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Dynamic Analysis of Irregular Building under Lateral Load with Combination of shear wall with Friction Dampers and Bracings : A Review

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ABSTRACT

The application of the shear wall system in reinforced concrete (RC) buildings has become widely used to minimize seismic consequences. Besides, the buildings using concentrated steel bracings system are used for the same reasons in steel structures buildings. Both of the systems have significance of the structural performance. Although both systems are used for same the reasons, their effect shows unequal variations and behaviour against seismic load. This is for the reason that the values of response factors are miscellaneous for varying structural systems. In this paper we will present review of literatures related to utilization of lateral load resisting techniques.

Keywords : Irregular Building, Damper, Steel Bracing, Dynamic Analysis, Story Drift , Story Displacement

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I. INTRODUCTION

Generally shear wall are often outlined as structural vertical member that's able to resist combination of shear, moment and axial load elicited by lateral load and gravity load transfer to the wall from alternative support. Reinforced concrete walls, that embrace raise wells or shear walls, area unit the same old requirements of Multi story Buildings Style by coinciding centre of mass and mass centre of the building is the ideal for a Structure. Shear walls have terribly high in-plane stiffness and strength, which may be wont to at the same time resist massive horizontal masses and support gravity masses, creating them quite advantageous in several structural engineering applications. associate degree introduction of shear wall represents a structurally economical resolution to stiffen a building structural system as a result of the most operate of a shear wall is to extend the rigidity for lateral load resistance.

Fig 1 : Damage on building due to earthquake

In trendy tall buildings, shear walls are usually used as a vertical structural component for resisting the lateral masses that may be elicited by the impact of wind and earthquakes. Shear walls of varied cross sections.

In this chapter we are presenting review of researches and publications related to structural analysis of building frames with advance technologies and materials to enhance structural efficiency, utilization of analysis tool and analysis and designing of structures as per Indian provisions.

II. LITERATURE SURVEY

Ali and Minhaj (2014) the primary focus of the research paper was to determine the solution for shear wall location in multi-storey building. A RCC building of six storey placed in HYDERABAD subjected to earthquake loading in zone-II was considered and an earthquake load was calculated by seismic coefficient method using IS 1893 (PART–I):2002 and analyses were performed using ETABS. The ground storey height was 3.5m and floor to floor height was 3m. Spacing of frame was 4m. Concrete used was M20 and structural steel was Fe415.

Four different models were designed namely structure without shear wall, Structure with L type shear wall, Structure with shear wall along periphery and Structure with cross type shear wall. The results stated that least deflection was found in structure with cross type shear wall.

Ravikanth Chittiprolu and Ramancharla Pradeep Kumar (2014) A study on an irregular highrise building with shear wall and without shear wall was analyzed to understand the lateral loads, story drifts and torsion effects. A residential building of G+15 irregular structure having the base dimension of plan 24.38m x 25.98m with a stilt floor of height 4m and typical floor of height 3m is considered for the analysis. The structure is planned to be reinforced concrete with cement/ fly ash brick infill wall. The superstructure is modelled using standard software ETABS as a space frame with a grid of columns in the vertical direction, interconnected with beam members in the orthogonal directions at each floor level. Design service loads are expected to act on the structure during its intended life and they are considered with reference to relevant codes of IS 875 part1- 1987 for dead loads and imposed loads, IS 875 part3-1987 for wind loads, IS 1893 part1-2002 for earthquake loads.

Conclusion stated that Dynamic linear analysis using response spectrum method was performed and lateral load analysis was done for structure without shear wall and structure with shear wall. Results are compared for the frame lateral forces and story drifts of both the cases. It was even observed that lateral forces are reducing when the shear walls are added at the appropriate locations of frames having minimum lateral forces. Therefore, it is inferred that shear walls are more resistant to lateral loads in an irregular structure. Also they can be used to reduce the effects of torsion.

Meshra and Munde (2018) the primary main aim of the project was to work out the solution for shear wall location in multi-storey building.It's administrated to work out the strength of RC shear wall of a high-rise building by dynamical shear wall location. Three completely different cases of shear wall position for a building was analysed. associate degree earthquake load was calculated by the unstable constant technique victimization IS 1893 (PART–I): 2002. STAAD professional V8i software was used for the analysis of structures. The structures area unit compared on four completely different parameters specifically joint displacement, axial force, bending moment and base shear.

Analysis results concluded that time period decreases as the mode frequency increases for all model. Maximum lateral displacement increases as storey height increases for all models. Minimum lateral displacement of the building reduced due to the presence of shear wall placed at the model with shear wall at center in comparison to all models. The maximum base shear observed in model with central shear wall as compare to other models in x and y direction. Hence, it was said that building with central cross section shear wall was more efficient than all other types of shear wall.

Poonam et. Al. (2012) In this paper, response of a 10-storeyed plane frame to lateral loads was studied for mass and stiffness irregularities in the elevation. These irregularities are introduced by changing the properties of the members of the storey under consideration. Floor-mass ratios ranging from 1 to 5 are considered for mass irregularity. The mass irregularity is introduced at different storey levels—fourth and seventh levels. To introduce stiffness irregularity, the fourth and fifth storeys stiffnesses are reduced to 50% of that of other storeys in the base frame. Other than the first-storey, other storeys are also given similar stiffness irregularity.

In this paper, various frames having different irregularities but with same dimensions have been analysed to study their behaviour when subjected to lateral loads. All the frames were analysed with the same method as stated in IS 1893-part-1: 2002. The base frame (regular) develops least storey drifts while the building with floating columns shows maximum storey drifts on the soft storey levels. Hence, this is the most vulnerable to damages under this kind of loading. The other buildings with irregularities also showed unsatisfactory results to some extent. The frame with heavy loads develops maximum storey shears, which should be accounted for in design of columns suitably.

The analysis proves that irregularities are harmful for the structures and it is important to have simpler and regular shapes of frames as well as uniform load distribution around the building. Therefore, as far as possible irregularities in a building must be avoided. But, if irregularities have to be introduced for any reason, they must be designed properly following the conditions of IS 1893-part-1: 2002 and IS- 456: 2000, and joints should be made ductile as per IS 13920:1993. Now a days, complex shaped buildings are getting popular, but they carry a risk of sustaining damages during earthquakes. Therefore, such buildings should be designed properly taking care of their dynamic behaviour.

Vishal N et. Al. (2020) In order to study the structural behaviour of a 20-storey building with vertical setback irregularity was modelled and analysed by response spectrum method considering with and without Construction Sequence Analysis (CSA) using different structural systems in CSI ETABS V16 as per BIS 1893:2016 (Part 1). Finally, results such as axial force, shear force, bending moment are drawn for the structural members and response such as storey displacement, storey shear and storey drift are plotted and compared for each structural system.

Results stated that for response spectrum in X-direction, maximum displacement at top storey is decreased by 49% for dual system and by 30% for braced system similarly for response spectrum in Y-direction, maximum displacement at top storey is decreased by 55% for dual system and by 24% for braced system when compared with moment frame system. Higher the stiffness greater the base shear. Dual system has performed well in both horizontal direction for response spectrum. Base shear at the ground level was found around 75% more in dual system and 55% more in braced system when compared with moment frame system. Provision of shear wall and bracings to the building has considerably reduced the drift of storey which is also within the permissible drift limitation. Time period obtained from mode shape of dual system was 1.25 seconds which is nearly half than that of moment frame system which proves will act safe during earthquake excitation. For all the three structural systems, axial force in exterior column was found to be more in conventional analysis than CSA and for in interior column the axial force was more in CSA than the conventional analysis. Bending moment in beam has shown a gradual increase from bottom storey to 2/3rd of the building height and thereafter the value has decreased considerably when analyzed in Construction Sequence Analysis. This may be due to the fact that bottom storeys are involved in numerous cycles of analysis in CSA than the conventional method. The column shear force from the bottom storey is more in CSA and it gradually decreased at the top by slight variation for all the structural systems.

Sandeep Singla et. Al. (2019) the research paper presented comparative analysis of earthquake resisting techniques on a G+10 story building with the help of different types of Shear walls & Bracings, using software. The comparison was done between an un-Resisting structure, parallel shear walls, L-shaped shear wall, diagonal bracings, X-shaped bracings & V-shaped bracings. The use of shear walls and bracings helps to strengthen then structure to make it more Earthquake resistant. The analysis was done on a G+10 building for seismic zone III as per IS 1893:2002 codal provisions. The software used to carry out this analysis was Staad pro v8. It was found out that shear walls and bracing contribute largely in reducing the deflection by increasing the strength and stiffness of the building.

Results stated that the displacement observed in the models, which are without shear walls & bracings is more as compared to the models having shear walls and bracings at different locations. It has been observed that the Max deflection is significantly reduced after providing the shear walls or bracings in the RC frame in X-direction as well as in Z-direction. It is also been observed that Story shear effectively decreased by introducing Shear Walls and Bracings at different locations. The best location of shear wall in multi-storey building was parallel shear walls. And the best type of bracings that can be used is cross bracing. The lateral deflection of column for building with cross bracing was reduced maximum as compared to all models. The least story shear is found in the model with cross bracing. The shear force is maximum at the ground level & the bending moment is maximum at roof level. By providing shear walls and bracings to the high-rise structure, seismic behavior will be affected to a great extent and also the stiffness and the strength of the buildings is increased. Finally, it is concluded that, optimization using cross bracings is the best procedure, in present work mode for maximum earthquake resistance.

Pardeshi et.al (2017) the research paper presented experimental investigation on reducing the size of the member to make structure economical and efficient by locating shear wall at varying places in irregular shape building. The usefulness of shear walls in the structural planning of multistory buildings has long been recognized. When walls are situated in advantageous positions in a building, they can be very efficient in resisting lateral loads originating from wind or earthquakes. Reinforced concrete framed buildings are adequate for resisting both vertical and horizontal loads acting on them. Extensive research was done in the design and analysis of shear wall high-rise buildings. A study on an irregular high-rise building with shear wall and without shear wall was studied to understand the lateral loads, bending moment, shear effects. Staad Pro V8i was used to analyze the certain irregular high rise building by changing the location of shear wall and see what the effects on structure.

The results concluded that Top deflection was reduced and reached within the permissible deflection after providing the shear wall in shorter direction. Shear wall symmetrically in the outer most moment resisting frames give better performance for regular shape building. Size of the member like column can be reduced with shear wall so less obstruction will be there because of reduced size of members. The shear wall location was found to be more effective towards shorter column as compared to other locations. Shear wall at outer side was most efficient and resulting in 26.4% reduction in base shear as compared to original building.

Mahajan and Vyas (2019) The research paper conducted response spectrum analysis of structural frame models using SAP 2000 vs. 19. Accurate modeling of all models consist various elements is very important in earthquake analysis. In present study, frame element is modeled with elastic flexural hinge using elastic model and shear wall is design as area element providing concrete property. G+10 building with bare frame and Shear wall frame structure was considered for the analysis. Four different building models with bay width of 6m in X-direction and story height equal to 4m were considered. The column section defined for the frame satisfies both the requirement for strength and stiffness. All the selected models were designed with M-25, M-30 grade of concrete are used and Fe-415 grade of reinforcing steel as per Indian standards. Four different models were considered namely structure with bare frame, regular shear wall structure, irregular shear wall structure and regular shear wall with varying thickness.

The base shear in irregular shear wall structure was found less as compare to other models due to vertical irregularity of the shear wall. The storey drift of regular shear wall was comparatively lesser than other model due to its regularity. The storey force distribution of regular shear wall is comparatively lesser than other models because of symmetrical cross-section plan of shear wall.

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Results stated that maximum displacement, maximum base shear and maximum shear force reduced by 50%, 20% and 30% in comparison to bare frame hence the results proved the structure with shear wall was more effective than other models.

Agrawal et. Al. (2017) In this study a G+19 story unsymmetrical [Floor plans] commercial building [L>3.6 least lateral dimension of building], H> 3.3 least lateral dimension of building and was modeled with different position of shear walls and analysis conducted for joint displacement, Storey drift, Storey stiffness and Base shear force. These models were modeled with ETABS for static analysis as per IS 1893 -2002. The analysis results for different models and plotted to compare and to know the behavior of RCC frame structure with different position of shear walls.

Mallesh et. Al. (2019) the research focused to analyze the behaviour of the Buildings with Plan Irregularities under Earthquake loads. frames with unsymmetrical plan configuration of L shape was taken and G+15 storey building is modelled in ETABS 2016 software with seismic zone V and Medium soil type, and that irregular structure to be converted to regular structure with the provision of expansion joint. Where three case to be considered one with Bare Frame Sections with and without Expansion Joint, Shear Wall Frame Sections with and without Expansion Joint and Shear Wall and Bracing Frame Sections with and without Expansion Joint these models was analysed under response spectrum method.

Results stated that the storey displacement values of the bare frame 8% and 4%, bare frame with shear wall 30% and 19%, Frame section with shear wall plus bracings 59% and 34%, Reduced with the provision of expansion joint in comparison to models without expansion joint, along X and Y directions respectively. The storey drift values of models without expansion joint of bare frame, bare frame with shear wall and bare frame with shear wall plus bracing were found to be having lesser values than that of the models with expansion joint. The storey force values of models with expansion joint were found to be having lesser values than that of the models without expansion joint. The storey stiffness values in the bare frame, bare frame with shear wall and bare frame with shear wall plus bracing with expansion joint was found to be slight lesser in comparison to that of their respective models without expansion joint. The base shear values in the bare frame with shear wall and bare frame with shear wall plus bracing with expansion joint was found to be less in comparison to that of their respective models without expansion joint. The results concluded that the regular frame structure performs better than the irregular frame structure in plan.

S.S. Pathan et. Al. (2017) the research paper discussed the performance evaluation of reinforced concrete building with irregular plan like C shape. Three models for multi-storey structure was considered for the described in IS: 1893-2002, model in E-tabs software. The analysis for the storey stiffness and storey displacement using friction damper and shear wall.
The results concluded that performance of a building is better in case of plan with friction damper the displacement is reduced as compare to shear wall. The stiffness of building is increase by using damper and shear wall but more effect using the shear wall. The performance of building is increase on the periphery along the damper and shear wall.

Kushwah et. Al. (2017) The research focused on the performance and behavior of regular and vertical irregular G+10 reinforced concrete (RC) buildings under seismic loading. Two types of vertical irregularities namely stiffness and setback was considered in this study. Total eight regular and irregular buildings were modeled and seismic analysis is carried out using response spectrum analysis (RSA) method. Different seismic responses like storey displacement, storey drift, overturning moment, storey shear force, and storey stiffness are obtained. By using these responses, a comparative study has been made between regular and irregular buildings. The result remarks the conclusion that, a building structure with stiffness and setback irregularity provides instability during seismic loading. To control the instability, a proportionate amount of stiffness is beneficial in RC building.

In case of stiffness irregular buildings, the overturning moment and storey shear force in case of irregular buildings are slightly greater than that in regular building. A moderate increase in the slope of the shear force curve has been observed at the irregular storeys. In case of setback irregular buildings, the overturning moment and storey shear force are less than that of the regular building. As the amount of setback increases, the overturning moment decreases. In case of stiffness irregular buildings, a sudden decrease in stiffness of the building has been observed at the irregular storeys. The results of setback irregular buildings show that, as the amount of setback increases the stiffness of the building decreases. The analysis shows that the vertical irregularities widely affect the performance of a RC building under seismic loading. As far as possible these irregularities must be avoided, but if it has to be introduced they must be properly designed.

Vimala and Azharuddin et. Al. (2019) the objective of research was to compare the performance of G+11 multi-storied building considering five different models of regular, single step vertically irregular, dual step vertically irregular building with and without shear walls. Two different cases of aspect ratio in the geometric irregular frames were considered. In the first case, single step vertically irregular structure with and without shearwall at an aspect ratio(A/L) of 0.28 after third storey in x and y-direction. In second case, dual step vertically irregular structure with and without shearwall at an aspect ratio(A/L) of 0.57 after sixth storey in x and y-direction. In addition to that, the study included the failure criteria in formation of hinges and behavior of formation of hinges in different structures strengthened with shearwall. In this study Nonlinear static pushover analyses was conducted to study and analyze the structure. The buildings was modeled using ETABS 2017 software and seismic loads are calculated as per IS: 1893-2002(Part-1). As the vertical irregularity aspect ratio was increased from 0.28 to 0.57 the base shear is decreased by 7.11% and 10.7% when compared to regular building. Therefore it was concluded that increased aspect ratio in the seismic prone areas is not recommended without shear wall. Further conclusion stated that the failure of the irregular structure with shear wall is a ductile failure as the local members are yielding first.

Mishra and Rizwanullah (2017) the research paper presented comparison of seismic behaviour of G+10 storey buildings having horizontal irregularity with the regular building of similar properties with and without shear wall by using ETAB software was done. For this purpose four multistory building plans are considered that are symmetric plan, L shape, T shape, and + shape. For the comparison, parameters taken are lateral displacement, storey drift and model period. All the four buildings were analyzed for zone IV. Modal Period with different configuration of building, Storey Displacement of structure with different configuration of building, Storey Drift with different configuration of building were investigated and their comparison was done.

Alashkar et.al (2014) in this paper, seismic performance of RC building rehabilitated with shear wall and concentrated steel bracing. An earthquake load is calculated and applied on nine stories building located in zone III. A comparison has been made between the effectiveness of different types of steel bracings with concrete shear wall at different locations of the building. The performance of the building is evaluated in terms of story drifts, lateral displacements, bending moments and base shear.
The results concluded that he addition of new concrete shear wall is more oftenly practiced technique which has prove to be effective for controlling global lateral drifts and reducing damages in frame structures. Shear walls reduces significant amount of lateral displacement, bending moment and shear forces in frame members as compared to other

techniques of retrofitting. Optimal location of shear walls in frame system is critically important to reduce the lateral forces. Shear walls located at the core of building shows better performance than at the boundary of building. Steel bracing is one of advantageous and economic technique to enhance the seismic performance or strengthen the structure. The increment in dead load due to addition of steel bracings is significantly less than the other strengthening techniques. The V-type bracings show some additional flexural moment in columns and beams due to concentric load at the point where they are attached. The X-bracing system shows the minimum moment as compared to other types of bracings.

III. CONCLUSION

In all of the previous work static analysis of buildings is considered but none of them defined the variation caused due to Lateral forces with irregular building.

In previous studies no comparison was done on the effects of bracing system with dampers for high rise building project.

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