Seismic Analysis of Multistorey Building with Different orientation of shear wall using ETABS

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Abstract: India's high population density necessitates high-rise buildings due to limited land. Past earthquakes have shown the severe impact on structures, making it essential to consider seismic effects when designing medium- to high-rise buildings for safety. This study analyzes the seismic performance of a 15-story (G+14) building in seismic Zone IV, focusing on how different shear wall placements affect stability and resistance to earthquakes. Four building models were tested: one without shear walls, and others with shear walls at the corners, periphery, and center. Using ETABS software and following IS 1893:2016 standards, each model was subjected to the same loading conditions and evaluated through response spectrum analysis. The study confirms that shear walls significantly enhance lateral stability, reducing lateral displacement and inter-story drift, with the best performance observed when shear walls are placed at the corners. This configuration offers optimal stiffness and strength, improving the building's resistance to seismic forces. The findings provide valuable insights for engineers and architects in designing earthquake-resistant structures to ensure higher safety in seismic regions.

Keywords: Multistorey Building, Reinforced Cement Concrete, Response Spectrum Analysis, Seismic Analysis, Shear Wall

I. INTRODUCTION

In today’s rapidly developing India, urbanization is occurring at an astonishing pace, accompanied by evolving construction designs and building types, especially during the high-growth period of recent decades. The current demands of urbanization have led to an increase in tall buildings. However, earthquakes pose a significant threat to these high-rise structures, making it crucial to prioritize their design to withstand seismic loads. This also necessitates setting vertical height limits above ground to address urbanization challenges effectively.

An earthquake occurs when two sections of the Earth’s crust suddenly slide past each other along a surface known as the fault or fault plane. The point below the Earth’s surface where the earthquake begins is called the hypocenter, while the epicenter is the point directly above it on the surface. Earthquakes may be preceded by smaller tremors called foreshocks, which occur in the same area as the main earthquake, though scientists cannot confirm an earthquake as a foreshock until after a larger quake happens. The largest earthquake in a sequence is called the mainshock, and it is often followed by aftershocks—smaller quakes that take place in the same region. Depending on the mainshock’s size, aftershocks may continue for weeks.

India’s latest Seismic Zoning Map, as per the Earthquake Resistant Design Code IS:1893:2016 (Part-1), divides the country into four seismic zones based on zone factors. Unlike earlier versions, which included five or six zones, India’s current zoning now has four zones: two, three, four, and five, with Zone 5 indicating areas of highest seismicity and Zone 2 indicating areas of lowest seismicity.

The aim of this study is to perform seismic analysis and design of a 15-story (G+14) building with shear walls placed at various locations, using the Response Spectrum Analysis method to assess story drift, displacements, and other parameters in seismic Zone IV. This analysis, conducted through the Response Spectrum method, evaluates story displacement, drift at support, base shear, stiffness, and shear force to deepen understanding of structural behavior as per Indian Standard Codes. Additionally, this study examines design parameters for beams, columns, slabs, and shear wall components, creating a 3D model using ETABS software. The objective is to provide detailed insight into the seismic performance of a building under earthquake loads.

II. LITERATURE REVIEW

In this study by Ashikur Rahman Simona et al (2023), the authors analyze the optimal placement of shear walls in a 10-story reinforced concrete (RC) building to minimize deflection and drift. Using ETABS software, the study models various shear wall locations, including at the center, sides, inner walls, periphery, corners, and center-edges. Results show that implementing shear walls reduces lateral displacement, story drift, and time period, while increasing structural stiffness. Notably, shear walls placed at the periphery demonstrated the best performance in controlling earthquake-induced drifts and displacements. Abhishek Mishra et al (2022) studied the impact of seismic forces on a G+20 building in seismic Zone IV, with a focus on the effect of shear walls. Using Bentley Staad Pro V8i software, the study analyzes key parameters—story drift, displacement, and base shear—comparing results for buildings with and without shear walls. Findings emphasize that shear walls, especially placed at the outer periphery, significantly reduce lateral forces and enhance the building's seismic resilience by resisting wind, earthquake, and other horizontal loads. The study underscores the importance of shear walls in mitigating drift and displacement in high-rise structures under seismic loads. CK Chandravansi et al (2022) examined the seismic analysis of multistory buildings with different slab configurations—conventional slab, flat slab with drop panel, and flat slab without drop panel—using ETABS 2016. Two building models, an eleven-story (G+10) and a twenty-one-story (G+20) structure, situated in seismic Zone IV (Patna), are analyzed according to IS 456:2000 and IS 1893:2016 codes, with M30 concrete and Fe-500 steel grades. The study focuses on key parameters such as story drift, displacement, and shear under seismic loads. By comparing the seismic performance across different slab types, the study identifies optimal structural configurations for improved earthquake resilience. Yashas Hiriyal M. & Roopanjali S. (2022) and Chintala Balakrishna & S.N. Saishanker (2022), seismic performance and design optimization of reinforced concrete (RC) shear walls in high-rise buildings were analyzed using ETABS. Yashas Hiriyal M. and Roopanjali S. focused on multi-story buildings over 15 floors, examining shear walls' ability to resist seismic and wind loads efficiently across various seismic zones (III, IV, and V). Despite limited updates in the Unified Building Code over the past 20 years, the study highlighted the importance of shear walls for lateral load resistance.

In the study by Chintala Balakrishna and S.N. Saishanker, a G+10 structure was analyzed to optimize the positioning of different shear wall types, adhering to the Limit State Design as per Indian Standards. The study emphasized the importance of assessing lateral drift and deflection under transient seismic loads, with the IS-1893:2002 standard guiding the analysis to determine the optimal shear wall configuration.

Asadullah Dost and Anil Kumar Chaudhary (2021) was analyzed on G+15, G+20 and G+25 in seismic zone IV and concluded that lateral stability trend was provided crucial importance to seismic resisting structures. Mohammad Qadeem Afghan et al (2020), reviewed the seismic response of a G+10 multi-story reinforced concrete (RC) framed building with different shear wall placements. Four models of the building were analyzed: one without shear walls and three with shear walls positioned at various locations. The study applied the Equivalent Static Method (Seismic Coefficient Method) and Response Spectrum Analysis to evaluate the seismic performance of these models. The results aimed to determine the optimal placement of shear walls for better earthquake resistance.

III. METHODOLOGY

The study considers a G+14 multi-story building with four different models: one without a shear wall and three with shear walls at different locations. All models have the same dimensions and geometry. Table I in the study provides a comprehensive overview of the critical parameters and characteristics of the building models, including details on the location, dimensions, material grades, and specific structural elements used in the analysis. In this study we determine the parameters like storey displacements, storey shear, storey drift and base shear the following seismic analysis method will be adopted for the analysis purpose using Response spectrum method.

Table I: Geometry of Building

Type of frame	R.C.C Frame
Type of Structure	Multistorey Residential Building
Geometry of Building	Symmetrical
Number of storeys	G+14
Total Height of Building	52.5m
Dimension in X-Direction	25m
Dimension in Y-Direction	25m
Size of Building	25x25m

Storey Height	3.5m
Slab Thickness	150mm
R.C.C Beam Size	300x450mm
R.C.C Column Size	450x450mm
Thickness of Shear Wall	200mm
Type of Wall	Bricks Masonry
Thickness of wall	230mm
Grade of Concrete	M-30
Grade of Steel	Fe-415
Method of Analysis	Response Spectrum Analysis

Four models having the same number of floors with G+14 having the same floor plan of 25 m x 25 m are considered for the study, in which three models having same thickness of shear wall 200 mm in all models except Model 1. The building floor height was considered 3.5 m for all the floors. Data-based modelling of the structure has been done using the structures software ETABS 2021 with different load conditions mentioned in Table II.

- Model 1 – Building without Shear Wall
- Model 2 – Building with shear wall at corner
- Model 3 – Building with shear wall at Periphery
- Model 4 – Building with shear wall at center

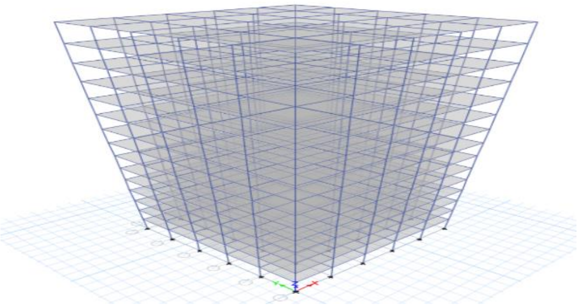

Fig. 1: Model 1 Building without Shear Wall

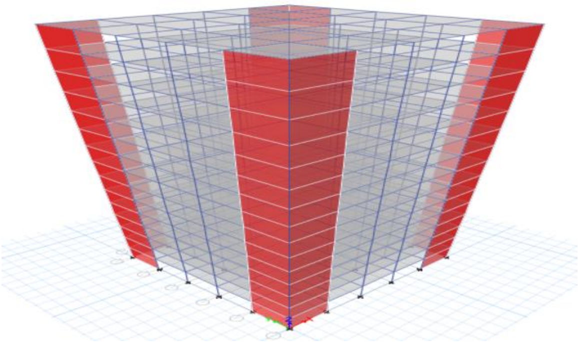

Fig. 2: Model 2 Building with shear wall at corner

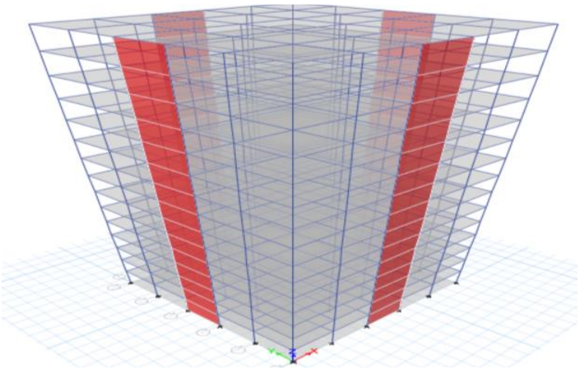

Fig. 3: Model 3 Building with shear wall at Periphery

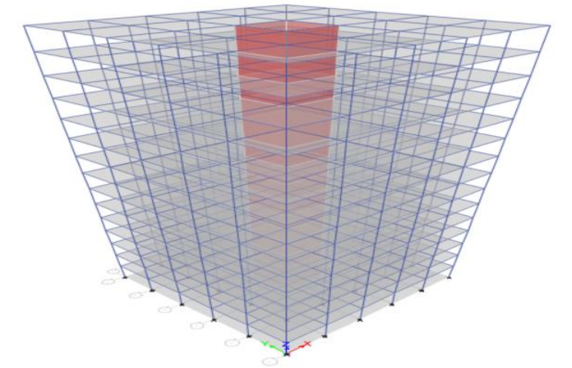

Fig. 4: Model 4 Building with shear wall at center

Table II: Load Combination

S.No	Load Combinations
1	1.5(D.L + L.L)
2	1.2(D.L + L.L + Ex+)
3	1.2(D.L + L.L + Ex-)
4	1.2(D.L + L.L + Ey+)
5	1.2(D.L + L.L + Ey-)
6	1.5(D.L + Ex+)
7	1.5(D.L + Ex-)
8	1.5(D.L + Ey+)
9	1.5(D.L + Ey-)

IV. RESULTS AND DISCUSSION

The four building models are analysed in ETABS and data are extracted in forms of Storey Drift, Storey Displacement, Storey Shear and Base Shear. After designing four different models with shear wall at different location in ETABS by using Reponses Spectrum Analysis with all the load combinations and generate the result. All the building models present different locations of Shear Wall. Further results on each parameter can be summarized as follows.

Table III: Model 1 Data Analysis

Storey	Storey Displacement (mm)	Storey Drift	Storey Shear (KN)
Storey15	59.822	0.00042	298.9533
Storey14	58.680	0.00063	576.2047
Storey13	56.980	0.00083	789.2413
Storey12	54.725	0.00098	948.7784
Storey11	51.962	0.00111	1076.9662
Storey10	48.744	0.00121	1186.7223
Storey9	45.110	0.00130	1281.5707
Storey8	41.093	0.00137	1367.2339
Storey7	36.713	0.00145	1451.3490
Storey6	31.984	0.00152	1535.3797
Storey5	26.916	0.00158	1617.7741
Storey4	21.521	0.00165	1702.2262
Storey3	15.811	0.00171	1790.3157
Storey2	9.847	0.00169	1866.2193
Storey1	3.948	0.00112	1903.3228
Base	0	0	0

Table IV: Model 2 Data Analysis

Storey	Storey Displacement (mm)	Storey Drift	Storey Shear (KN)
Storey15	39.888	0.000709	615.3463
Storey14	36.844	0.000727	1148.4392
Storey13	33.736	0.000742	1521.1709
Storey12	30.569	0.000754	1783.5281
Storey11	27.352	0.000760	1984.6458
Storey10	24.104	0.000759	2156.5400
Storey9	20.852	0.000750	2318.7385
Storey8	17.630	0.000730	2486.7109
Storey7	14.481	0.000700	2668.4144
Storey6	11.453	0.000656	2859.8947
Storey5	8.606	0.000597	3051.2964
Storey4	6.010	0.000519	3232.5042
Storey3	3.746	0.000421	3388.6788
Storey2	1.910	0.000297	3497.9531
Storey1	0.612	0.000140	3545.2333
Base	0	0	0

Table V: Model 3 Data Analysis

Storey	Storey Displacement (mm)	Storey Drift	Storey Shear (KN)
Storey15	46.256	0.000845	539.3993
Storey14	43.493	0.000893	969.1025
Storey13	40.593	0.000943	1256.246
Storey12	37.535	0.000992	1457.1085
Storey11	34.301	0.001036	1606.7924
Storey10	30.895	0.001071	1726.081
Storey9	27.334	0.001096	1836.4189
Storey8	23.648	0.001107	1954.2743
Storey7	19.882	0.001103	2087.2634
Storey6	16.097	0.001076	2236.1113
Storey5	12.378	0.001018	2392.1734
Storey4	8.837	0.000921	2542.7455
Storey3	5.62	0.000772	2676.6525
Storey2	2.913	0.000557	2775.5535
Storey1	0.956	0.000256	2819.1372
Base	0	0	0

Table VI: Model 4 Data Analysis

Storey	Storey Displacement (mm)	Storey Drift	Storey Shear (KN)
Storey15	45.954	0.000997	536.4177
Storey14	42.614	0.001037	988.0136
Storey13	39.115	0.001058	1292.6677
Storey12	35.565	0.001078	1484.285
Storey11	31.944	0.00109	1610.3995
Storey10	28.274	0.001092	1716.0898
Storey9	24.585	0.001082	1828.6483
Storey8	20.91	0.001059	1956.4997
Storey7	17.293	0.001021	2100.5839
Storey6	13.788	0.000964	2262.2234
Storey5	10.464	0.000884	2438.9984
Storey4	7.401	0.000778	2616.7345
Storey3	4.7	0.000639	2770.1236
Storey2	2.48	0.000465	2874.2682
Storey1	0.879	0.000251	2918.6374
Base	0	0	0

Table VII: Base Shear Comparsion

S.No	Building Models	Base Shear (KN)
1	Model 1	3333.2237

2	Model 2	3914.2731
3	Model 3	3696.3795
4	Model 4	3623.7484

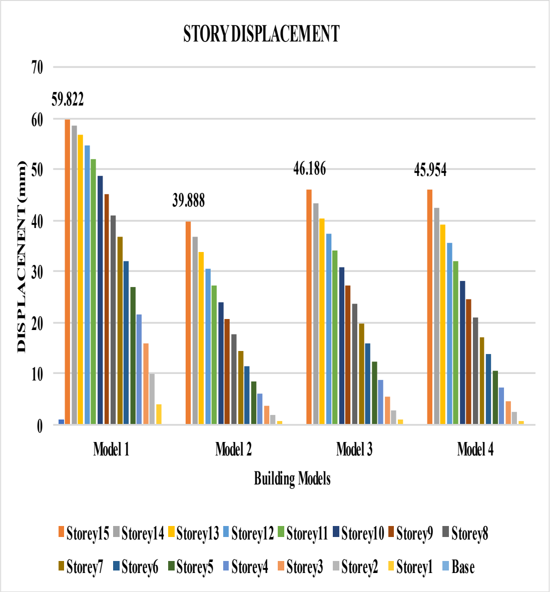

Fig. 5: Graphical Comparison of Storey Displacement of all Models

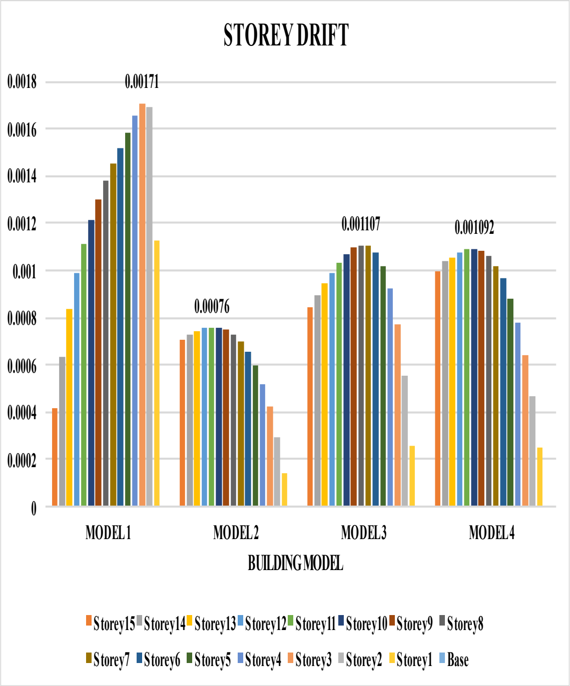

Fig. 6: Graphical Comparison of Storey Drift of all Models

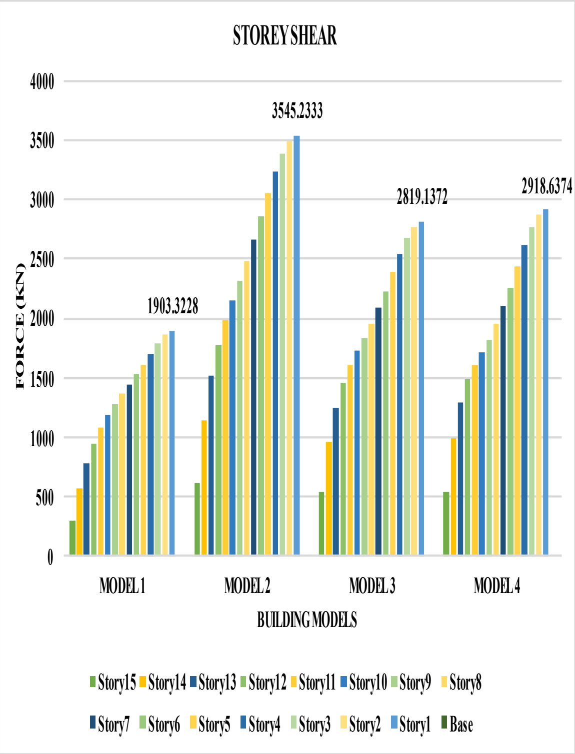

Fig. 7: Graphical Comparison of Storey shear of all Models

V. CONCLUSIONS

The findings underscore reveals significant differences in performance and structural behaviour under seismic loading and enhancing the lateral stability and overall resilience of structures subjected to seismic forces it has been concluded that:

1. Shear Wall Placement and Stiffness: The building with shear walls placed at the corners offers better stiffness during seismic events, providing a more stable and predictable response, enhancing occupant safety and comfort.
2. Storey Displacement: Buildings with corner shear walls experience 33% less lateral displacement compared to those without shear walls. Displacement reduction is 22% for shear walls at the periphery and 23% at the center, with corner placement being the most effective in reducing displacement.
3. Storey Drift: The storey drift decreases by 55% when shear walls are placed at the corners, compared to a 35% reduction at the periphery and 36% at the center, indicating that corner placement offers the best seismic performance.
4. Storey Shear and Base Shear: The storey shear and base shear increase when shear walls are included, due to the additional weight of the shear

wall, which affects the building's overall structural load.

5. Performance Comparison: Buildings with corner shear walls show superior lateral stiffness and stability. Shear walls help reduce lateral displacements and inter-story drift, essential for maintaining structural integrity during earthquakes.
6. Optimization of Shear Walls: Placing shear walls at corners optimizes design efficiency by improving structural performance while reducing material use, making the structure safer and potentially more cost-effective.

Summary of all conclusions indicate that Model 2 Shear wall at corner provides best results in all criteria among all models.

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