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Seismic Drift Consideration in soft storied RCC buildings: A Critical Review

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Abstract:- Reinforced concrete frame buildings are becoming increasingly common in urban India. Many such buildings constructed in recent times have a special feature – the ground storey is left open for the purpose of parking, i.e., columns in the ground floor do not have any partition walls (of either masonry or Reinforced concrete) between them. Such buildings are often called open ground storey buildings. The relative horizontal displacement in the ground storey is much larger than storeys above it. The total horizontal earthquake force it can carry in the ground storey is significantly smaller than storeys above it. The soft or weak storey may exist at any storey level other than ground storey level. The presence of walls in upper storeys makes them much stiffer than the open ground storey. Still Multi storey reinforced concrete buildings are continuing to be built in India which has open ground storeys. It is imperative to know the behavior of soft storey building to the seismic load for designing various retrofit strategies. Hence it is important to study and understand the response of such buildings and make such buildings earthquake resistant based on the study to prevent their collapse and to save the loss of life and property.

Keywords:- Bare frame, framed structure, Seismic analysis, Dynamic analysis, seismic response,drift demand, drift consideration, Soft storey.

I. INTRODUCTION

We know that earthquake produces waves which vibrate the base of structure in various manners and directions, because of which lateral force is developed on structure which shears the column or sometimes even it buckles the whole column resulting in failure of structure.Many urban multistory buildings in India today have open first storey as an unavoidable feature. The upper storeys have brick in filled wall panels. The draft Indian seismic code classifies a soft storey as one whose lateral stiffness is less than 50% of the storey above or below. Interestingly, this classification renders most Indian buildings, with no masonry infill walls in the first storey, to be "buildings with soft first storey." 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 first soft storey, the upper storey being stiff, undergo smaller inter-storey drifts. However, the inter-storey drift in the soft first storey is large. .For the upper storeys, however, the forces in the columns are effectively reduced due to the presence of the Building with abrupt changes in storey stiffness have uneven lateral force distribution along the height, which is likely to locally induce stress concentration. This has adverse effect on the performance of buildings during ground shaking. Such buildings are required to be analyzed by the dynamic analysis and designed carefully. Soft storey buildings are characterized by having a storey which has a lot of open space due to functional utility like parking garages, for example, are often soft storey, as are large retail spaces or floors with a lot of windows.

II. FAILURE MECHANISM OF SOFT STOREY

The most frequent failure mode of reinforced concrete frame buildings caused by earthquake is called "soft storey" mechanism. It consists in a localization of buildings' seismic deformations and rupture in the bottom story of the building . This phenomenon is caused by the fact that the overall shear force applied to the building by an earthquake is higher at the base due to the following factors: - wide openings are present in the bottom story and not present at upper levels and weaken the structure - ground level is often used for offices, shops, lobby in hotels, etc. The columns which are at ground level are too slender. It is seen that the lower story is weakened, than the above infills are the most stresse and causing failure. In many applications, architectural considerations result in a taller first story, which causes a soft-story formation due to sudden change in the vertical stiffness between following stories. The presence of a soft story also results in a localized excessive drift that causes heavy damage or collapse of the story during a severe earthquake. Another typical case of soft story arises when the first floor is left open to serve a commercial function (stores) or as a parking garage while upper floors are infilled with unreinforced masonry walls. A relatively rare case results when the strength of the two adjacent stories is significantly different (weak story) leading to localized deformations similar to the soft-story mechanism.

III. LITERATURE REVIEW

On this topic many paper has published and gave their views which are important in seismic drift consideration to control on failure in soft storey buildings during severe earthquake.

1 **Akira WADA (2004)**[1]. This paper demonstrate the effect of the sever earthquake on the entire building how they get collapse before reaching their yielding limit of stresses which causes failure of different structural system like beam column particularly in soft storey buildings. Results obtained from some static cyclic loading test for moment resistant frame only shows that the advantage of damage control structure can be achieved by allowing them to yield before failure.

2 **Ramanujan Jayasree et al.(2014)** [2],this paper present to understand the behavior of Reinforced Concrete framed structures by pushover analysis and the Comparative study was done for different models in terms of base shear, displacement, performance point. The inelastic behavior of the example structures are examined by carrying out displacement controlled Pushover analysis.

3 **J. Prakashvel et al. (2012)** [3]Evaluated the seismic response of RC frame building with soft first storeys. This paper highlights the importance of explicitly recognizing the presence of the open first storey in the analysis of the building. The error involved in modeling such buildings as complete bare frames, neglecting the presence of infills in the upper storeys, is brought out through the study of an example building with different analytical models.

4 **Chandurkar P. P., Pajgade P. S. (2013)**[4] This paper demonstrate the effect of shear wall in multi-storey building with different modeling and locations to find the economy and effectiveness with respect to height.It is observed that 1. Changing the position of shear wall will affect the attraction of forces, so that wall must be in proper position. 2. If the dimensions of shear wall are large then major amount of horizontal forces are taken by shear wall. 3. Providing shear walls at adequate locations substantially reduces the displacements due to earthquake.

5**Arum Chinwuba, Akinkunmi Akinloye (2011)** [5] The results of the work showed that the dual system was the most efficient lateral-load resisting system based on deflection criterion, as they yielded the least values for lateral displacements and inter-storey drifts. The moment frame was the least stiff of the resisting systems, yielding the highest values of both the lateral displacement and the inter-storey drift.The lateral displacement in moment frames is the greatest among the three lateral load resisting systems investigated; the lateral displacement in dual frames is the least while the lateral displacement in shear wall systems is slightly higher than that of the dual system. It is seen that Inter-storey drift is greatest in moment frames and least in dual systems while that of the shear wall system is slightly higher than that of the dual system.

6**Guney D., Aydin E. (2012)** [6] Theaim of this paper is to show the contribution of infill walls to the building response during earthquake. Different type of configuration of infill walls are modeled and analyzed by the Finite Element Method. These models also have soft story risk. The nonlinear force-displacement behavior is used for structural analysis.

7. **IWABUCHI Kazunori et al.(2004)** [7] Test was conducted a substructure pseudo-dynamic test in order to investigate the feasibility and advantages of the structural control by HPFRCC devices, and to confirm effectiveness of the seismic response analyses. As the result of the experiment, the seismic response of the RC buildings with soft story was successfully controlled as expected by using HPFRCC device, and the reliability of the analytical tool has also been clarified.

8.**DINARYOUSUF et al. (2013)**[8] This study investigates as well as compares the performances of bare, different infill percentage level and two types of Shear wall consisting building structures and suggests from which level of performance shear wall should be preferred over the infill structure. Periphery Shear wall in bare frame generates much better result than both Parallel Shear wall in bare frame and 100% infill so to get significant amount of performance in terms of deflection and base shear, in construction period of a high rise building in high seismic prone region, periphery Shear wall will be highly beneficial.

9**Bajaj Ketan. et a l. (2013)** [9] Abuilding is modeled in SAP-2000 having different Winkler's springs as its foundation corresponding to different soil properties. This research has immense benefits in the Geotechnical Earthquake engineering field.It has been seen with the change in soil property from hard to medium and from hard to soft the base shear has increased by 26.85% and 43.25% respectively for flexible base. In case of flexible foundation, with the change in zone from III too IV and from III to V with same hard soil the deflection has increased by 10.68% and 21.53% respectively for the same type of symmetric building

10. **Satpute S G and Kulkarni D B (2013)**[10] The scope of the present work was to study seismic responses of the ten storey RC shear wall building with and without opening. Developed mathematical modeling and analyzed the reinforced concrete shear wall building by using different nonlinear methods (time history and

pushover method). By using the SAP2000 nonlinear software tool. The following conclusions are drawn on the basis of the numerical results obtained by software.

11.**Hirde Suchita and Bhoite Dhanshri (2011)** [11]The results obtained with this analysis shows that bare frame analysis and frame with infill effects are compared in the form of capacity spectrum curve, performance point and hinge formation at performance point and conclusion are made. It is seen that the masonry infill contribute significant lateral stiffness, strength, overall ductility and energy dissipation capacity.This work will be very useful for understanding the contribution of infill walls in formation of plastic hinges in beams and columns in multistory frame.

12.**JeniferR. M. et al. (2012)**[12]In this paper focus has been done to have a study on effect of soil structure interaction on multi storeyed buildings with various foundation systems. It is seen that Lateral deflection, Storey drift, Base shear and Moment values increases when the type of soil changes from hard to medium and medium to soft for fixed and flexible base buildings. Lateral deflection, Storey drift, Base shear and Moment values of fixed base building was found to be lower as compared to flexible base building. Hencesuitable foundation system considering the effect of Soil stiffness has to be adopted while designing building frames for seismic forces.

13.**Desai Pallavi T, Rajan A. (2013)** [13] Focus has been made to analyze a building with different modelling according to their stiffness and configuration including its ductility etc and result obtained shows that the under-lying principle of any solution to this problem is in (a) increasing the ductility and stiffness of the first storey such that the first storey is at least 50% as stiff as the second storey, i.e., soft first storey are to be avoided, and (b) providing adequate lateral strength in the first storey. The possible schemes to achieve the above are (i) provision of stiffer columns in the first storey, and (ii) provision of a concrete service core in the building

14. **ChippaAmbika and Nampalli Prerana(2014)** [14] In different load resisting system following conclusion has been obtained 1.In case of MRF structure, Storey Drift and Base Shear are increasing for bare frame and frame with infill walls with increase in bays for same storey and same seismic zone, with increase in height for same bay and same seismic zone and with change in seismic zone from II to V for same bay and same storey2. For seismic zone II and III, SMRF is economical than OMRF.3. Storey Drift and Base Shear are more for MRF structure without Shear Wall than MRF structure with Shear Wall (Dual system) for same storey, same bays, same seismic zone, in bare frame and frame with infill walls.4. MRF structure with Shear Wall (Dual system) is economical as compared to MRF structure without Shear Wall for seismic zone IV and V.

15**VIJAYWARGIYA DHARMESH (2014)** [15] The main finding obtained from this analysis is that great variation in the ground storey column forces is too much with the presence of infill wall in the upper storey and most of the horizontal displacement on the building occurs in the soft ground storey itself.

16.**Mohommed Anwaruddin et al.(2013)** [16] Present study aims towards doing Nonlinear Static Pushover Analysis of G+3 medium rise RCC residential building frame which is to be designed by Conventional Design Methodology. A Nonlinear Static Analysis (Pushover Analysis) had been used to obtain the inelastic deformation capability of frame. It was found that irregularity in elevation of the building reduces the performance level of structure there is also decrease in deformation or displacement of the building.

17. **Aainawala M.S., Pajgade P. S. (2014)**[17] From above analysis,different model developed forthe G+12, G+25, G+38 Storey building, constructing building with shear wall at corner location gives minimum drift and minimum displacement. Size of members like column can be reduced economically in case of structure with shear wall as compared to the same structure without shear wall. It is also seen that variation in column size at different floors affects the storey drift More carpet area will be available in the building as the sizes of columns are reduced when shear wall is provided.

18 **SAIRAJ P.and PADMANABHAM K.(2014)** [18] This study makes an attempt, to develop efficient geometric models for new constructions, and to provide necessary structural configuration against retrofitting of the existing structures, constructed in earthquake prone regions.

19.**Harne Varsha R.(2014)** [19] These analyses were performed using STAAD Pro. A study has been carried out to determine the strength of RC shear wall of a multistoried building by changing shear wall location. Three different cases of shear wall position for a 6 storey building have been analyzed. Incorporation of shear wall has become inevitable in multi -storey building to resist lateral forces.

20.**KhanRahiman G. and, M. R. Vyawahare (2013)** [20] From present analysis model in ETABS it can be concluded that, As we shift the soft storey to higher level the intensity of hinge formation becomes lower and lower and at the same time displacement increases and base shear also. Maximum yielding occurs at the base storey, because of soft stories maximum plastic hinges are forming though the base force is increasing. As we shifted soft storey to higher level yielding is less than lower level soft storey and lower intensity hinges are forming after maximum number of pushover steps.Which means soft storey is safer at higher level in high rise building. It is advisable to provide soft storey at higher levels in addition to ground soft storey.

IV. CONCLUSIONS

In short we can say that,open ground storey (stilt floor) used in most severely damaged or, collapsed R.C. buildings, introduced ‘severe irregularity ofsudden change of stiffness’ between the ground storey and upper storeys since they had infilled brick walls which increase the lateral stiffness of the frame by a factor of three to four times.It is also seen that,the dynamic ductility demand during the probable earthquake gets concentrated in the soft storey and The Building Sank evenly about 1 m due to soil liquifaction. The displaced soil caused a bulge in the road. The solid building tilted as a rigid body and the raft foundation rises above the ground. Hence it is suggested that the ‘soft’ storey is severely strained causing its total collapse, much smaller damages occurs in the upper storeys, In view of the functional requirements of parking space under the buildings, more and more tall buildings are being constructed with stilts. To safeguard the soft first storey from damage and collapse,clause 7.10 of IS: 1893-2002 (Part 1)provides two alternative design approaches (i) The dynamic analysis of the building is to be carried out which should include the strength and stiffness effects of infills as well as the inelastic deformationsunder the design earthquake force disregarding the Reduction Factor R. (ii) The building is analysed as a bare frame neglecting the effect ofinfills and, the dynamic forces so determined in columns and beams of the soft (stilt) storey are to be designed for 2.5 times thestorey shears and moments: OR the shear walls are introduced in the stilt storey in both directions of the building which should be designed for 1.5 times the calculated storey shear forces.

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