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Seismic Behavior of RC Framed Building with Soft Storey

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***Abstract*— Open ground storey system is being adopted in many buildings presently due to the advantage of open space to meet the economical and architectural demands. For offices or for any other purpose such as communication hall etc. soft storey at different levels of structure is constructed. Hence in this study an attempt has been made to investigate performance of a building with soft storey (G+14) at different level along with ground level. Also it has been tried to investigate on adding of shear wall to structures in order to reduce soft storey effect on seismic response of building. The linear response spectrum analysis was carried out and the results obtained from models were compared in terms of storey displacement, storey drift, storey shear, time period and best alternative for construction in earthquake-prone area was selected.**

Keywords—Soft storey, Shear wall, Storey drift, Storey displacement, Storey shear, Time period, Time history analysis, Response spectrum analysis, ETABS.

I. INTRODUCTION

A soft story known as weak story is defined as a story in a building that has substantially less resistance or stiffness or inadequate ductility (energy absorption capacity) to resist the earthquake-induced building stresses. Soft story buildings are characterized by having a story which has a lot of open space [1]. Many urban multistory buildings in India today have open first storey as an unavoidable feature. This is primarily being adopted to accommodate parking or reception lobbies in the first stories. The upper stories have brick unfilled wall panels. The draft Indian seismic code classifies a soft storey as one whose lateral stiffness is less than 70% of the storey above [Draft IS: 1893, 2002]. Whereas the total seismic base shear as experienced by a building during an earthquake is dependent on its natural period, the seismic force distribution is dependent on the distribution of stiffness and mass along the height. In buildings with soft first storey, the upper storey's being stiff undergone smaller inter-storey drifts. However, the inter-storey drift in the soft first storey is large [2]. Due to the presence of infill walls in the entire upper storey except for the ground storey makes the upper storey much stiffer than the open ground storey. Thus, the upper storey 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, this type of buildings sway back and forth like inverted pendulum during earthquake shaking, and hence the columns in the ground storey columns and beams are heavily stressed. Therefore it is required that the ground storey columns must have sufficient strength and adequate ductility [3]. Soft storey can form at any level of a high rise building to fulfill required functional necessity and serve various purposes. Due to various needs a soft storey is also unavoidable and thus it becomes important to study the performance of a soft storey building and study its effects [4].

II. REVIEW OF LITERATURE

A. General

Misam.A and Mangulkar Madhuri.N. (2012) discussed about severe structural damage suffered by several modern buildings during recent earthquakes illustrates the importance of avoiding sudden changes in lateral stiffness and strength. The lower level containing the concrete columns behaved as a soft story in that the columns were unable to provide adequate shear resistance during the earthquake. Usually the most economical way to eliminate such failure in a building is by adding shear wall to soft stories. In this paper occurring of soft story at the lower level of high rise buildings subjected to earthquake has been studied. Also has been tried to investigate on adding of shear wall in various arrangements to the structure. Four different models were prepared in this paper & they are as follows:

Model 1: The structure without lateral load resistance system is called model-I.

Model 2: The model-I (Soft story at bottom) is modified into this model with adding the shear wall.

Model 3: This model is also a shear wall-frame building. The shear wall is added at the corners bays of the building.

Model 4: This model is also a shear wall-frame building. The shear wall is added at the two center bay of building. In this model, the soft story at the lowest floor has been added the shear wall in center bay too. [1]

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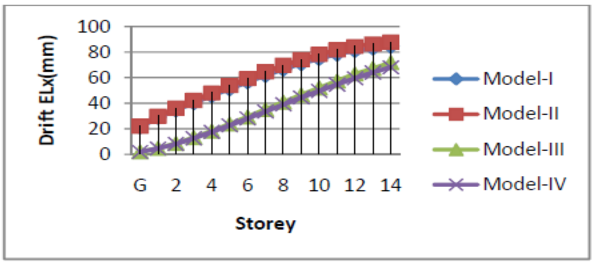

Figure. 1 Drift of building [1]

Mohamed Riyas N.K, Dr. Raneesh K.Y and Marshiyth K.P (2016) studied the seismic vulnerability of building with an Example of G+24 building with soft storey at intermediate floor using linear static analysis. Analysis and design were carried out on a RCC moment resisting framed tall building without Infill wall on different floors with the help of Software ETABS 2015 and concluded that deflection and displacement are always maximum at soft storey level. Models considered for the study are as follows:

Model 1: Soft storey at ground floor level

Model 2: Soft storey at 6th floor level

Model 3: Soft storey at 12th floor level

Model 4: Soft storey at 18th floor level

Model 5: Soft storey at 24th floor level [2]

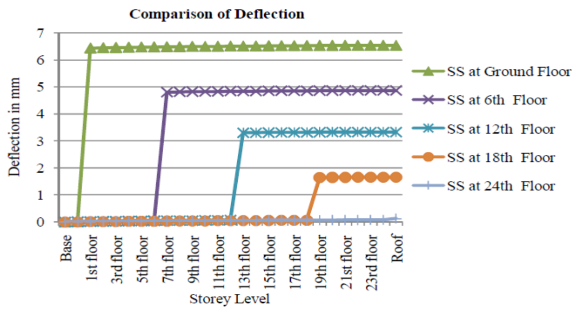

Figure. 2 Comparison of deflection [2]

Ranjit V. Surve, Prof. D.S. Jagtop and Y.P. Pawar (2015) investigated on finding the best place for soft storey in high rise building with ground level and also focused on natural time period of multistoried structure. He concluded that shifting of the soft storey to higher level results in reduction of number of hinges and if soft storey is provided at ground level, the base shear was found to be maximum. [5]

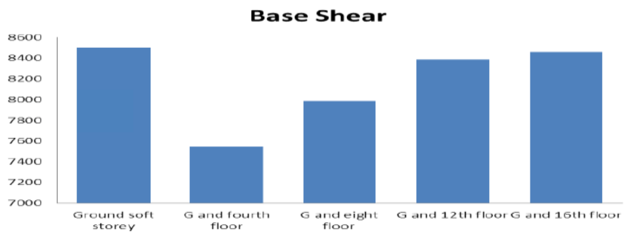

Figure. 3 Comparison of base shear [5]

B. *Modeling of infill walls*

Al-Chaar et al. (2002) proposed an eccentric equivalent strut as shown in below figure which was pin connected to the column at a distance l_e from the face of the beam to model the masonry infill wall. [6]

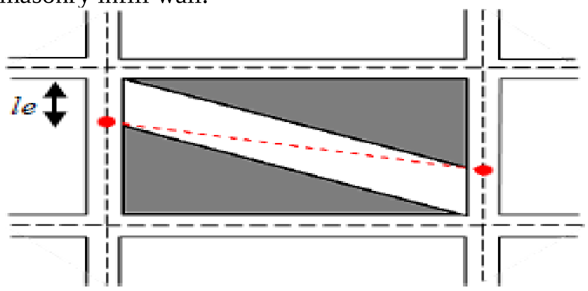

Figure. 4 Position of eccentric strut [6]

Asokan et al. (2006) studied how the presence of masonry infill walls in the frames of a building changes the lateral stiffness and strength of the structure. This research proposed a plastic hinge model for infill wall to be used in nonlinear performance based analysis of a building and concludes that the ultimate load (UL) approach along with the proposed hinge property provides a better estimate of the inelastic drift of the building. [7]

Murty C. V. R. and S. K. Jain (2000) made significant experimental and analytical research effort till date in understanding the behavior of masonry in-filled frames. In-fills interfere with the lateral deformations of the RC frame; separation of frame and in-fill takes place along one diagonal and a compression strut forms along the other. Thus, in-fills add lateral stiffness to the building. [8]

Under lateral loading the frame and the infill wall stay intact initially. As the lateral load increases the infill wall get separated from the surrounding frame at the unloaded (tension) corner, but at the compression corners the infill walls are still intact. The length over which the infill wall and the frames are intact is called the length of contact. Load transfer occurs through an imaginary diagonal which acts like a compression strut. Due to this behavior of infill wall, they can be modeled as an equivalent diagonal strut connecting the two compressive corners diagonally. The stiffness property should be such that the strut is active only when subjected to compression. Thus, under lateral loading only one diagonal will be operational at a time. This concept was first put forward by Holmes et al. (1961). [9]

Deodhar and Patel (1998) pointed out that even though the brick masonry in in-filled frame is intended to be non-structural, they can have considerable influence on the lateral response of the building. [10]

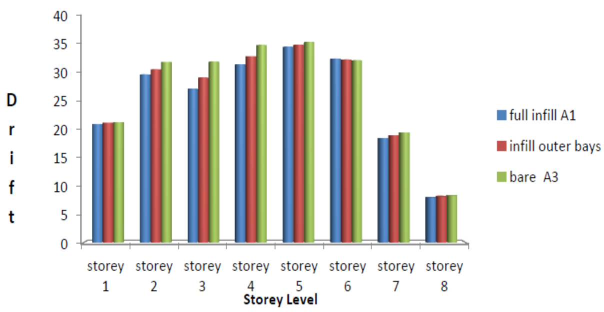

Figure. 5 Storey drift v/s storey level for different infills [10]

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Karisiddappa et al. (1986) here examined the effect of openings and their location on the behavior of single storey RC frames with brick infill walls. [11]

Scarlet et al. (1997) studied the qualification of seismic forces in OGS buildings. A multiplication factor for base shear for OGS building was proposed. This procedure requires modeling the stiffness of the infill walls in the analysis. The study proposed a multiplication factor ranging from 1.86 to 3.28 as the number of storey increases from six to twenty. [12]

III. PROBLEM STATEMENT OF STUDY

In present work, in order to determine dynamic response of Soft Storey at different floor levels in seismic zone III will be modeled and analyzed in ETABS software. Dynamic response spectrum analysis and non linear time history analysis will be performed on the structure. In present work 8 number of conventional RC frame with soft storey (G+14) building models are considered and will try to investigate on adding of shear wall to structures in order to reduce soft storey effect on seismic response of building.

A. Models of building

Model-1: Soft storey at G.L. & 2nd floor.
Model-2: Soft storey at G.L. & 6th floor.
Model-3: Soft storey at G.L. & 10th floor.
Model-4: Soft storey at G.L. & 14th floor.
Model-5: Soft storey at G.L. & 2nd floor with shear wall.
Model-6: Soft storey at G.L. & 6th floor with shear wall.
Model-7: Soft storey at G.L. & 10th floor with shear wall.
Model-8: Soft storey at G.L. & 14th floor with shear wall.

B. Design data of building

TABLE I. DESIGN DATA OF PROBLEM STATEMENT

Data for building	Dimension
No. of storey	15 (G+14)
Plan dimension	30 m X 25 m
Storey height	3.5 m
Slab thickness	150 mm
Column size	900 x 900 mm
Beam size	300 X 600 mm
Wall thickness	External Wall: 230 mm Internal Wall: 115 mm Shear Wall: 250 mm
Live load	For Floor, Roof: 3, 1.5 kN/m^2
Floor finish	1 kN/m^2
Water proofing	1.5 kN/m^2
Grade of concrete	M 25
Grade of steel	Fe 415
Earthquake data	Zone-III, Type II medium soil, Importance factor-1.

C. Elevation of building

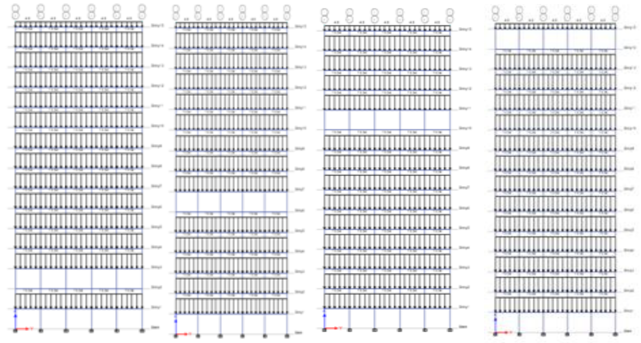

Figure. 6 Model-1 to 4

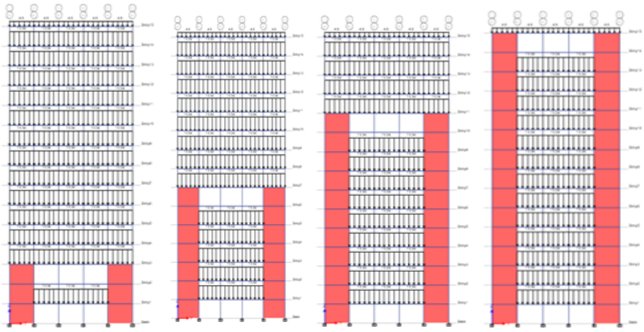

Figure. 7 Model-5 to 8

IV. RESULTS AND DISCUSSION

Dynamic analysis for RC Frame building with soft storey is done by using response spectrum analysis and time history analysis for earthquake zone III as per Indian standard code. Loads are calculated and distributed as per the code IS: 875 (part-1 to 3) 1987. The effect of location of soft storey at different height of building and effect of shear wall up to the height of soft storey is evaluated. There is significant change in seismic parameters like storey displacement, storey drift, storey shear and time period and is noticed and discussed below.

A. Storey displacement

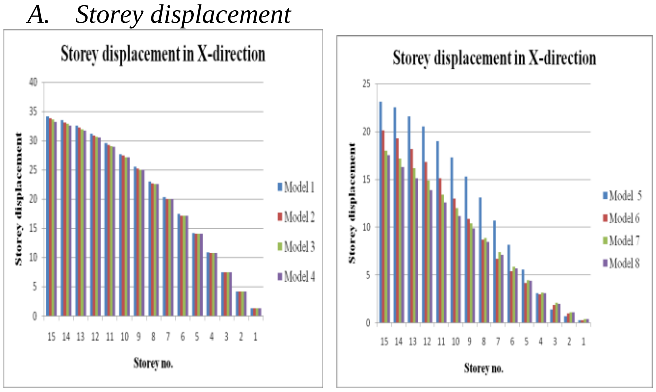

Chart. 1 Storey number v/s storey displacement

As the level of the soft storey decrease the value of displacement increase. The displacement value of model 1 is about 1.16%, 1.75%, 2.92% higher compared to model 2, 3, 4 in x direction and displacement value of model 5 is about 12.98%, 22.07%, 24.24% higher compared to model 6, 7, 8 in x direction.

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B. Storey drift

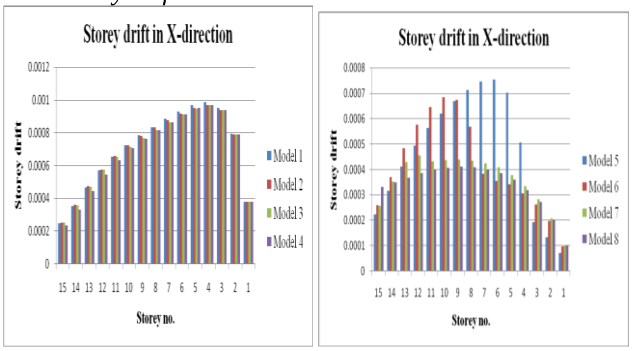

Chart. 2 Storey number v/s storey drift

As the level of the soft storey increase the value of drift decrease. The drift value of model 1 is about 1.72%, 1.72%, 1.62% higher compared to model 2, 3, 4 in x direction and drift value of model 5 is about 9.41%, 41.64%, 45.49% higher compared to model 6, 7, 8 in x direction.

C. Storey shear

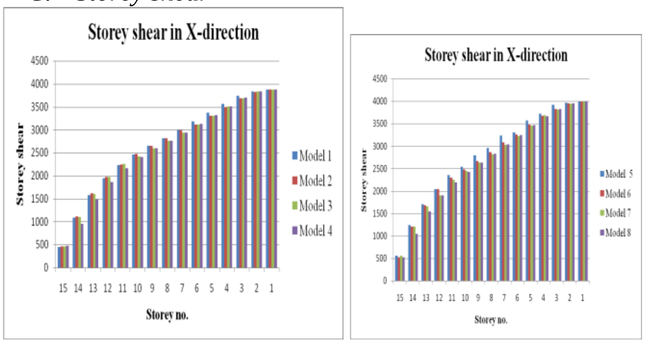

Chart. 3 Storey number v/s storey shear

From the above charts (model 1 to 4) it was observed that maximum storey shear is same for all the models because same amount of load is removed from all models. The storey shear value of model 8 is about 0.25%, 0.33%, 0.37% higher compared to model 7, 6, 5 in x direction.

D. Time period

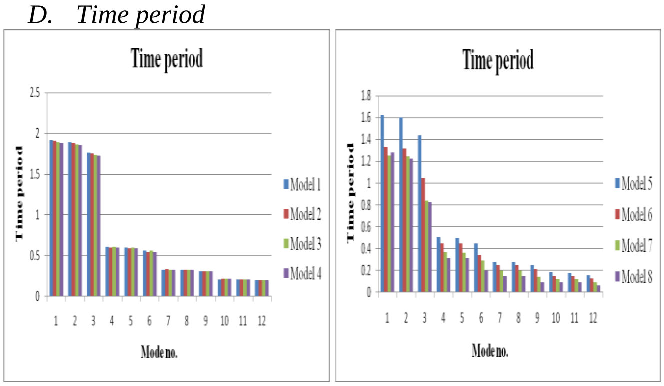

Chart. 3 Storey number v/s storey shear

As the level of soft storey increases the value of time period decreases. The time period of model 1 is about 0.52%, 1.40%, 2.08% higher compared to model 2, 3, 4 and time period of model 5 is about 17.87%, 22.81%, 20.90% higher compared to model 6, 7, 8.

V. CONCLUSION

- Storey displacement, storey drift and time period of model 1 was found to be maximum as soft storey was provided at lower level compared to model 2, 3 and 4.
- Storey displacement, storey drift and time period of model 8 was found to be minimum as soft storey was provided at higher level (top floor) compared to model 5, 6 and 7.
- As the level of the soft storey increase the value of displacement decrease.
- As the level of the soft storey decrease the value of drift increase.
- As the level of soft storey decreases the value of time period increases.
- The storey shear is maximum at ground level and keeps on decreasing towards the top storey of the structure.
- Therefore, it is advisable to provide soft storey at higher levels and shear wall should be provided to reduce the earthquake effect in soft storey.

VI. FUTURE SCOPE OF STUDY

- The structure can be analyzed in different seismic zones and with different soil types.
- The structure can be analyzed with effect of bracing or damper.
- Non linear pushover analysis of RC building with soft storey can be performed using ETABS, SAP-2000.
- Comparison of different locations of shear wall on soft storey building can be done and also design can be carried out.
- Soil structure interaction can also be performed and analyzed on the structure.
- Optimum design of building with soft storey in earthquake prone areas can be done.
- Time history analysis of RC framed building with soft storey can be performed using ETABS, SAP-2000.

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REFERENCES

[1] Misam.A and Mangulkar Madhuri.N, "Structural response of soft storey high rise buildings under different shear wall location", International journal of civil engineering and technology (IJCIET) Vol 3, Issue 2, July-December (2012), pp.169-180.

[2] Mohamed Riyas N.K, Dr.RaneeshK.Y and MarshiyathK.P, "Effect of soft storey on tall building at different floor levels", International journal of innovative research in science, engineering and technology (IJIRSET) Vol 5, Issue 8, August 2016.

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[3] Saurabh Singh, Saleem Akhtar and Geeta Batham, " Evaluation of Seismic Behavior for Multistoried RC Moment Resisting Frame with Open First Storey", International journal of current engineering and technology Vol 4, No.1, February (2014).
[4] Vipin V. Halde and Aditi H. Deshmukh, "Soft storey effect on structural response of high rise building", International journal of research in advent technology (IJRAT) Vol 4, No.1, January (2016).
[5] Ranjit V. Surve, Prof. D.S. Jagtop and Y.P. Pawar, "Performance based on analysis of multistoried building with soft storey at different levels", International journalof engineering research and technology(IJERT) Vol 4, Issue 04, April (2015).
[6] Al-Chaar, G. (2002), "Evaluating strength and stiffness of unreinforced masonry infill structures", U.S. Army Corps of Engineers. Technical Report NO. ERDC/CERL TR-02-1, Construction Engineering Research Laboratory, Campaign, USA.
[7] A. Asokan (2006), "Modelling of Masonry Infill Walls for Nonlinear Static Analysis of Buildings under Seismic Loads" M. S. Thesis, Indian Institute of Technology Madras, Chennai.
[8] Murty, C. V. R. and S. K. Jain (2000), "Beneficial influence of masonry infill walls on seismic performance of RC frame buildings", Proceedings of the 12th World Conference on Earthquake Engineering, Paper no. 1790.
[9] Holmes, M. (1961), "Steel frames with brick and concrete infilling", Proceedings of Institution of Civil Engineers. 19, pp473-478.
[10] Deodhar S. V. and A. N. Patel (1998), "Ultimate strength of masonry infilled steel frames under horizontal load", Journal of Structural Engineering, Structural Engineering Research Centre. 24, 237-241.
[11] Karisiddappa (1986), "Effect of position of openings on the behaviour of infilled frames", M.Tech Thesis, Indian Institute of Technology Madras, Chennai.
[12] Scarlet, A. (1997), "Design of Soft Stories – A simplified energy approach", Earthquake Spectra. 13, 305-315.
[13] Smith S. B. (1966), "Behaviour of Square Infilled frames", (ASCE) Journal of the Structural Division. 92, 381-403.
[14] IS 1893 Part 1 (2002), "Indian Standard Criteria for Earthquake Resistant Design of Structures", Bureau of Indian Standards, New Delhi.

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