Seismic Behavior of soft Storey Building : A Critical Review

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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 arrangement in soft storey building when subjected to static and dynamic earthquake loading. It is observed that , providing infill improves resistant behaviour of the structure when compared to soft storey provided.

Keywords: Soft storey, Static and dynamic analysis, Seismic loads.

I. INTRODUCTION

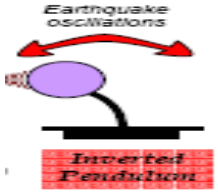
Due to increasing population since the past few years so that car parking space for residential apartments in populated cities is a matter of major problem. So that constructions of multi-storeyed buildings with open first storey is a common practice in all world. Hence the trend has been to utilize the ground storey of the building itself for parking or reception lobbies in the first storey. These types of buildings having no infill masonry walls in ground storey, but all upper storeys infilled in masonry walls are called 'soft first storey or open ground storey building'. Experience of different nations with the poor and devastating performance of such buildings during earthquakes always seriously discouraged construction of such a building with a soft ground floor This storey known as weak storey because this storey stiffness is lower compare to above storey. So that easily collapses by earthquake.

Due to wrong construction practices and ignorance for earthquake resistant design of buildings in our country, most of the existing buildings are vulnerable to future earthquakes. So, prime importance to be given for the earthquake resistant design. The Indian seismic code IS 1893 (Part1): 2002 classifies a soft storey as "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

II. GENERAL BEHAVIOUR OF SOFT STOREY

Stability of earth is always disturbed due to internal forces and as a result of such disturbance, vibrations or jerks in earth's crust takes place, which is known as an earthquake.

Earthquake produces low –high waves which vibrate the base of structure in various manners and directions, so that lateral force is developed on structure. In such buildings, the stiffness of the lateral load resisting systems at those stories is quite less than the stories above or below.



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Such building act as an Inverted Pendulum which swing back and forth producing high stresses in columns and if columns are incapable of taking these stresses or do not posses enough ductility, they could get severely damaged and which can also lead to collapse of the building. This is also known as inverted pendulum. Soft stories are subjected to larger lateral loads during earthquakes and under lateral loading. This lateral force cannot be well distributed along the height of structure. This situation causes the lateral forces to concentrate on the storey having large displacement. The lateral force distribution along the height of a building is directly related to mass and stiffness of each storey. The collapse mechanism of structure with soft storey under both earthquake and gravity loads. Therefore dynamic analysis procedure is accurate distribution of the earthquake and lateral forces along the building height, determining modal effects and local ductility demands efficiently.

III. REVIEW OF LITERATURE

A significant amount of research work on seismic behaviour of soft storey building has been done by many investigators research area Such as

[1] Suchita Hirde and Ganga Tepugade(2014), Discussed the performance of a building with soft storey at different level along with at ground level. The nonlinear static pushover analysis is carried out. Concluded it is observed that plastic hinges are developed in columns of ground level soft storey which is not acceptable criteria for safe design. Displacement reduces when the soft storey is provided at higher level.

[2] Hiten L. Kheni and Anuj K. Chandiwala (2014), Investigate many buildings that collapsed during the past earthquake exhibited exactly the opposite strong beam weak column behaviour means columns failed before the beams yielded mainly due to soft storey effect. For proper assessment of the storey stiffness of buildings with soft storey building, different models were analysed using software. Concluded the displacement estimates 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.

[3] Dhadde Santosh(2014), Investigate nonlinear pushover analysis is conducted to the building models using ETABS and evaluation is carried for non-retrofitted normal buildings and retrofitting methods are suggested like infill wall, increase of ground story column stiffness and shear wall at central core. Concluded storey drift values for soft storey models maximum values compare to other storeys and the values of storey drift decreases gradually up to the top.

[4] Rakshith Gowda K.R and Bhavani Shankar(2014), Investigate the soft storey's are provided at different level for different load combinations and ETABS is used for modeling and analysis RC buildings. Concluded the inter storey drift was observed to be maximum in vertically irregular structure when compared with that of regular structure.

[5] Mr.D.Dhandapany(2014), Investigate the seismic behaviour of RCC buildings with and without shear wall under different soil conditions. Analyzed using ETABS software for different soil conditions (hard, medium, soft). The values of Base shear, Axial force and Lateral displacement were compared between two frames. Concluded The design in STAAD is found to be almost equal results to compare in ETABS for all structural member.

[6] Susanta Banerjee, Sanjaya K Patro and Praveena Rao(2014), Analysis response parameters such as floor displacement, storey drift, and base shear. Modelling and analysis of the building are performed by nonlinear analysis program IDARC 2D. Concluded lateral roof displacement and maximum storey drift is reduced by considering infill wall effect than a bare frame.

[7] **D. B. Karwar and Dr. R. S. Londhe(2014),** Investigate the behaviour of Reinforced Concrete framed structures by using nonlinear static procedure (NSP) or pushover analysis in finite element software "SAP2000".and the Comparative study made for different models in terms of base shear, displacement, performance point. Concluded base shear is minimum for bare frame and maximum for frame with infill for G+8 building.

[8] Miss **Desai Pallavi T(2013),** Investigate the behaviour of reinforced concrete framed structures by using Staad Pro. Modelling four structure and compare stiffness this models. Concluded provide the stiffer column in first storey.

[9] Amit and S. Gawande(2013), Investigate the seismic performance and design of the masonry infill reinforced concrete structure with the soft first storey under a strong ground motion.

[10] Nikhil Agrawal(2013), Analysis the performance of masonry infilled reinforced concrete (RC) frames including open first storey of with and without opening. The increase in the opening percentage leads to a decrease on the lateral stiffness of infilled frame. Concluded Infill panels increase stiffness of the structure.

[11] A.S.Kasnale and Dr. S.S.Jamkar(2013), Investigate the behaviour of five reinforced RC frames with various arrangement of infill when subjected to dynamic earthquake loading. Concluded providing infill wall in RC building controlled the displacement, storey drift and lateral stiffness.

[12] Dande P. S. and, Kodag P. B.(2013), Investigate the behaviour of RC frames with provided strength and stiffness to the building frame by modified soft storey provision in two ways, (i) By providing stiff column & (ii) By providing adjacent infill wall panel at each corner of building frame. Concluded the walls in upper storeys make them much stiffer than open ground storey. Difficult to provide such capacities in the columns of the first storey.

[13] Narendra Pokar and Prof. B. J. Panchal(2013), Investigate the behaviour of RC frames with Testing of scaled models is essential to arrive at optimal analytical model and special design provisions for such structures. Structure is modeled and analyzed using SAP platform including seismic effect. Concluded both steel and RCC model gives nearest result for full scale model.

[14] N. Sivakumar and S. Karthik(2013), Investigate the behaviour of the columns at ground level of multi-storeyed buildings with soft ground floor subjected to dynamic earthquake loading. ETABS used for modelling of the six and nine storey structure, line element was used for columns and beams and concrete element was used for slabs. Concluded reducing the drift as well as the strength demands on the first storey columns so that provides stiffer columns in the first storey.

[15] Dr. Saraswati Setia and Vineet Sharma(2012), Analysis seismic response of R.C.C building with soft storey. Equivalent static analysis is performed for five different models by using the computer software such as STAA Pro. Concluded minimum displacement for corner column is observed in the building in which a shear wall is introduced in X-direction as well as in Z-direction.

[16] P.B.Lamb and Dr R.S. Londhe(2012), Analysis multistoried building with soft first storey, located in seismic zone IV. It is intended to describe the performance characteristics such as stiffness, shear force, bending moment, drift. Concluded shear wall and cross bracings are found to be very effective in reducing the stiffness irregularity and bending moment in the columns.

[17] V. Indumathy and Dr.B.P. Annapurna (2012), Investigate the four storied one bay infilled frame with soft storey at ground floor and window openings in higher floors. Shape of opening - square opening showed lower lateral deformation compared to rectangular opening and on other hand rectangular opening oriented horizontally exhibit lower lateral deformation than vertical orientation. Concluded square opening showed lower lateral deformation compared to rectangular opening and on other hand rectangular opening oriented horizontally exhibit lower lateral deformation than vertical orientation.

[18] M.Z. Kabir and P. Shadan(2011), Investigate the effect of soft story on seismic performance of 3D-panel buildings. Results verified numerically with finite element model using ABAQUS program and 3D-panel system has considerable resistance. Concluded applying several ground motions final cracks is appeared at the end of columns and beam-column connections. However, upper stories had no crack during shaking table test.

[19] G.V. Mulgund and D.M. Patil(2010), Investigate the behaviour of RC frames with various arrangement of infill when subjected to dynamic earthquake loading and result of bare and infill frame are compared. Concluded masonry infill panels in the frame substantially reduce the overall damage.

[20] A. Wibowo and J.L. Wilson, (2009), Analysis an analytical model has been made to predict force-displacement relationship of the tested frame. The experimental investigation the load deflection behaviour and collapse modelling of soft storey building with lateral loading. Concluded the large drift capacity of the precast soft storey structure was attributed to the weak connections which allowed the columns to rock at each end.

[21] Sharany Haque and Khan Mahmud Amanat (2009), Investigate the effect of masonry infill in the upper floors of a building with an open ground floor subjected to seismic loading. The number of panels with infill is varied from bare frame condition (zero percent infilled panels) and 10, 30, 50 and 70 percent of panels with infill on the upper floors and Comparison of base shear. Concluded the design shear and moment calculated by equivalent static method may at least be doubled for the safer design of the columns of soft ground floor.

[22] Seval Pinarbasi and Dimitrios Konstantinidis(2007), Investigate the hypothetical base-isolated building with a soft ground story. Comparison is made with how soft-story flexibility affects the corresponding fixed-base building. Concluded performance of a soft-story building, is also effective in particularly reducing the seismic demand (i.e., interstory drift) on the soft-story level, which is the primary cause of catastrophic collapse in these types of buildings.

[23]s **Dr. Mizan Dogan and Dr. Nevzat Kirac(2002),** Investigate the quake results, it is observed that partitioning walls and beam fillings enable buildings to gain great rigidity. Also solutions were Investigate d for making the soft storeys in the present constructions and in the ones to be built resistant to quake.

[24] Jaswant N. Arlekar, Sudhir K. Jain and C.V.R. Murty(1997), Investigate the behaviour of reinforced concrete framed structures by using ETABS . The nine models of building compare stiffness. Concluded such buildings will exhibit poor performance during a strong shaking. solution to this problem is in increasing the stiffness of the first storey.

IV. CONCLUSION

RC frame buildings with soft story are known to perform poorly during in strong earthquake shaking. Because the stiffness at lower floor is 70% lesser than stiffness at storey above it causing the soft storey to happen. For a building that is not provided any lateral load resistance component such as shear wall or bracing, the strength is consider very weak and easily fail during earthquake. In such a situation, an investigation has been made to study the seismic behaviour of such buildings subjected to earthquake load so that some guideline could be developed to minimize the risk involved in such type of buildings. It has been found earthquake forces by treating them as ordinary frames results in an underestimation of base shear. Investigators analysis numerically and use various computer programs such as Staad Pro, ETABS, SAP2000 etc. Calculation shows that, when RC framed buildings having brick masonry infill on upper floor with soft ground floors subjected to earthquake loading, base shear can be more than twice to that predicted by equivalent earthquake force method with or without infill or even by response spectrum method when no infill in the analysis model.

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