

A Review on Study on Strengthening of Soft Storey Building for Seismic Resistance

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ABSTRACT: The increase in urban population for the past few years has made the vehicle parking a major concern. And hence the first storey of the apartment is used for parking. RC frames buildings with open first stores (soft storey) are known to perform poorly during strong earthquake shaking, the presence of masonry infill wall influences the overall behaviour of the structure when subjected to lateral forces, when masonry infill are considered to interact with their surrounding frames the lateral stiffness and lateral load carrying capacity of structure largely increase. Earthquakes that occurred recently have shown that a large number of existing reinforced concrete buildings especially soft storey building are vulnerable to damage or even collapse during a strong earthquake. The first storey of the building behaved as a soft story in which the columns were unable to provide adequate shear resistance during the earthquake.

KEYWORDS: Push over analysis, soft storey building, shear wall, bracings and column drop.

I. INTRODUCTION

The presence of masonry walls has a significant impact on the seismic response of an RC frame building; increasing structural strength and stiffness of the building Infill panels are generally not considered in the design process and treated as architectural (non-structural) components. In name of parking of vehicles the first storey of the buildings are made open without any infill. Parking floor has become an unavoidable feature for the most of urban multi-storied buildings. Though multi-storied buildings with parking floor (soft storey) are vulnerable to collapse due to earthquake loads, their construction is still widespread. These buildings are generally designed as framed structures without regard to structural action of masonry infill walls. They are considered as non-structural elements. Due to this in seismic action, RC frames purely acts as moment resisting frames leading to variation in expected structural response.

II. SOFT STOREY

The ground storey of a building which consists of open space for parking is known as stilt building and this storey with open space is known as stilt Floor or Soft-Storey. When a sudden change of stiffness takes place along the building height, the storey of which the drastic reduction of stiffness is observed is known as soft storey. A Soft storey building is a multi-story building with wide doors, commercial spaces, or the ground storey is left open for the purpose of parking, i.e., columns in the ground storey do not have any partition walls (of either masonry or RC) between them. As per IS-1893:2002 (part I). An Soft Storey is the one in which the 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 storeys above.

- Extreme Soft Storey

An extreme soft storey is the one in which the lateral stiffness is less than 60 percent of that in the storey above or less than 70 percent of the average stiffness of the three storeys above.

III. SOFT STOREY FAILURE

The shortage of land in the urbanized area has made the engineers to build the first storey of the building with open space for parking, etc. The strength demand on the column in the first storey for these building is also large, but however in the upper stories the forces in the columns are effectively reduced due to presence of brick infill walls

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which share the forces. If the stiffness of the first floor is significantly less strong or more flexible, a large portion of the total building deflections tends to concentrate in that floor. The presence of walls in upper stories makes them much stiffer than the open ground storey of the building. Due to these provisions, the lateral displacement of whole structure is governed mostly by the deformation at the lower stories. Therefore, it is essential to estimate the demand and supply in the force and deformation of the members at this part of the building to achieve a reasonable design of these structures

IV. LITERATURE REVIEW

[1]. **Umadevi et al (2015)** have investigated the behaviour of RC frame buildings with different models that include bare frame, infilled frame and open first storey frame. The parameters such as base shear, time period, natural frequency, storey drift and bending moments are studied. The software SAP2000 is used for the analysis of the entire frame models. Modal analysis was carried out to obtain natural frequencies and mode shapes and the results are compared with available experimental results obtained from shake table tests results conducted at CPRI, Bangalore and the models are validated. Equivalent static and response spectrum analysis are carried out to obtain base shear and displacement for all the zones (zone II- V) as per IS 1893 (Part 1):2002, time history analysis are carried out using Bhuj earthquake data to obtain displacement. The natural frequency of soft storey decreases by 60% compare to MI. It is observed that base shear is least for bare frames and highest for MI frames. It is observed that the displacement in the soft storey is maximum in the lower storeys as compared to the other two conditions which show its criticality in the earthquake resistant design. Whereas in the above floors, the displacements are higher in bare frame as compared to soft storey condition.

[2]. **Umesh P. Patil et al (2015)** analysed the seismic performance of two structures G+15, one made of composite steel concrete material and other one is made up of RCC, situated in the earth quake zone III, having a medium soil were investigated analytically for their performance using ETABS software, Equivalent static and response spectrum method are used for the analysis of RCC and composite structures with soft storey. In this method multiple modes of vibrations are considered where base shear of each mode can be calculated separately. Storey drift is reduced by 10% in composite models compared to RCC in soft storey level. It is possible to control the drift in soft storey by providing 1) Shear walls 2) Bracings 3) Stiffer column 4) Lateral load resisting system. The beams and columns in the soft storey are designed 2.5 times of obtained bending moments and shear forces and shear walls are designed by a factor of 1.5 times the storey shear.

[3]. **Priyanka Hanamantrao Jagadale et al (2015)** the seismic performance of soft storey building are modelled and analysed using SAP2000. For this eight different models were analysed. Equivalent static analysis is performed on all the models. Loads are calculated and distributed as per the code IS1893:2002. The use of stiffer column increases the stiffness up to 73%. Shear wall is found to be quite effective in increasing the stiffness. In this case stiffness of first storey is increased to 80%. Cross bracing reduces the displacement to 54% of model II. Stiffer column reduces the displacement to 70%. By introducing the shear wall reduces the displacement to 80%. It is found that the use of cross bracing, stiffer column, shear wall, light weight material infill increases the stiffness of first storey and reduces the lateral drift demand.

[4]. **Hiten L. Kheni et al (2014)** has analysed the seismic performance of (g+5) RC building with soft storey. The main objective of the study is to find out inter story drift for soft storey by considering stiff column and height variable of soft first storey at first storey level. Different models are analysed separately and then it is compared with other models results. Soft stories with infilled frame of variable first soft storey is analysed using the software MIDAS GEN. The displacement of the codal lateral load patterns are observed to be smaller for the lower stories and larger for the upper stories and are independent of the total number stories of the models. The uniform lateral load pattern leads to overestimations of displacements for all of the models and deformation levels of the building.

[5]. **Mohammed Khaja Moiuddin et al (2014)** conducted a study on 12 different models of 21 storey building model, the model was analysed for time period using both ETABS and SAP2000, the base shear was calculated using both response spectrum analysis, and equivalent static analysis, the seismic base shear was analysed using both ETABS and SAP2000. The model was analysed for time period using both ETABS and SAP2000; the base shear was calculated using response spectrum analysis and equivalent static analysis, the seismic base shear was analysed using both ETABS and SAP2000. When the structural action of masonry infill is taken the fundamental natural time got reduced

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58% when compare with bare frame model. When the structural action of masonry infill is taken the fundamental natural time got reduced 58% when compare with bare frame model.

[6]. **Raghavendra S. Deshpande et al (2014)** performed an seismic analysis of a RC concrete building with soft storey, the building comprises of a g+9 storey, about 4 different models are analysed separately and the Equivalent static analysis has been performed as per IS 1893 (Part 1): 2002 for each model using ETABS. Lateral displacement of bare frame model is higher than other models, due to absence of masonry infill walls. First storey displacement of soft first storey model is maximum than other models due to absence of infill in the first storey. The drift between the first and second storey is higher when compared with the second storey drift which is only 18.28% of first storey. Provision of infill at specific locations, increasing the size of the column in the first storey, there is significant increase in the stiffness, reduction of lateral drift demand. When the equivalent diagonal struts are provided at specific positions the first storey stiffness significantly increases upto 36.93% of second storey stiffness. The Inclusion of infill also reduces the fundamental time period of the building.

[6]. **Shinde et al (2014)** has performed a Pushover analysis for the seismic performance evaluation of G + 10 building. Building designed with IS 1893:2002 found to have a better performance under given earthquake.

[7]. **Spoorthi et al (2014)** performed a pushover analysis of a tall building with symmetrical plan and elevation of 5,10,15 storey building, and they buildings were analysed by using ETABS 9.7.4 for seismic zone V, base shear obtained from pushover analysis is much more than the base shear obtained from the equivalent static analysis. Storey displacements, storey drifts and storey shears obtained from pushover analysis are about twice the storey displacements, storey drifts and storey shears of equivalent static analysis

[8]. **Suchita Hirde (2014)** analysed four models with soft storey at different levels are considered along with soft storey at ground level and these models with incorporation of shear walls are considered. The g+20 building were considered with eight different models were considered. Pushover analyses of the models with and without shear walls are carried out. This study highlights the poor seismic performance of G+20 RCC building with soft storey at different level along with soft storey at ground level. After retrofitting of all the models with shear walls hinges are not developed in any of the columns. Provision of shear walls results in reduction in lateral displacement. Displacement reduces when the soft storey is provided at higher level. After retrofitting the base shear carrying capacity is increased by 8.45% to 13.26%.

[9]. **Susanta Banerjee et al (2014)** analysed three types of buildings in which the building designates ordinary moment resisting bare frame, building designates ordinary moment resisting frame with infill, building designates ordinary moment resisting frame with soft first storey. All buildings are analysed as Ordinary Moment Resisting frames. Designs are carried out in STAAD-Pro. The Time-history analysis and inelastic damage analysis of buildings are performed using IDARC 2D. The drift demands for ground storey column are large for soft storey buildings. Soft storey building shows poor performance during earthquake.

[10]. **Vikas Govalkar et al (2014)** has analysed totally eight models of a building to study the effect of shear wall in bare frame and infilled frame. In which four model for bar frame type public building and four models for infilled structural system with different position of shear walls. From the results it shows that shear wall frame interaction systems are very effective in resisting lateral forces induced by earthquake. When shear wall provided in bare frame and infilled frame it will help to reduce axial force significantly in bare frame and infilled frame. When Shear wall provided at corner on each side the structure gives better result than the all position.

[11]. **Zubair Ahmed et al (2014)** analysed a hypothetical building is assumed for seismic analysis that consists of a (G+5) R.C.C. residential building. The plan of the building is irregular in nature as it has all columns not at equal spacing. Dynamic analysis of the building models is performed on ETABS. The lateral loads generated by ETABS correspond to the seismic zone V and the 5% damped response spectrum given in IS: 1893-2002. Storey drift of steel braced system at bottom storey is within the limit. Deflection in case of bare frame is very large, when compared to other cases. The presence of steel bracing system can affect the seismic behavior of frame structure to large extent, and the steel bracing system increases stiffness of the structure. It is found that the steel bracing system at open bottom storey contributes to the structural stiffness and reduces the maximum inter story drift, lateral displacement of R.C.C building.

[12]. **Munde et al (2012)** has analysed four types of frame models such as Bare frame, Frame with infill except the first storey, First storey containing wall at specific locations, Soft first storey with stiffer column compared with other storey columns. The linear elastic analysis was made using ETABS on these frames The drift and the strength demands in the

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first storey columns are very large for buildings with soft ground storeys, increasing the stiffness's of the first storey such that the first storey stiffness is at least 50% as stiff as the second storey.

[13]. **Haroon Rasheed Tamboli et al (2012)** has performed a study which involves seismic analysis of RC frame (ten storey) building with different models that include bare frame, infilled frame and open first storey frame. The parameters such as base shear, time period, natural frequency, storey drift and bending moments are studied, the building model was analysed using ETABS. The seismic analysis of RC (Bare frame) structure leads to under estimation of base shear. In case of an open first storey frame structure, the storey drift is very large than the upper storeys, which may cause the collapse of structure during strong earthquake shaking.

[14]. **Saraswati Setia et al (2012)** has performed a study on 6 storied RC frame building model and is analysed using the software STAAD PRO.2006. The static analysis is then performed for the modelled RC frame building using the computer software STAAD PRO. 2006 . Five models are generated with this plan of the building by introducing different variation and displacement, story drift, base shear and story shear are the various parameters. Lateral displacement is largest in bare frame with soft storey defect both for earthquake force in X-direction as well as in Z direction for corner columns as well as for intermediate columns. Buildings with shear wall in core and shear wall in X direction as well as in Z-direction have uniform displacement because of shear wall. Which shows a gradual change of stiffness between the lower soft storey and the upper floors that is essentially required.

[15]. **Lamb et al (2012)** has carried out on reinforced concrete moment resisting frame building with open first storey and unreinforced brick infill walls in the upper storeys. The building considered is the office building having G+6 stories.. The building is kept symmetric in both orthogonal directions in plan to avoid the torsional response under pure lateral forces. The building is modelled using the finite element software SAP 2000.From the displacement profiles it is observed that large displacement occurs in case of soft storey building (model II). If there is uniform infill in all the storeys (model I), the displacements are very small in the first storey. Cross bracing (Model IV) reduces the displacement to 54% of model II Stiffer column (Model V) reduces the displacement to 70%.By introducing the shear wall (Model VI) reduces the displacement to 80% of model II. Shear wall and cross bracings are found to be very effective in reducing the stiffness irregularity and bending moment in the columns. The use of cross bracings significantly increases the first storey stiffness. The first storey stiffness comes out to be 70% of second storey stiffness. Shear walls are found to be most effective in reducing the stiffness irregularity, storey drift and strength demand in the first storey. When shear walls are introduced the stiffness of first storey increased to 80% and moments are reduced by 50-60%.When shear walls are introduced the stiffness of first storey increased to 80%.

[16]. **Amin et al (2011)** have performed an analysis of the building model which is deliberately kept symmetric in both orthogonal directions in plan to avoid torsional response under pure lateral forces. The number of storey was varied from (3,6,9,12) but the plan was unaltered. Soft storey level was altered for every storey level and then analysis was performed. Linear elastic analysis for equivalent static method was performed for the nine models of the building using ETABS 9.6.0 analysis package. For a twelve storey building, if the 2nd and the 3rd floor is kept open then it shows an average of 18.2% and 17.6% more drift respectively at that floor level compared to drift at that level if other floors are kept soft. Same values reduce to 17.1% and 16.6% respectively for 2nd and 3rd floor for a nine storey building. For the 6th and 7th floor these values are 16% and 15.5% respectively for twelve storey building and 15.2% an 14.7% for nine storey building.

[17]. **Kasnale et al (2013)** have investigated the behaviour of multi-storey, multi bay soft storey infilled frames to evaluate their performance level when subjected to earthquake loading. For this study five different models of a six storey building are considered. Response reduction factor for the special moment resisting frame has taken as 5.0.Equivalent static analysis has been performed as per IS 1893 (part R) 2002 for each model using ETABS 9.5 (computer and structures) software. The IS code methods are describing very insufficient guidelines about infill wall design procedures. It is observed that the ETABS provide overestimated values of fundamental period. According to relative values of all parameters, it can be concluded that provision of infill wall enhances the performance in terms of displacement control, storey drift and lateral stiffness.

V. CONCLUSIONS

From the above literatures, we conclude the following results on the analysis of the soft storey building:

1. The seismic performance of the soft storey building were very poor, when compared with the normal RC structure

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2. It is observed that plastic hinges are developed in columns of ground level soft storey which is not acceptable criteria for safe design.
3. In case of an open first storey frame structure, the storey drift is very large than the upper storeys, which may cause the collapse of structure during strong earthquake shaking.
4. We can conclude that as the number of storey increases lateral load carrying capacity does not increase but corresponding displacement increases.
5. Provision of shear walls results in reduction in lateral displacement. Displacement reduces when the soft storey is provided at higher level.
6. When Shear wall provided at corner on each side the structure gives better result than the all position
7. The IS code methods are describing very insufficient guidelines about infill wall design procedures. Software like ETABS is used as a tool for analysing effect of infill on the structural behaviour.
8. It is observed; ETABS provide overestimated values of fundamental period.
9. Steel Bracing acts as an extra redundant in frames there by reducing inter storey drift.
10. Structures with uniform profile in elevation have more lateral load capacity, when compared to structures with non-uniform profile in elevation.
11. Bare frame structures are having highest R value as compared to the infill frame structures. Fundamental time period decreases when the provisions of different types of bracings are considered.
12. Behaviour of square column is better than rectangular column, in terms of storey drift, base shear & roof displacement.
13. Seismic performance is very much dependent on the mass, stiffness, strength regularity and ductile or non-ductile behaviour.

REFERENCES

1. Amin.M.R, Hasan.P, Islam.B.K.M.A, (2011), 'Effect of soft storey on multistoried reinforced concrete building frame' 4th Annual Paper Meet and 1st Civil Engineering Congress, pp.267-272.
2. Haroon Rasheed Tamboli, Umesh.N.Karadi, (2012), 'Seismic Analysis of RC Frame Structure with and without Masonry Infill Walls', International Journal of Scientific & Engineering Research, vol. 35, pp. 1137-1147.
3. Hiten L. Kheni, Anuj K Chandiwala, (2014), 'Seismic Response of RC Building with Soft Stories' International Journal of Engineering Trends and Technology, vol.10.
4. IS 456: 2000. "Indian Standard Code of Practice for plain and reinforced Concrete", Bureau of Indian Standards, New Delhi. ETABS Non-linear 9.7 Computers and Structures Inc, Berkeley.
5. IS 1893 (Part 1)- 2002, 'Criteria For Earthquake Resistant Design Of Structures'- Part 1 General Provisions And Buildings', 5th Revision, 2002, Bureau of Indian Standards, New Delhi, India.
6. Karwar1.D.B, Londhe. R.S, (2014), 'A performance of RC framed structure using pushover analysis', International Journal of Emerging Technology and Advanced Engineering', vol 4,pp 488-491
7. Kasnale.A.S, Jamkar,S.S, (2013), 'Study of Seismic performance for soft basement of RC framed Buildings', Journal of Mechanical & civil, pp. 47-51.
8. Lamb.P.B, R.S.Londhe,(2012), 'Seismic behavior of soft first storey', Journal of Mechanical and Civil Engineering, vol.4, pp.28-33
9. Mohammed KhajaMoinuddin, Vishwanath. B. Patil, (2014), 'Seismic Evaluation of R.C. Framed High Rise Structural System with the Effect of Ground and Intermediate Soft Storey', International Journal of Engineering Research & Technology, vol. 3, pp. 602 -608.
10. Munde P.K, Magarpatil H.R, (2012), 'Seismic Response of RC Framed Masonry Infilled Buildings with Soft First Storey', International Journal of Engineering Research & Technology, vol. 1 Issue 9, pp.1-7.
11. PriyankaHanamantraoJagadale, SuchitraHirde, (2015) 'Seismic Performance of Multi-storeyed Reinforced Concrete Building with Soft Story', International Journal of Innovative Science, Engineering & Technology, Vol. 2, pp.1135-1142.
12. Raghavendra S. Deshpande, Surekha A. Bhalchandra, (2014), 'Seismic Analysis of Reinforced Concrete Building with Soft First Storey' International Journal of Scientific & Engineering Research, Volume 5,pp.49-56.
13. SaraswatiSetia, Vineet Sharma, (2012) 'Seismic Response of R.C.C Building with Soft Storey' International Journal of Applied Engineering Research, vol.7
14. Shinde, D.N, Nair veena V, PudaleYojana M, 'Pushover analysis of multy story building', International Journal of Research in Engineering and Technology, vol.3, pp.691-693.
15. Spoorthi S K, jagadishkori G, (2014), 'Effect of soft storey on tall buildings at various storeys by pushover analysis', International journal of Engineering Research, vol.3, pp.91-98.
16. SuchitaHirde, Ganga Tepugade, (2014), 'Seismic Performance of Multistorey Building with Soft Storey at Different Level with RC Shear Wall', International Journal of Current Engineering and Technology, vol.4.
17. Susanta Banerjee, Sanjaya K Patro, Praveena Rao, (2014), 'Inelastic Seismic Analysis of Reinforced Concrete Frame Building with Soft Storey', International Journal of Civil Engineering Research, vol. 5, pp. 373-378.
18. Umadevi, Kavitha, Sahana S Sastri, (2015), 'Seismic Performance of a RC Frame with Soft Storey Criteria', International Journal of Research in Engineering and Technology, vol. 4, pp.255-257.



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19. Umesh P. Patel, Suryanarayana M, (2015), 'Analysis of g+15 rcc and composite structure having a soft storey at ground level by response spectrum and equivalent static methods using etabs 2013', International Research Journal of Engineering And Technology, vol.02,pp.59-64.
20. VikasGovalkar, Salunke.P.J, Gore.N.G, (2014), 'Analysis of Bare Frame and Infilled Frame with Different Position of Shear Wall', International Journal of Recent Technology and Engineering, vol.3,pp.67-72.
21. ZubairAhmed.S, Ramana.K.V, Ramancharla Pradeep Kumar,(2014), 'Seismic Response of RC Frame Structure with Soft Storey', International Journal of Research in Engineering and Technology, vol.3, pp.180-186.