|| Volume 8 || Issue 11 || November 2024 || ISSN (Online) 2456-0774
INTERNATIONAL JOURNAL OF ADVANCE SCIENTIFIC RESEARCH AND ENGINEERING TRENDS

Review-Dynamic Analysis of Symmetrical & Unsymmetrical High Rise Structure with Curtailed Shear Wall

AASHISH NIMBE[1] RAGHVENDRA SINGH[2]
[1]*M.Tech Scholar, Department of Civil Engineering, Ujjain Engineering College, Ujjain*
[2]*Professor, Department of Civil Engineering, Ujjain Engineering College, Ujjain*

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Abstract: This review paper investigates the dynamic analysis of symmetrical and unsymmetrical high-rise buildings with curtailed shear walls, focusing on key parameters such as axial force, node displacement, and base shear. Symmetrical structures, with their uniform mass and stiffness distribution, offer predictable dynamic responses, whereas unsymmetrical structures, characterized by irregularities in geometry, mass, or stiffness, pose significant challenges due to torsional effects. Curtailing shear walls—reducing their height to optimize material usage and architectural flexibility—further complicates these analyses. Through an extensive review of analytical and experimental studies, this paper highlights the influence of curtailed shear walls on the aforementioned parameters. Findings indicate that while curtailed shear walls can reduce construction costs and enhance architectural freedom, they also lead to increased node displacements, altered axial force distributions, and reduced base shear capacity, particularly in unsymmetrical structures.
Keywords: *Shear Wall, Axial Force, Node Displacement, Base Shear*

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I.INTRODUCTION:

High-rise structures have become a hallmark of urbanization, providing solutions to increasing population densities and limited land availability. However, their design must account for dynamic forces such as wind and seismic activities, which can critically impact structural integrity and safety. Shear walls, often integrated as vertical elements within the structural framework, are essential for resisting these lateral forces by enhancing stiffness and controlling inter-story drift. Traditionally, shear walls are constructed continuously throughout the height of a building. While effective, this approach can impose limitations on architectural designs, increase construction costs, and lead to unnecessary material consumption in areas where their full strength is not required. To address these challenges, the concept of curtailed shear walls has emerged. By terminating the walls at selected heights, this approach reduces structural redundancies and offers greater design flexibility without compromising lateral load resistance. However, the introduction of such discontinuities alters the dynamic behavior of the structure, particularly under seismic forces. This complexity is further amplified in unsymmetrical high-rise buildings, where asymmetries in mass, stiffness, or geometry can cause coupled translational and torsional responses. Understanding the dynamic implications of curtailed shear walls in both symmetrical and unsymmetrical configurations is therefore critical to achieving safe and efficient designs.

II. OBJECTIVE OF STUDY

The objectives of the present study can be identified as follows:

1. Identify the challenges associated with the curtailed shear wall design in both symmetrical and unsymmetrical buildings.
2. Highlight the influence of structural irregularities on dynamic performance.
3. Examine the effectiveness of advanced modeling and monitoring technologies in addressing these challenges.

III. LITERATURE REVIEW

General: Many researchers have been continuously carried out from last decayed on effect of shear wall & curtailment of shear wall in medium rise & high rise structures. The research contributions which have a direct relevance are treated in greater detail. In the recent past tremendous work has been done on seismic analysis high rise & medium rise structures with curtailed shearwall some of them are presented in the following lines of dissertation.

Detailed Literature Reviews

Literature reviews on dynamic analysis of effect of shear wall and curtailment of shearwall in highrise structures. **[1] Ankur Rathore & Prof. Afzal Khan [2022]:** The main scope of this project is to apply class room knowledge in the real world by designing a multi-storied residential building. Shear walls are more efficient in resisting lateral loadsin multistoried buildings. Steel and reinforced concrete shear walls are kept in major positions of multi storied buildings which are made in consideration of seismic forces and wind forces. To solve this purpose shear walls are a very powerful structural elements, if used judiciously can reduce deflections and stresses to a very great extent. Our project contains a brief description of building with shear wall and without shear wall thoroughly discussed structural analysis of a building to explain the application of shear wall. The design analysis of the multi storied building in our project is done through STAAD-PRO, most popular structural engineering software. It is featured with some ultimate power tool, analysis and design facilities which make it more users friendly.

[2] Basant Khare & Kavita Golghate [2020]: The most important objective of this study is to the behavior of the structure in high seismic zone IV and also to evaluate Storey overturning moment, Storey Drift, Lateral Displacement, Design lateral forces. During this purpose a 10 storey-high building on four totally different shapes like Rectangular, C- shape, H-shape, and with shear wall without shear wall are used and also used alternative shear wall with glass frame as a comparison. The complete models were analyzed with the assistance of STAAD.Pro 2015 version. In the present study, Comparative Dynamic Analysis for all four cases have been investigated to evaluate the deformation of the structure. Results & Conclusion: The results indicates that, building with severe irregularity produces more deformation than those with less irregularity particularly in high seismic zones. And conjointly the storey overturning moment varies inversely with height of the storey. The storey base shear for regular building is highest compare to irregular shape buildings. We can say finally shear wall reduce all forces as well as we can adopt C-type of building with alternative shear wall.

[3] Yash Joshi et.al [2019]: Frame structural system also known as dual structural system, such type of buildings behaves very well when exposed to seismic forces. Commonly shear wall are provided up to the full height of building. From the past research it is found that the effect of shear wall in top most storey in resisting horizontal load is very less most of the load is taken care by frame. Therefore removing shear wall from top most storey doesn't effects seismic performance of building. Five different cases of shear wall in building are considered in this study. Variation in shear wall thickness and curtailment are considered for twenty storey building. Dead load and gravity loads are applied on the building as per IS codes and response spectrum method of dynamic analysis is carried out. Responses of models are compared for seismic parameters like displacement, time period, axial force in columns.

[4] Patil S.S. and Sagare S.D. [2018]: Investigation on Symmetrical models of plan dimensions 9m x 22.5m considered with no. of stories 20 with following conditions as model-01 (Bare frame without any lateral load resisting system), model-02 (soft storey frame with brick infill at upper storey), model-03 (soft storey at bottom changed by adding brick infill at the all corners and the shear wall as a lift at the central core), model-04 (shear wall at corners instead of brick infill and central lift) and all models has been analysed with same properties and similar loading conditions. On the basis of results analysis carried out to find variation of period for various models and variation of displacement of different models at various storey level due to earthquake force. Hence it has been concluded that upto model-04 there is almost 150% variation in frequencies and displacement with storey height increases and with different conditions of model displacement decreases as in model-01, 02, 03 & 04.That shows the role of shearwall and different infill condition evaluate behavior of soft storey.

[5] Israa H. Nayel, Shereen Q. Abdulridha, Zahraa M. Kadhum (2018) study checking the drift ratios help us state the deflections and story drifts are forcefully changed due to the increase in the height of the building. It is observed that displacement in building are greater in the top stories and lesser in the bottom stories. Displacement varies in each model for every corner shear wall, internal shear wall and side shear wall. The stiffness are increasing in the first storey with shear wall in corner (L-shape) other than floating columns without shear wall. As for safety, visually shear wall building has shown the best behaviour; however, its installation in building having lesser height is no economically accepted. It is clearly shown the building with shear wall system worked well in case of corner than in other models building, difference is stated in higher stories of the building, so it is may be recommended. This study covers the performance of multisory floating column building with and without shear wall in various positions and according to the earthquake excitation. The analysis of response spectrum is achieved, and it has been concluded that the maximum storey drift values and shifts are becoming larger for the floating column. The results represented that the base shear increased in case of core center shear wall in building when compared with another models which were considered in the present study.

[6] G. Vimalanandan and Dr. S. Senthilselvan [2017]: study on A thirty storeyed symmetrical building has been studied and models are characterized by ductile shear wall with special RC moment resisting frame (SMRF) with shear wall at the edges and central lift core. Six different models are generated with the provision of shear wall up to 100%, 90%, 80%, 70%, 60% & 50% of total height of building, rectangular plan with 25m X 20m is considered with 5 bays and 4 bays in x and z direction. Analysis of six different models were performed based on displacement, storey drift, bending moment, shear force and axial forces which are presented under same properties and similar loading conditions and result computed on behaviour of building model due to symmetrical nature of building. Modeled structures bearing both horizontal and gravity load under combined action of beam, columns & shear wall system with maximum base shear at the bottom hence models shows there is almost 70% contribution of shear wall and 30% contribution of balance part of framed structure to resist maximum base shear amongst all six models in which analysis has been carried out. Second thing lateral displacement compared to full height of shearwall,2.1% decreased in model in which shear wall curtailed from top single storey similarly decreased 3.4%,2.2%,1.7%,8.1% when shear wall has been curtailed from top second, third, fourth & fifth storey of the structure hence total 80% less displacement has been shown as compared to full height of the structure. As per above displacement of the building storey drift computed which falls in permissible limit of 0.004 times of storey height among all models with various shear wall curtailed conditions.

[7] Govardhan Bhatt and Abhyuday Titiksh, [2017]: Reviewed an analytical study has been carried out to know behavior of medium rise structure subjected to seismic loading. Six models were prepared by terminating the shear walls at intermediate stories and then analyzed using RSA. For that model of plan dimension 25m x 25m,ten storey & 200mm thick shear wall throughout height has been taken and shearwall curtailed for each model from top single storey in each case hence in last model there is shear wall eliminated upto half storey height all models has been analysed under same properties and similar loading conditions and results computed on the basis of parameters as storey displacements, drift and maximum shear of the structure. On completion of above steps this is recognizing that at the level of curtailment, storey drift was increased by almost 40%, floor displacement was increased by 15%, storey forces near the bottom floors got decreased by almost 25% and stiffness was reduced by almost 90%.

[8] Dr. S. B. Shinde and N.B. Raut, [2016]: In this study on “They performed seismic analysis of G+24 model for different thickness of wall as 100mm,150mm,200mm,250mm and 300mm.In each and individual model they curtailed shearwall in each interval of five storey from top of model as G+24(full shearwall),G+19(Curtailed five storey from top),G+14(Curtailed ten storey from top), G+9(Curtailed fifteen storey from top), G+4 (Curtailed twenty storey from top) with keeping thickness same in each model & shear wall placed along central core and all four corners..Same procedure has been followed for different thickness as mentioned above under similar properties and loading conditions.They computed deflection ,drift storey & storey shear with the help of this parameters,this has been analysed that shearwalls at corner substantially reduces the displacement due to earthquake,lateral drift and deflection of the structure and thickness of the shearwall is proportional to the stiffness of the structure, Curtailment and less thickness of shearwall increase the deflection of the structure.

[9] Ashwinkumar Balaso Karnale , Dr. D. N. Shinde (2015): In this study results found plotted to get actual behaviour of structure and to judge the objectives of study. The results and their significance discussed here briefly. From the graph of base shear for 6 storeys it clears that the base shear is maximum for model having shear wall at core of the structure. Base shear is least for structure without shear wall. When we increase the size of shear wall the seismic weight of structure increases and also the natural time period reduced so ultimately base shear increases. The graph of displacement reflects that for structure having core shear wall the displacement is least. The maximum structural displacement for 6 storey building is 0.0281m for bare frame structure and least value is 0.0107m for structure with shear wall at core location. The displacement observed is within the limits specified in IS 1893:2002 (Part I).

[10] R.S.Mishra, V.Kushwaha, S.Kumar (2015): In this study on analysis based on designed structure with various positional configuration of shear wall with respect to seismic load acting as calculated from STAAD.Pro software shows that, Intermediate position of shear wall is best suited with respect to core and periphery positions of the structure. The lateral displacement in X- direction and Z- direction is restricted more by the intermediately configured shear wall making building structure safe to shear failure. The Proportionate material requirement for the restriction of applied load safely; in the construction of building also shows the Intermediate configuration will be more economical than other with exception of steel in core and concrete in periphery position; but this could not retard structural buckling considerably. The shear wall make the structure safe by enhancing stiffness, ductility and reducing lateral and vertical drift of the storey at joints, which is due to direct reduction of displacement of member along the propagation of seismic force.

[11] Anila Anna Samson, Preetha Prabhakaran, Dr. Girija K (2014): In this study the seismic performance of the structure is determined on the basis of its damage state under 3 earthquake ground motion. The nonlinear response of structures is very sensitive to the structural modelling and ground motion characteristics. From the 3 time history analysis, the maximum displacement obtained for building with core type shear wall is 143.2357 mm and for building with L type shear wall is176.4972 mm. i.e, storey displacement is reduced when shear wall is provided as core type. Shear wall absorb more lateral force as the height of the building increased. Therefore, more systematic and complete parametric studies, considering different periods and different earthquake ground motions, will be required to establish definite criteria for efficient design of reinforced concrete special moment resisting frame system.

[12] U.L.Salve1 and R.S.Londhe [2014]: In this study on two Symmetrical Structures of 15-storey and 21-storey are analyzed to know response and behavior of the structure under different way of shear wall conditions with the same properties and similar loading conditions of framed structure system. They performed study on two symmetrical structure of different storey G+15 and G+21 with same plan dimension 18.5m x 18.5m to know the effective contribution of shear wall in different conditions. They analysed model of 21-storey in which first model of without shear wall, second with full height shear wall, third in which shear wall curtailed from top of single storey, fourth model in which shear wall curtailed from top of double storey, fifth model in which shear wall curtailed from top of third storey, sixth model in which shear wall curtailed from top of fourth storey, seventh model in which shear wall curtailed from top of fifth storey, eight model in which shear wall curtailed from top of sixth storey, same procedure has been applied for the 15-storey model to find out lateral displacement and storey drift comparison for all models. In terms of reactions in model's member as column's bending moment, displacement, shear.axial forces from the mentioned procedure in above statement they concluded following results as displacement in 15-storey model with full height of shear wall and verying height is only 0.5% and same for the other column's group. Similar displacement in 21-storey model as 0.5% also.Similarly on the basis of displacement drift computed 0.533 which is also falls on required limit hence there it has been seen that there is no significant increase in the value of axial forces,shear forces and bending moments for all the column groups since the shear wall is decreased upto considerable floors.Hence shearwall also can used upto 60% of total height of the structure.

[13] Shahzad Jamil Sardar and Umesh. N. Karadi (2013): In his study of experiment defined that this paper also deals with the Dynamic linear Response spectra method and static method on multi-storey shear wall building with variation in number and position of shear wall. Based on the analysis results they found that as per the analysis storey drift in the Model M2 is less than Model M1.For earth quake forces in X and Y direction i.e. EQX and EQY shows that Story Drift along Y is larger than along X for M2. Story drift in model M1 is larger than model M2 ,Story Drift due to SPECX and SPECY is along Y is larger than along X .also story drift in model M1 is larger than model M2 Story. Show that base shear obtained in response spectra in X is larger than Y i.e. (spec X > spec Y.) for both model M1 & M2 and also base shear obtain in Response spectra for M2 is larger than M1. Thus shear walls are one of the most effective building elements in resisting lateral forces during earthquake. By providing shear walls in proper position can be minimized effect and The seismic analysis of reinforced concrete frame structure is done by both static and dynamic analysis to determine and compare the base shear; it has been found that maximum base shear in model-5 along longitudinal and transverse direction as compared to the other models. In equivalent static analysis it has been found that model-5 shows lesser displacement as compared to other models in longitudinal direction. In response spectrum analysis model-5 shows lesser displacement as compared to other models in longitudinal direction. In equivalent static analysis it has been found that model-5 shows lesser interstorey drift as compared to other models in longitudinal direction. In response spectrum analysis model-5 shows lesser inter-storey drift as compared to other models in longitudinal direction.

IV. CONCLUSIONS

- Dynamic analysis of high-rise buildings with curtailed shear walls reveals significant differences in the behavior of symmetrical and unsymmetrical structures. Parameters such as axial force, node displacement, and base shear are influenced by the geometry and configuration of the structure.
- While curtailed shear walls offer material and cost savings, their impact on structural performance must be carefully evaluated. Future research should focus on advanced modeling techniques, experimental validation, and integration of smart technologies to address these challenges and improve the resilience of high-rise buildings.

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