSM, Displacement)

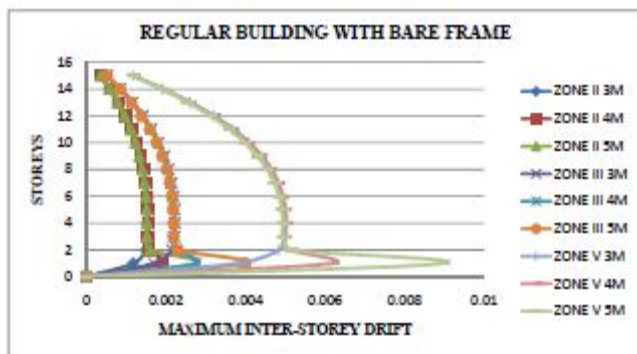


Figure 7. Regular building with bare frame (SCM, Drift)

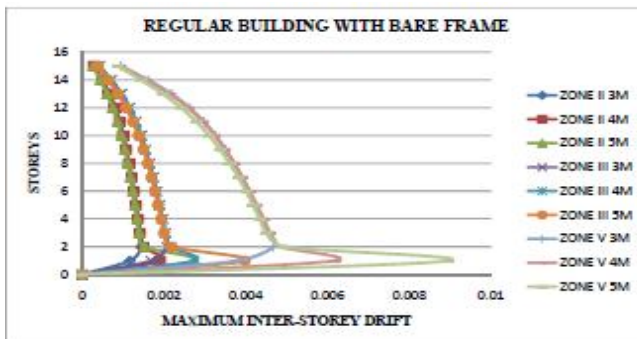


Figure 8. Regular building with bare frame (MSM, Drift)

TYPE B:

In this type of comparison major parameters considered are Zones which are considered for the project work that is Zone II, III and V. Here also displacement and drift are considered. Two methods that is Seismic coefficient Method and Mode superposition Method are compared for all the models. For example considering Zone II, displacement as a parameter, regular building with bare frame having varying storey height, two methods that is Seismic coefficient Method and Mode superposition Method are compared.

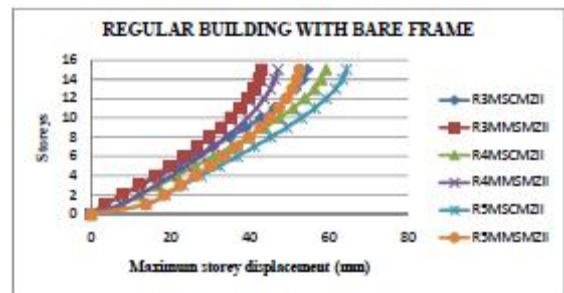


Figure 9. Regular building with bare frame by SCM and MSM (Displacement, Z II)

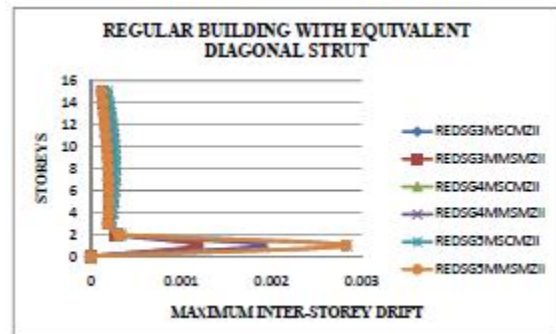


Figure 10. Regular building with Equivalent diagonal strut by SCM and MSM (Drift, Z II)

VIII. CONCLUSIONS

In regular building with bare frame by Seismic Coefficient method, the displacement is more in 5m storey height building. This is because it has less stiffness when compared to the storeys above. With the increase in height of the ground storey increase in displacement can be observed which clearly shows that there is reduction in stiffness of that storey

In Irregular building symmetric in both directions with bare frame by Seismic Coefficient method, it is observed that for buildings considered irrespective of storey height, there is less amount of displacement observed in all zones considered. This clearly shows that in any zone irregular symmetric buildings will show almost similar displacements

irrespective of their storey heights. Same conclusion can be drawn for irregular building asymmetric in both directions

In regular building with Equivalent Diagonal strut by Seismic Coefficient method, it can be observed that there is large amount of reduction in displacement when compared to bare frame building. Here there is an overlapping of 3m and 4m storey height of Zone III on Zone II buildings. This shows that the displacements in these zones are almost similar and behavior of these buildings in both the zones is same. There is a huge amount of increase in stiffness in the buildings because of the provision of Equivalent Diagonal strut. Same conclusion can be drawn for Irregular building asymmetric in both directions.

In Irregular building symmetric in both directions with Equivalent Diagonal strut by Seismic Coefficient method, it can be observed that irrespective of storey heights there is a very close range of graphs for all considered zones and also Zone II and Zone III buildings are very close. This shows that the behavior of these buildings in both the Zones is similar and there stiffness is also almost same.

In Regular building with Double height column by Seismic Coefficient method, it can be observed that buildings provided with strut has less displacement when compared to the one not provided. The stiffness in the strut DHC is more in all zones considered.

In Irregular building symmetric in both directions with Double height column by Seismic Coefficient method, it can be observed that there is an overlapping of strut DHC of zone V with regular DHC in zone II. Though there is difference in the building and zones their behavior is same because the provision of strut increases the stiffness and more over building in zone V is already in severe zone. The building in zone II with regular DHC has less stiffness. Hence they match up with each other.

In Irregular building asymmetric in both directions with Double height column by Seismic Coefficient method, it can be observed that for storey height 5m there is more amount of displacement in both strut and regular buildings.

In regular building with bare frame by Seismic Coefficient method, it can be observed that there is soft storey effect in 5m storey height building and weak storey effect in 3m storey building. Whereas in case of 4m storey height building there is no such soft or weak storey effect. This shows that there is similar storey heights in the building then there is a possibility of occurrence of weak storey. If the ground storey height more than 1.5 times the typical storey

height then there is soft storey effect. Hence there should be moderate amount of increase in height of ground storey.

In Irregular building symmetric in both directions with bare frame by Seismic Coefficient method, it can be observed that there is soft storey effect in 3m and 4m storey height. 5m storey height building has no soft or weak storey effect. Here there is no weak storey effect.

In Irregular building asymmetric in both directions with bare frame by Seismic Coefficient method, it can be observed that there is existence of all three cases in this type of building. 3m storey height building has weak storey, 5m storey has soft store and 4m storey height building has no such effects. Hence with moderate ground floor height we can get good results for earthquake resisting building.

In regular building with Equivalent Diagonal strut by Seismic Coefficient method, it can be observed that there are soft storeys in all storey heights of the buildings. Because of the provision of Equivalent Diagonal strut there is a sudden collapse in the building. 5m storey height building is highly vulnerable to earth quake. Hence ground storey height must be limited.

REFERENCES

- [1] Abhishek Arora. Alternative approach to Soft Stories in Seismic Analysis of R.C building structures, SSRG International Journal of Civil Engineering (SSRG-IJCE) – EFES April 2015
- [2] M.R. Amin, P. Hasan, B.K.M.A Islam. Effect of soft storey on multistoried reinforced concrete building frame. 4th Annual paper meet and 1st Civil Engineering Congress, December 22-24, Dhaka, Bangladesh
- [3] Amit V Khandve, Seismic Response of RC Frame Buildings with soft storeys. International Journal of Engineering Research and Applications, Volume 2, Issue 3, pp 2100 – 2018.
- [4] M D Rihan Maaze and S S Dyavanal. Seismic evaluation of multistoried building with soft storey. International Journal of Engineering Research and Applications, eISS 2319- 1163, pISSN 2321-7308.
- [5] S.K.Duggal. “Earthquake resistance design of structures”
- [6] Pankaj Agarwal and Manish Shrikhande. “Earthquake resistance design of structures”

- [7] Larry J Segerlind. “Applied finite element analysis”.
- [8] Scale factor for IS 1893 Indian code. “CSI knowledge base”.
- [9] CSi Analysis reference manual. E-TABS 2015 Computers and Structures Inc, Structural and Earthquake Engineering Software.