REVIEW ON SEISMIC PERFORMANCE OF MULTI-STORIED RC BUILDING WITH SOFT STOREY

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Abstract

Soft storey is a storey in which the stiffness is less than 70% of the storey above or less than 80% of the combined stiffness of three storeys above. In a multi-storied building, soft storey is adopted to accommodate parking which is an unavoidable feature. This open ground storey is vulnerable to collapse during earthquake. Soft storey in a building causes stiffness irregularity in a structure. Due to this the structures undergoes unequal storey drift, formation of plastic hinges and finally collapse. The presence of infill wall improves the performance of building under the lateral forces. This paper deals with the study of literature of previous researches. These researches focus on the combination of measures adopted on the structure to reduce the effect of soft storey through static and dynamic analysis. The parameters studied in these researches are storey drift, axial and shear forces bending moment, displacement, time period, base shear. Also, it focuses on the equivalent strut approach to consider the effect of infill wall on the performance on building. From these researches, the interest arises to perform static and dynamic analysis to reduce the stiffness irregularity which is the main reason behind the poor performance of the building with soft storey.

Keywords: *Soft storey, Stiffness, Storey drift, Lateral Displacement, Infill wall*

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1. INTRODUCTION

Many multistoried buildings are constructed as open first storey being an unavoidable feature in residential as well as commercial buildings.. Open ground storey is adopted to accommodate parking, reception lobbies etc. Also for offices, communication hall etc. soft stories at different levels of structure are constructed. A soft storey is also known as a weak storey or stilt storey. It is a storey in a building that has substantially less stiffness value than the stories above or below. It also has inadequate shear resistance and ductility to resist the earthquake forces. These features are highly undesirable in buildings that are constructed in seismically active areas. IS 1893:2002 defines the soft story as the "one in which the lateral stiffness is less than 70% of that in the story immediately above, or less than 80% of combined stiffness of three stories above."

Moreover, typical multistoried construction in India comprises RC frames with brick masonry infill. Unreinforced masonry panels may not contribute towards resisting gravity loads, but contribute significantly, in terms of enhancement in stiffness and strength in case of earthquake (or wind) induced lateral loading. The effect of infill may be positive or negative depending on large number of influential factors. Also infill have energy

dissipation characteristic that contribute to improve seismic resistance but its self-weight increases the earthquake inertia forces. Generally designer used to treat infill as a "non-structural" and treat the frame as bare frame which is far away from its true behavior. The parameters that affect the weak storey formation are i) Height of the weak storey ii) Existence of mezzanine floor.iii) column stiffness in weak storey iv) Overhang and cantilever projection existed in weak storey v) Infill wall material properties vi) Soil class and properties vii) Floor number viii) Seismic conditions.

2. PROBLEM STATEMENT

Soft storey in a structure causes structural irregularity in terms of stiffness. Unfortunately, most of the buildings in India leads to collapse under lateral forces due to structural irregularity. In commercial and residential buildings soft storey is provided to accommodate parking facility. The structure with open ground storey, higher soft storey height and less infill wall reduces stiffness and lateral load resistance and progressive collapse becomes unavoidable under severe earthquake. The total base shear experienced by the structure during earthquake depends upon the natural period and seismic force distribution depends upon distribution of stiffness and mass along the total height of the building.

The storey above the soft storey being more stiff undergoes smaller storey drift , however the storey drift in the soft storey is comparatively large. The strength demand on the column at ground storey is large, and the forces in the columns at upper stories are effectively reduced due to presence of abrupt storey stiffness and uneven lateral force distribution along the height of building which is likely to induce stress concentration at the ground storey. Soft storey are subjected to larger lateral forces, hence it is necessary to adopt some measures to reduce the effect of soft storey during design of the member at the soft storey level.

3. LITERATURE REVIEW

Jaswant N Arlekar et al[1] (1997) This paper argues to adopt immediate measures to prevent the indiscriminate use of soft storey in a building. This paper brought out the errors involving in modelling the building as complete bare frame and neglecting infill panel in the upper storeys. Static and dynamic analysis is carried out on different models to study the effects of soft storey and presence of infill wall in the model. This study concludes that building with first soft storey exhibits poor performance during earthquake. It is necessary to increase the stiffness of first storey by atleast 50%. Adequate stiffness and lateral strength can be adopted by providing stiffer columns. Soil flexibility is the main criteria to finalise the analytical model of the building.

C. V. R Murthy, Sudhir Jain[2] (2000) In this paper seismic behavior of weak storey is studied for which different building models are consisting of various storeys, storey heights and span with some existing building damaged during earthquakes. The results are compared with the building code. It gives the idea of precautions to be taken while analyzing design and construction of building with structural irregularity. It also tells about effect of infill wall material on seismic performance. It concludes, the building designed according to latest building code and to reconstruct or reinforce the existing buildings according to updated codes by adopting different retrofitting techniques. It also suggests to use light weight infill wall for building with soft storey.

Robin Davis et al[3] (2004) In this paper two buildings are located in moderate seismic zone Structurally symmetric (bare frame) is compared to the building with plan and vertical irregularity (soft Storey) Infill wall on the upper floor are modelled using equivalent stiffness strut approach. Equivalent static analysis, response spectrum and Non-linear pushover analysis is performed to determine the structural response of building to earthquake. This study concludes that presence of masonry infill panel considerably increases total storey shear bending moment in the ground floor column and failure occurs due to soft storey mechanism. Hence present structures with soft storey need to be retrofitted.

F. Hejazil et al[4] (2011) The writer studied seismic behavior of multi-storied building with soft storey by adding bracings to the soft storey. He concluded that, location and number of bracings plays an important factor for soft storey structure to displace during earthquake The displacement will be smaller of the storey provided with bracings. Also provision of bracing reduces the effect of soft storey and vulnerability to collapse.

P. B. Lamb and Dr. R. S. Londhe[5] (2012) This papers gives a parametric study on multi-storied RC building with soft storey located in seismic zone IV. The static and dynamic analysis is carried out on different models to describe the performance characteristics such as stiffness, shear force, bending moments, drift of the model and comparison between them. The performance characteristics were studied for building with uniform infill, soft storey, cross bracings in soft storey, tapered columns and light weight infill. Concluded that shear wall and cross bracings are most effective in reducing stiffness irregularity and Bending moment in column. Time period and frequency is more in soft storey and in light weight infill as compared to other models.

Dr. Saraswati Setia and Vineet Sharma[6] (2012) This paper deals with the analytical study of RC building with soft storey and the influencing parameters which affects the behavior of building under high seismic zone. The parametric study of storey drift, storey shear had been carried out using equivalent static analysis on different models. The effects are studied for bare frame, frame with masonry infill in the upper floors, shear wall at the core and increased column stiffness. The conclusions were made that, storey displacement is minimum with masonry infill and with stiffened columns. Whereas shear wall provides gradual change in the stiffness and minimum storey shear is achieved with shear wall and stiffened columns.

Dande P. S., Kodag P. B[7] (2013) The writer studied the seismic behavior of RC structure providing strength and stiffness by stiffening the columns and by providing adjacent infill wall panel at each corner of building frame. The conclusions were made that incorporating infill wall shortens the time period of building as compared to the time period of bare frame. Also infill frame reduces storey drift. Provision of stiff column at soft storey increases the stiffness and reduces lateral displacement.

Nikhil Agrawal et al [8] (2013) The writer highlights the performance of masonry infilled RC structure with soft storey and analyse the performance of building models with and without infill. The infilled frames were modelled using equivalent strut approach. He concluded that infill panels increases stiffness whereas increase in percentage of opening in infill panel will reduce the lateral stiffness of building. Deflection in case of opening at centres is high as compared to corner opening.

N. Shivkumar et al [9] (2013) The writer in his paper studied the behavior of column at ground level of multistoried building with soft storey when subjected to dynamic earthquake loading. He concluded that provision of stiffer column at soft storey and provision of concrete service core will leads to reduction in lateral drift and strength demand on first soft storey column.

Md Rihan Maaze, S. S. Dyavanal [10] (2013) The writer performs equivalent static and response spectrum analysis on infill frame and solid concrete block and compared to bare frame. Also, non-linear pushover analysis is carried out for hinge properties. He concluded that SMRF building models are found more resistant to earthquake loads as compared to OMRF in terms of performance level point and hinge variation. Hence ductile detailing is must for building under high seismic zone.

Dhadde Santosh[11] (2014) The writer carried out the performance evaluation on non-retrofitted buildings. Soft storey is located at ground, intermediate and top and compared to retrofitted model. The performance evaluation was based on lateral deformation, storey shear, and hinge formation From the study, he had concluded that storey drift is maximum at soft storey and it decreases gradually upto the top. Plastic hinge formation, base reaction and roof displacement is more in existing soft storey building but less in retrofitted models.

Hiten L. Kheni, Anuj K.Chandiwala[12] (2014) In this paper collapse mechanism of different buildings damaged under earthquakes are assessed and makes a design concept of strong column weak beam such that during earthquake, beam yield before column collapse. Based on this concept, different building models were analysed using software. Writer concluded that estimation of displacement of codal lateral load pattern are smaller for lower stories and larger for upper stories and are independent of total number of stories of the model.

Mohammad H. Jinya, V. R. Patel [13] (2014) In this paper seismic behavior of RC frame building is analysed by performing multi-model static and dynamic analysis. The results of bare frame, masonry infill panel with outer wall opening, and soft storey are discussed. The conclusions made in this study is infill wall(diagonal strut) change the seismic performance of RC building. Storey drift and displacement were decreased. It is suggested that at least soft storey should be provided with outer masonry infill panel to increase stiffness of soft storey.

Suchita Hirde, Ganga Tepugade [14] (2014) The writers in their paper investigates behavior of RC building with soft storey at different levels. Non-linear static pushover analysis was carried out. Concluded that ground level soft storey leads to formation of plastic hinges in columns which is not acceptable. Shear wall prevents formation of plastic hinges and reduction in lateral displacement. Moreover displacement is reduced when soft storey is provided at higher level.

Varsha R. Harne[15] (2014) The writer investigates to determine the solution of shear wall location in multi-storied building located in zone II by performing seismic analysis on building models. From this analysis she conclude that L-type shear wall at corner is most efficient to resist lateral forces.

4. CONCLUSION

Soft storey at ground level in RC frame building shows poor performance during earthquake as the stiffness of soft storey is less than 70% of the storey above.

Previous investigations on seismic analysis on multi-storied building with soft storey shows that, Provision of shear wall, bracings, stiffened column provides lateral strength and stiffness to the building and improves performance of building under earthquake shaking. It reduces storey drift, storey shear and lateral displacement of building. Soft storey at higher level reduces base reaction and reduces formation of plastic hinges at base. Presence of masonry infill at upper floors shortens the time period of building.

SMRF are found to be more resistant than OMRF for the buildings constructed in high seismic zone. Hence it is necessary to increase lateral strength and stiffness of building to sustain under heavy earthquake shaking.

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