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Analysis of Tall Structure Considering Soft Storey Under Dynamic Loading using ETABS A Review

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ABSTRACT

There has been a steady rise in urbanisation in the last few years which has led to major issues in parking vehicles and made the street busy. Such cases have led engineers to plan parking spaces even on the first floor for the purpose of parking. Structures with RC frames with the open ground floor without infill are subjected to heavy lateral loads and prove to fail in case of heavy earthquake loads. When masonry infill interacts with its surrounding frames, the lateral stiffness and lateral load-carrying capacity of the structure significantly increase. The presence of masonry infill walls affects how the structure behaves overall when subjected to lateral forces. 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 building's first floor exhibited soft behaviour, and the earthquake prevented the columns from offering enough shear strength.

This paper presents review of literature related to analysis of a soft storey tall structures.

Keywords : Soft Storey Building, Cross Bracings, Strength Factor, Response Reduction Factor.

I. INTRODUCTION

In the most recent earthquakes, several buildings with parking lots or commercial spaces on the first storeys sustained severe structural damage and collapsed. Soft stories and resulting damage are caused by large open spaces, a lack of infill and exterior barriers, and greater floor levels at the bottom level. The lateral load resisting systems in such buildings are far less stiff at such storeys than they are at stories above or below. If there are unusual inter-story drifts between neighbouring stories during an earthquake, the lateral stresses will not be evenly distributed throughout the structure's height. Due to this circumstance, the lateral pressures are focused on the story or stories with the largest displacement (s). Additionally, due to the high level of load deformation (P-Δ), if the local ductility requirements are not met in the design of such a building structure for that storey and the inter-storey drifts are not controlled, a local failure mechanism or, worse yet, a storey failure mechanism could form, which could cause the system to collapse.

Lateral displacements calculated during the elastic design process can also provide very important information regarding the structural behaviour of the device codes outline smooth storey irregularity by stiffness contrast of adjoining floors, displacement-based criteria for such irregularity determination, and so on. If the P-Δ impact is thought to be the primary cause of the dynamic fall apart of building structures during earthquakes, it should be determined that this is the case.

Earthquake is generated in the earth's crust. It will be for a short period of a few seconds or a minute. The main loads which we get through gravity effect are Dead load and Live load. Apart from these two types of loads there is a lateral load which is produced by seismic effect and also known as Earthquake load and wind load. Sometimes Earthquake will cause a large loss to the human beings but sometimes will be a minor attack, inspite of knowing that buildings are destroyed due to seismic effect still the buildings are constructed such that the basements are kept open without any walls or any other strengthening material.

II. Literature Survey

Mariem M. Abd-Alghany et.al (2021) Using the finite element method, a research report examined the seismic performance of RC buildings with soft storeys. The height of the soft storey, the irregularity in the building plan dimensions, and the placement of the soft storey along the building height were all taken into consideration in this study. An attempt was made to find the optimum location of the soft storey through the building height to minimize its effect. In addition, the impact of applying simple strengthening techniques was investigated to promote structural safety without significant changes in the architectural and functional requirements of the building. The results included the effect of the investigated parameters on stiffness, displacement and storey drifts by using equivalent static load method and modal response spectrum method (MRS). P-Delta effect and cracked stiffness ratio are included in analysis.

Results stated that shear walls are found to be very effective in improving the stiffness irregularity and decreasing the displacement and drift. For example, after adding a shear wall with increasing soft storey height, the displacement decreases by 46%. while the drift decreases by 60% at soft storey height equal to 6 m as compared to MRF system. Despite adding the shear wall, the effect of the soft storey is still present when soft storey height is greater than twice the height of typical floor. Cross bracing is found to be very effective and economical technique for retrofitting building with soft storey and reducing the stiffness irregularity. Determining the position and ratio of bracing is very important to improve

the seismic performance of RC building with soft floor. On the other hand, adding the bracing only at soft storey is the best solution to reduce the soft storey irregularity. Adding cross bracing, the effect of soft storey was greatly reduced in most study groups despite increasing displacement and drifts.

Nilesh Bharat Vidhate and G. A. Sayyed (2021) research paper investigated the nonlinear behaviour and design of mid-to-high-rise RCC diagrid structures using ETABS with respect to different parameters such as storey drift, storey displacement, base shear and analyze demand capacity curve of diagrid structure and conventional with pushover analysis. Three G+7, G+11, G+16 diagrid building models for RCC were created and analyzed in ETABs software for different positions of shear wall in zone V with subsoil Type medium -II. To confirm seismic activity with the same storey and storey height, both of the buildings were subjected to the same earthquake packing.

The analysis concluded that the diagrid structure was more economical than normal structures up to the 11th floor, but G+16 less economical than the G+7 and G+11 structures. The diagrid structure has a greater capacity resisting force than the normal structure.

Vijay Shankar Sahu and Himanshu Shrivastava (2020) The nonlinear behavior of the structure taken as case study of Zone V (Guwahati) was analyzed for Time Historey as well as Pushover Analysis. It was subjected to a suite of six different earthquakes which were scaled as per the target spectrum of Zone-V and the performance of the structure was evaluated. Building was modelled in commercial software STAAD Pro. Seismic force demand for each individual member was calculated for the design base shear as required by IS-1893:2002. Corresponding member capacity was calculated as per Indian Standard IS456:2000.

The storey drift, storey displacement, base shear, time period, performance points and capacity spectrum was observed and evaluated for base model and retrofitted with shear wall and cross bracings (both in different models). The behavior of retrofitted structure with shear wall may be significantly different from what has been observed for base model and cross bracing retrofitted structure. The performance flaws in the various models are highlighted by the pushover study. It was demonstrated that the base model performs poorly when compared to the other two models. The structure is safer after adding a shear wall to the original model since the hinges are no longer produced beyond the level of immediate occupancy.

Akshay Shaji et al (2019) Models of five-story buildings were subjected to Design Response spectrum analysis in accordance with IS 1893:2002. (part 1). Four distinct models were chosen, and ETABs 2015 was used for the analysis. Storey displacement, Inter storey drift, Storey stiffness and Base shear of each models were compared and anayzed. The dimensions and loads were selected according to IS 456 : 2000 and IS 875 : 1987 codes.

When building with shearwall was compared with building with bracings it has 95% increase in stiffness and there is 56% decrease in drift and displacement. As the shear wall model was compared with model with thicker ground floor columns, it was found that that the shearwall model has 131% increase in stiffness and about 62% decrease in displacement and drift. Base shear of shearwall model is found minimum compared to other modes. Hence results concluded that that building with shearwalls at corner has better performance when seismic forces were applied.

Deepak P. Kadam et al (2019) objective of this work is to study the impact of tunned mass damper (TMD) on the dynamic forces brought about by seismic tremor and wind excitations in standard just as unpredictable in tall RC building structures. For that three 22 storey RC building structures are considered with a similar arrangement out of which one ordinary regular structure and the other two are irregular RC structures are demonstrated in Etabs. In irregular RC structures, Stiffness irregularity and torsional irregularity are considered. For assessing seismic and wind reactions of structures, time historey analysis, and static analysis used, with and without the tuned mass damper in ETABS. The outcomes acquired from the investigation of three 22 storey RC structures with and without tuned mass damper were compared. In case of structures with various irregularities, performance of TMD is better in reducing excessive deflection, drift, time period etc. Regular structures but with some improper mass distribution also can give better results in dynamic analysis. Due to use of extra mass in structure in the form of TMD, drastic changes in base shear is not observed but the time period is reduced up to some extent. TMD was observed to be very effective in structures having torsional irregularities. Application of TMD damper reduces the large amount of displacement of the structure. Hence results concluded that the TMD can be used to control vibration of the structure. Absolute reduction in displacement of the structure causes less ductility requirement to resisting earth-quake forces.

Pravesh Gairola and Sangeeta Dhyani (2019) In a research paper, an analysis of the seismic behaviour of soft storey buildings with various models (Bare frame, Infill frame, Bracing Frame, Shear wall frame) under earthquake loading was reported. Using the analytical tool ETABS, a 3d G+9 storey Ordinary Moment Resisting Frame structure with several configurations was created (Bare frame model, Infills model, Bracings frame model, Shear wall frame model). Results were analyzed in terms of lateral forces, storey displacements, storey drifts, storey shear, and overturning moment and storey stiffness.
According to the results using equivalent static method, the lateral load is zero at the ground and maximum at the top storey for all the structures. The first level was found to have the highest storey shear force, while in every case, the top storey had the lowest storey shear force. In contrast to other buildings, the bare frame building showed significant displacement. It suggests that buildings with bare frame structures may exhibit larger displacement than the remainder of the structure in high seismic zones. Since the shear wall model exhibits less displacement than the other models, this suggests that it is both more practical and secure. Hence conclusion stated that the shear wall system provide better restrained and feasibility against seismic variation.

Pankaj Kumar Malviya et al (2018) research paper dealt with comparative study of behaviour of G+5 soft storey building frames, by considering geometrical configurations of building under wind loading and earthquake loading. The framed buildings was subjected to lateral loads and vibrations because of wind and earthquake and therefore lateral load analysis is necessary for these framed structures. The fixed base system was analysed by employing different equivalent inclined column frame structures in seismic and wind loading by means of STAAD Pro software. The responses of the same building frames was investigated and evaluated for the best geometry which satisfies lateral loadings.
Results stated that equivalent inclined column strengthens the structure from the soft storey. It was concluded that Equivalent inclined column not only strengthen structure but also provide better stiffness.

Rozaina Ismail et al (2018) The focus of the research was to compare the strength and stiffness of soft storey structures by performing Equivalent Static Analysis (ESA), Response Spectrum Analysis (RSA), and Time Historey Analysis (THA) on reference samples and shear wall systems. As a retrofitting technique, shear wall system locations and shapes were utilised. Five models were used in the retrofitting of soft storey structures, with one model without shear walls serving as a reference sample and the other four models having shear wall systems in various locations and shapes. The models underwent strength of structure testing using the SAP200 computer programme. The models checked the values of base shear resistance and lateral displacement.
According to the results, adding a shear wall rendered a soft storey building stronger and more rigid. In comparison to other models, the swastika form of the shear wall and the centre offer experienced the greatest base shear resistance in all X, Y, and Z directions and the least displacement. The application of a shear wall system improved the stiffness and strength of a soft storey structure in response to an earthquake, according to the conclusion.

Shaikh Irshad Akbar and Dr. Uttam B. Kalwane (2018) in the research paper, two models were prepared on ETABS 2016. One model was of bare frame while the other was with the bracings around the soft stories and the different loads and load combinations were applied on each model. Seismic analysis and wind analysis was investigated to understand the behaviour

of multi-storeyed RC frame building with four different models prepared according to IS 1893 (Part 1): 2002 using commercial software ETABS.
Results stated that time duration of the structure was more in bare frame, whereas it reduces in case of braced frame. Base shear in case of bare frame was more, whereas after the provision of bracings it was observed that base shear reduces. Drift and displacement of the structure was more in case of bare frame. And these can be lowered by making the provision of bracings at the level of soft storey. Stiffness of the soft storey in case of bare frame was less than the upper storey and it was seen that stiffness of the storey increases by providing the bracings at soft strey level.

Lakshmi Baliga and Bhavani Shankar (2017) in the research paper, infill walls was modelled as equivalent diagonal strut and bracings was provided by considering different steel sections and whole performance was done through Equivalent static analysis method by using Etabs-15 software. A G+7 multi-storied building with X-type, Inverted V-type and steel tube section was provided and analyzed the structure for parameters in the terms of displacements, storey shear, storey drift, bending moment and time period in both X and Y directions.
Results concluded that that provision of infill wall and bracings decreases time period.

Shamshad Ali et al (2017) In the investigation, seismic analysis of the effects of soft storey building frames was done using 5 distinct models of G+6 buildings and altering the soft story to different floors. The effect of infill walls was disregarded while considering soft stories and the same floor heights were used. STAAD PRO v8i was utilised to analyse the structure, and findings were gathered in terms of base shear, storey drift, and storey displacements.
The building without soft storey was found to be safer during strong ground vibrations than the one with soft storey at any floor, according to the results. Due to the soft storey's lack of stiffness, any building with a soft floor is susceptible to earthquake damage. When compared to nearby floor levels, the drift was greatest at the floor with the soft story. By including shear walls, steel bracing, or dampers, this style of RCC frame construction may safely endure seismic activity.

S. Kiran et al (2017) research paper focused on studying the effects of soft storey configuration in the buildings and remedying it by using different structural arrangements, such as shear walls, diagonal steel bracing and cross steel bracings. The linear dynamic analysis (response spectrum analysis) was adopted for various symmetrical buildings such as low rise (G+6), medium rise (G+14) and high rise (G+24). The responses of the models, in terms of storey drift, lateral displacement, storey shear, storey stiffness and bending moment variation was compared for different configurations and presented. The modelling and analysis was done using analytical application ETABS.
Results stated that as the height of the building increases, the provision of shear wall as well as cross steel bracing becomes inevitable as these techniques reduce the bending moment concentration at the open ground storey up to a great extend. With increase in height of the building, the storey drift was reduced as far as 93% for low rises, 90% for medium rises and 90% for high rises by incorporation of shear wall. About 68% reduction in case of low rises, 70% for medium rises and 71% for high rises was achieved by using cross steel bracings. Stiffness becomes a governing factor with increase in height of the building. The stiffness of the building was increased up to 70% by using shear wall.

Tahmina Tasnim Nahar and Md. Motiur Rahman (2017) the primary objective of the research paper was to analyze and compare the seismic performance of different types of braced and non-braced steel frame models in terms of horizontal displacement in first soft storey and total building displacement. Equivalent static load method was used for analysis of all models by a commercial finite element analysis software (ETABS 2015).

The seismic effect on soft first storey in steel building acts as a very vulnerable situation which is need to recognize and take necessary step to improve the reduction of some definite parameters for this destructive condition. The open first storey cannot be eliminated because of its important functional requirement of almost all the urban multi-storey buildings. It may improve by different way where this paper explains a method to increase the stiffness of first storey column by installing a different arrangement of steel bracing. It was concluded that single diagonal bracing of equivalent area gives better performance then other types of bracing system.

Abdul Juned Siddiqui et al (2016) Investigating the most effective building frame with various geometries to endure under various seismic factors was the aim of the study work. In order to acquire results in terms of moments, forces, and deflections, the inquiry will involve modelling building frames using various geometries and analysing frames using Earthquake and Wind loads. The analytical tool Staad.pro was used to develop and assess a G+5 soft storey building.

Maximum displacement is exhibited in bare frames without equivalent diagonal struts, while minimal displacement is seen in equivalent diagonal struts at the centre in both directions when there is an earthquake load. The most important frame among them was a bare frame without equivalent diagonal struts, and the most effective frame had equivalent diagonal struts in the middle. This will result in a decrease in moment, shear force, displacement, and storey displacement while providing similar diagonal struts at corners. Equivalent diagonal struts give the structure more rigidity.

S.P. Nirkhe et.al (2016) In a research paper, the seismic response of soft story buildings with various configurations under static and dynamic earthquake loading was examined. When earthquake loading is applied to RC-framed buildings with brick masonry infill on the upper floors and soft ground floors, base shear may exceed the amount predicted by the equivalent earthquake force method, whether it includes infill or not, or even by the response spectrum method when there is no infill in the analysis model.

Vipin V Halde and Aditi H. Deshmukh (2016) research paper investigated the effect of a soft storey for multi-storeyed high rise building with different models having identical building plan. Equivalent diagonal struts was provided as suggested in FEMA-273 in the place of masonry to generate infill effect. Soft storey level was altered at different floors in different models & equivalent static analysis was carried out using SAP 2000 analysis package.

Results stated that deflection was more in case of bare frame as compared to that of infill frame, because presence of infill contributes to the stiffness of building. When the position of soft storey moved to a higher level then parameters tends to be reduced. Moments & Shear forces was always maximum at soft storey level in all Models. Intermediate soft storey should be avoided and if at all needed should be provided at top storey.

R. V. Surve et.al (2015) in the research paper, analytical study multistorey building was considered with soft storey at different level along with ground level. The building was modelled with infill wall using finite element software SAP2000 version 14.4.2 and non-linear static pushover analysis was performed on all building models. To improve the seismic performance of such buildings lateral load resisting element i.e. shear walls was used. Shear walls are provided at corner of building in L shaped to improve seismic performance of building. Reinforced concrete moment resisting G+12 storey buildings with soft storey at different levels was designed. Height of each storey was 3.2 m with building plan dimensions as 20 m x 20 m. In the analysis special RC moment-resisting frames (SMRF) were considered.

It was observed that plastic hinges were developed in columns of ground level soft storey which is not acceptable criteria for safe design. After retrofitting all the models with shear walls, hinges was not developed in any of the columns. Provision of shear walls results in reduction in lateral displacement. Displacement reduces when the soft storey was provided at higher level. After retrofitting the base shear carrying capacity was increased by 19.22 % to 34.64%. This research highlighted that as soft storey is shifted to higher level yielding is less than the lower level soft storey and lower intensity hinges was formed.

III. Conclusion

Here authors explained the effect f soft storey structuyres and how to overcome but none of the author utilize resisting methods.

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