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REVIEW-ANALYSIS AND DESIGN OF MULTISTOREY BUILDING BY CURTAILMENT OF SHEAR WALL

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Abstract: Shear walls are a critical structural element in high-rise buildings, providing resistance against lateral forces such as wind and earthquakes. However, the conventional design approach often extends shear walls continuously throughout the building height, which may lead to material overuse and unnecessary increase in construction cost. Curtailment of shear walls, i.e., strategic reduction in wall length or discontinuation beyond certain floors, offers potential optimization without compromising safety and serviceability. This review examines existing research and case studies related to shear wall curtailment in multi-storey structures. The focus lies on analyzing structural behavior, displacement control, base shear distribution, and cost efficiency under varying seismic zones. Various analytical methods, including finite element analysis in ETABS, STAAD Pro, and ANSYS, are reviewed. The study concludes that optimized curtailment can maintain performance while improving cost-effectiveness, provided careful evaluation of seismic demand, building height, and stiffness distribution undertaken.

Keywords: Curtailment of shear wall, Multi-storey building, Seismic analysis, Storey drift, Base shear, Optimization

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I.INTRODUCTION:

The demand for high-rise structures has increased significantly due to rapid urbanization, scarcity of land, and growing population in metropolitan areas. As buildings grow taller, their structural systems must be capable of resisting increased vertical loads as well as substantial lateral forces caused by wind and seismic activity. Among various lateral load-resisting systems, shear walls are one of the most effective and widely used solutions. They act as vertical cantilevers, resisting horizontal forces through their in-plane shear and bending stiffness, thereby reducing lateral deflections and enhancing overall stability. Traditionally, shear walls are provided continuously from the foundation to the roof level to ensure maximum stiffness and strength. While this approach provides excellent seismic and wind resistance, it also results in increased structural weight, higher material consumption, and higher construction costs. Moreover, in upper storeys of a building, the magnitude of lateral forces reduces considerably due to reduced seismic mass and wind pressure. This creates an opportunity for structural optimization by discontinuing or reducing the shear wall after a certain height—a concept known as curtailment of shear wall.

Curtailment of shear wall refers to the intentional termination or reduction of the shear wall at a particular floor level while maintaining the structural safety, serviceability, and performance criteria of the building. The primary objective of this method is to achieve material economy, cost efficiency, and architectural flexibility without compromising the building’s lateral stability. The design philosophy relies on the fact that lateral stiffness requirements are not uniform throughout the height of the building. In seismic design, the performance of a curtailed shear wall structure is evaluated by key parameters such as storey drift, storey displacement, base shear, time period, and mode shapes. Advanced software such as ETABS, STAAD Pro, and ANSYS are widely used to perform static and dynamic analyses on various curtailment schemes. Several researchers have reported that partial shear wall heights (typically 70–80% of total height) can produce nearly the same performance as full-height shear walls for medium-rise buildings, with substantial material savings.

However, improper curtailment may lead to stiffness irregularities, soft-storey formation, and increased lateral displacements, especially in high seismic zones. Therefore, a detailed analysis is necessary to determine the optimal curtailment level, considering the building height, seismic zone, structural system, and code provisions such as IS 1893:2016, IS 456:2000, and IS 13920:2016.

II.LITERATURE REVIEW

Review of Literatures-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.

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. 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.

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**.**

Patil S.S. and Sagare S.D. (2018) In this study Four 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.

1. **Israa H. Nayel, Shereen Q. Abdulridha, Zahraa M. Kadhum (2018)**

   In his 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.

2. **G. Vimalanandan and Dr. S. Senthilselvan (2017)**

   In this 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 ofbeam, 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 ofstorey height among all models with various shear wall curtailed conditions.

Govardhan Bhatt and Abhyuday Titiksh, (2017)

In this research 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 shear wall 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%.

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 shear walls at corner substantially reduces the displacement due to earthquake, lateral drift and deflection of the structure and thickness of the shear wall is proportional to the stiffness of the structure, Curtailment and less thickness of shear wall increase the deflection of the structure.

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).

3. **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.

4. **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.

III.CONCLUSION

From the previous studies the following conclusion drawn From the reviewed studies, it is evident that curtailment up to 70–80% of building height can yield nearly the same seismic performance as a full-height shear wall. Parameters such as storey drift, base shear, and roof displacement remain within IS 1893 limits, provided the curtailment is carefully planned. This directly translates into 10–20% savings in concrete and reinforcement, as well as reduced foundation loads due to a lower structural mass. In conclusion, the concept of shear wall curtailment presents a sustainable and cost-effective design alternative for multi-storey buildings. While its application has been validated in several research studies, wider implementation in practical projects requires the development of specific codal guidelines in IS 1893 and IS 13920 to standardize the method. With proper design, detailing, and analysis, curtailed shear wall systems can become a viable solution in the future of economical and efficient high-rise construction

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