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Analysis of A Tall Structure Considering Bracings and Base Isolation Using Analysis Tool ETABS A Review

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ABSTRACT

Safety of people in a building depends on capability of the building to resist earthquake waves and then stands upright after earthquake situation without or with few damage and maintenance. Various systems like dampers, base isolators, shear wall, elevated water tank, etc., are use to dissipate seismic energy. Effectiveness of these systems is based on its type and position of these elements.

In this research paper, presenting review of literatures related to analysis of structure.

Keywords: Time history analysis, storey shear, storey overturning moment, bracing, Lead Rubber Bearing.

I. INTRODUCTION

Dynamic action likes wind and earthquakes have major effect on structure. The main focus of earthquake resistant design of structure is to control the damage of structural element and also to control sequence of damage in different structural elements. Safety of people in a building highly depends on the capability of building to resist movement due to earthquake, and then on standing upright after the earthquake without or with few damage and maintenance. Losses due to building collapses can be reduce and protecting contents, services & utilities of buildings. Various syste\ms are use to dissipation of energy; also to control or reduce excessive structural vibration. Seismic effect on building can be reduce by using non structural elements or components like dampers, isolators, elevated water tank. Out of various seismic resisting systems Bracing, base isolation and dampers are effective and these are more commonly used. Effectiveness of these systems is based on its type and position of these elements. As per various research papers, Out of different bracings cross bracing is most effective; Lead Rubber Bearing (LRB) type of base isolators are most effective systems. In any structure seismic waves generate inertia forces which produce shear and overturning moments. Storey shear is lateral seismic load acting per storey.

II. LITERATURE REVIEW

The research papers from different authors were summarized from across the globe who have

extended that research towards understanding the behaviour of high rise structures when subjected to lateral loads and further taking different measures or use technologies to reduce its effect on the new or existing structure. Some of the research papers from scientists and researchers are sumamrized in the section below.

Arbaz Ahmad Lone et.al (2023) research paper aimed to provide insights about the diagrid and shear wall structural system and, the comparison has been done to find out which system is sustainability, costeffective, and superior in resisting lateral load for the buildings which is located in earthquake zone V. ETABS software was used to model and analyze all of the buildings following IS 1893:2016, the building location was presumed to be in seismic zone V, with an importance factor of 1.5. Fundamental period (T, seconds), story drift, base shear, lateral displacement, and overturning moment of structures are the structural parameters used to determine the response of the building.

Results concluded that dynamic analysis of a 30-story building RCC frame using ETABS software was used, each model has the same property of RCC frame with different cases showing the different results in earthquake impact. The diagrid bracing system was more fascinating than the shear wall system given at different locations. As a result, diagrid structures continue to be more cost-effective and sustainable than shear wall systems. It is because the lateral load resisting system overtakes the structural system in resisting gravity loads as the structure height increases.

M. Asif and N. Pasha (2023) in the research paper, 12 storey building in zone V and zone II was considered and analyzed with flat slab by changing various shapes of shear wall to determine different parameters like storey shear, storey displacement, storey drift and time period. Analysis is done using ETABS V.17.Software. Response spectrum analysis i.e. linear dynamic analysis was performed on the system to get the seismic behaviour. The analyses were carried out to assess the structural performance under earthquake ground motions. These models are compared in different aspects such as storey drift, storey displacement and storey shear.

Results stated that Storey displacing consistently rising when Cross bracing is providing with every floor. Storey displacement consistently increasing when bracing is provided for all the floors. As per IS 1893:2002 (part 1) in zone II, the values of storey drift for all of the stories are determined to be within the allowable limit, i.e. not further than 0.004 time for storey height.

Pilli Deepika and D.Surendra (2023) in the research paper, a G+9 story building was analyzed using a Rubber bearing isolation system and friction pendulum system in seismic zone Zone V with the help of IS 1893:2016 Code in SAP 2000 Software package. The analysis was made between Rubber bearing isolation system, friction pendulum system and Fixed base building for seismic parameters like joint displacement, shear force, bending moment, building torsion and time period frequency.

Results concluded that by using base isolation systems the values of base shear increased when we compared with fixed base building model. the storey shear values reduces to 35% in rubber isolation and 40% for friction pendulum models. The storey moment decreased to 25% in rubber base and 30% for friction pendulum model. The Optimum control of the parameters considered was observed when the building is damped with friction pendulum model in all the seismic zone conditions.

Hemanta Kalita et.al (2022) objective of the research was to to compare the different types of passive energy dissipating devices in a 3 bay 10 storey steel frame building for better seismic response. The

frame was modelled in SAP2000® and some of their responses to earthquake such as base shear, maximum joint displacement, inter storey drift were determined and compare during non-linear dynamic time history analysis in SAP2000®.The passive energy dissipating devices used in this study are diagonal bracing, v bracing, cross bracing, rubber base isolator and friction damper. At first a single storied shear frame model was tested in a shake table and results obtained from SAP 2000® were compared.

Results stated that addition of dampers to the system increases the stiffness to the frame. When compared, displacement for steel frame with dampers reduced by 80% and that with different bracing systems reduced up to 78% as compared to bare steel frame. For base isolators, base shear decreases up to 63.33% but an increase in the maximum joint displacement was observed.

K. Deshmukh and A. Hamane (2022) author investigated the effect of bracing and base isolation on the seismic analysis of various vertically irregular high-rise buildings using nine models. A 20-story high rise vertically irregular building with plan dimension 48 m x 30 m located in zone III with horizontal aspect ratio 1.6 and vertical aspect ratio 2 was designed as per IS 1893:2002 (part1) and IS 16700:2017 provisions. The seismic analysis of the various vertical irregularities namely setback irregularity, open grounded story irregularity and multiple setback irregularity was done by CSI ETABS software. A comparison between the seismic analysis of the various vertically irregular building without any earthquake resistant system, with X bracing system and with base isolation will be done.
By application of bracing and base isolation by lead rubber isolator technique it was seen that the base isolation proves to be better in controlling the seismic activity of the building by making the building flexible and by shifting the natural frequency of the structure to longer period less force period. Out of all the irregularities, model with irregularity on each side performs seismically better as compared to the other two irregularities. As the irregularity increases the seismic performance of the building reduces but it can be increased with the addition of base isolation by lead rubber bearing technique.

M.S.Jaballah et.al (2022) objective of the research paper was to combine the application of base isolators and ATMDs to minimize the structural responses under the influence of seismic excitations using two different controllers, LQR and PID.
Results concluded that the LQR controller outperforms the PID controller in reducing the structural responses. More than 50% of the top floor displacement is reduced by using the hybrid control system. Using a hybrid control system to control the vibration of a structure improves its performance in resisting strong earthquake excitations and makes the structure safer and more comfortable during earthquakes.

Mitali Shelke et.al (2022) objective of the research paper was to analyze the structure with and without elastomeric base isolation for a G+7 storey using ETABS and compared the results on parameter of storey, displacements, drifts and base share.
From the response analysis, the base shear of base isolated structure is minimum when compared with the fixed base structure indicating response of building is better in base isolated structure. Base isolated structure shows slight lateral deflection when compared to a fixed base structure. Due to the increase in flexibility of structure, displacement of isolated building increases. The base isolation system decouples the building from the earthquake when compared to that of the fixed base building.

M. Y. Laissy (2022) objective of the research paper was to evaluate the effects of different strengthening systems and to identify the most suitable one for seismic load resistance. The behaviour of buildings with different strengthening systems applied to seismic loads was investigated using ETABS V18.1 and response spectrum analysis. The comparison was made in terms of shear forces, displacement, drift, fundamental time period, base shear, and story stiffness.

Results demonstrated that the use of a combined strengthening system increased the stiffness and stability of the models and the resistance of RC buildings to seismic loads on sloped terrains. The joint displacement of a point was reduced from 24.48 mm for the frame configuration system and the value of the shear wall and bracing configuration system was 16.85 mm, which reduces the lateral displacement by 33.1%. Base shear reduces by 21.19% in comparison to the shear walls and 63.34 % in comparison to the bracing strengthening system.

S. M. R. Hosseini and Gh. R. Nouri (2022) author investigated the seismic performance of asymmetric isolated structures with different bracing systems under near-fault strong ground motions. Non-linear dynamic analyses was performed under the simultaneous application of horizontal and vertical components of seismic acceleration considering three types of chevron, cross and zipper bracing systems in 5 and 10-story structures with 0%, 10% and 20% mass eccentricity.

In 5 and 10 story isolated-structures, bracing system Z had the best performance of energy absorption (53%). With increasing the height of the structure, this value has decreased by 7%. As per results, among the structures with different braces, the structure with X bracing and the structure with V bracing have the lowest and highest torsion rates in the floors, respectively. With the increase in the number of structural floors from 5 to 10, the rotation of structural floors has also increased.

Hirendra and Mahesh Ram Patel (2020) in the research paper, G+10, G+15 and G+20 multi storey regular structure with different types of bracing system were considered. To obtain the accuracy and adequacy of results, initially the Seismic coefficient method was applied in the first two (bare and X type bracing structure) case and these results compared with the response spectrum method in STAAD.Pro. Later cases were calculated from STAAD.Pro software and compared with each other.

Results stated that the maximum base shear is found in cross (X) bracing frame as compared to other in all G+10, G+15 and G+20 high-rise buildings. The minimum average displacement has been found in cross (X) bracing frame type in all considered G+10, G+15 and G+20 high-rise building as compared to other types of structure. The fundamental frequency is more in case of cross (X) type bracing system and less in bare frame structure.

Jadhav Nachiket S. et.al (2020) in the research paper, seismic analysis of G+9, G+15, G+20 storey residential structure was investigated based on storey shear and overturning moment by Time History Analysis. Time history data was obtained From PEER Ground Motion Database. Based on maximum storey shear and storey overturning moment, effect of cross bracing, base isolation, Fluid viscous damper and shear wall was compared with Ordinary moment resisting structure.

Results stated that maximum storey shear decreases with increase in storey level. As compared to ordinary moment resisting structure, for G+9, G+15 and G+20 storey structure, the maximum reduction in maximum storey shear occurs in structure with base isolation and then with fluid viscous damper. There was an increase in maximum storey shear in structure with shear wall and with cross bracing by

about 76.2% and 41.8% respectively. Structure with Base isolation reduces 1.5% to 1.85% storey overturning moment and is suitable out of other seismic resisting components on basis of maximum storey overturning moment only. As there is increase in storey overturning moment by about 37.7% to 44.4% in structure with shear wall position on corner of structure, this position of shear wall is not suitable in designing

E.Dileep Kumar and Dr.N.Victor Babu (2019) in the research paper, a G+10 story was modeled using ETABS software and analyzed in push over analysis and the comparison was made between the general building, steel building and shear wall buildings to design the earthquake resistant structures design. The results were compared on parameters of story drift, story shear, story moment, building torsion, time period, and model stiffness.

Results concluded that building with shear wall case has more advantage than remaing cases(general building and steel bracings building) as we compared with general building the bracings building has 63% less values for bracings building and 75% less values for shear wall buildings.

Osama Ahmed and Dr.s.Amaresh Babu (2019) objective of the research paper was to evaluate the seismic response of the structure subjected to earthquake excitation with the help of ETABS 2015. The models considered were reinforced concrete ordinary moment resisting frame of five, ten and fifteen stories with same column sizes, with base isolators, with shear walls & with bracings. All these buildings were analysed by non- linear dynamic analysis [time history analysis]. The "Loma Prieta" earthquake data is used as ground motion data for performing non-linear time history analysis.

Conclusion stated that asymmetric structures with bracing system, showed reduction in story drift up to 27%, whereas base shear and base torsion was increased up to 60%, when compared with basic model for five, ten & fifteen stories in near-fault ground motions. Structures with shear walls provided showed the highest reduction in storey drift up to 94% for five and ten storey models, whereas the base shear and base torsion was increased by 74%, when compared with basic model in near-fault ground motions. For fifteen storey shear wall model drift was reduced up to 35%, whereas base shear and base torsion was increased up to 67%, when compared with basic model in near-fault ground motions. Hence the shear wall model for high-rise buildings, did not fare any better than the base isolator model. Structures with base isolators provided showed the highest reduction in base shear and base torsion up to 87% for five and ten storey models, whereas the storey drift was decreased marginally by 11% when compared with basic model in near-fault ground motions. However the fifteen storey base isolator model showed highest reduction in storey drift (up to 38%) and base shear, base torsion (up to 79%).

Ankush S Avhad et.al (2018) research paper aimed to compare the seismic behaviour of different damping systems in steel concrete composite buildings. The analysis of G+9,G+3 and G+14 building considering soil structure interaction was done considering a three dimensional modelling and analysis of the structure was carried out with the help of SAP 2000 software. Equivalent static analyses was carried out on all structures considering base isolation and single bracing system in analysis.

Results stated that storey drift is observed to decrease 30% in base isolation & viscous damper. Deformation due to self-weight is decreased up to 30-35% in damper system & 15% in base isolation. Hence it was observed that base isolation will only contribute to reduction in storey drift. After comparison with and without soil structure interaction for story drift along X and Y direction, it was observed that Story

drift Varies between 15%-40% for different storey. Hence it was concluded that SSI need to be considered for higher zone, multi storey building and weak soil. Deformation due to self-weight is observed 16% more in with considering soil structure interaction.

M. Abdul Mannan et.al (2018) objective of the research paper was to investigate isolated buildings considering eight models models compared with symmetrical (i.e rectangle building) and unsymmetrical buildings (i.e I shaped buildings, L shaped buildings and S shaped buildings) with fixed supports at base and with rubber isolator at the base by using commercial software by ETABS and results were compared for the storey displacement, storey shear, story moments and storey overturning moments.

By introducing base isolators the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure is considerably reduced. This concept has created a breakthrough in structural design and as years go by will prove to be a life-saving innovation of historic proportions. The performance of fixed base and isolated base structure depends on the type of underlying soil on which the structure rests. The response of the structure is different because of the different types of changes due to the changes in physical properties of an isolator. By comparing the with and without base isolators the base isolators shows less deflection and shear moments.

F.T. Zahura et.al (2016) author investigated different types of frame with base isolator and Rectangular shape frames considering 20 story SAC frame with different types of bracing under earthquake. Modal time period and frequency are compared between base isolated frame and rectangular frame with bracing. Displacement and drift is compared with the rectangular frame bracing and base isolated frame.

Results stated that base isolator reduce the inertia forces introduced in the structure due to earthquake by shifting the fundamental time period of the structure. The displacement of a base isolator frame is 42% higher than the E Bracing frame for the case of EI Centro and hereby increases the flexibility of the structure.

M.Gopinath et.al (2016) in the research paper, a model of building was created using STAAD.Pro software, with this model shear wall and bracings was provided, based on seismic analysis displacement and storey drift were calculated by using static method.

Lateral displacement was large in frame with soft storey. Minimum displacement for corner column is observed in the building in which a shear wall is introduced in X-direction as well as Z-direction. The over strength in a braced RC frame is due to the added strength of the brace system as well as an added strength in the RC frame due to stiffening effects of connections. The important parameter affecting the capacity interaction is recognised as the number of braced bays connections taken into consideration as a stiffness ratio. The value of ductility is higher for structures with bracing than that of structures without bracing system.

Rincy M. A and Shwetha Saju (2016) the primary objective of the research paper was to investigate various seismic control techniques adopted for the protection of structure against seismic effects and compare the response of the building such storey drift and displacement, time period performance of the fixed base structure with base isolated and structure with damping devices.

Results stated that structures with isolators and damping devices perform well during seismic loading. In base isolated structure, storey drift and storey displacement are reduced at greater extent. Performance points of both base isolated structure

and structure increased as compared to fixed base structure. In a structure with viscous damper, storey drift, storey acceleration and storey displacement are reduced. Viscous damper have better control effect on displacement.

III. CONCLUSION

The research papers primarily focused on comparing different damping systems for the high rise structure stability besides it found different applications considering the seismic zone. Different applications such as Staad.Pro, ETABS and ANSYS were used for the purpose of analyzing the structure considering different soil conditions. The research papers were summarized and results proved that base isolation system proved to be effective in major cases.

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