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Structural Analysis of Multistory Building with Shear Walls at different Locations using Various Methods

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***Abstract*— This work examines how modifying the position of the load-resisting wall affects the overall behaviour of a high-rise RCC building when acting under earthquake resultants. A G+13-storey building is used as the study model, and four varied arrangements of shear walls are examined. In every case, care is taken to ensure that the centroid of the structure is thereby minimised, thereby minimising twisting effects. The structure is idealised as a framed system and analysed using ETABS software. To understand how each configuration performs, responses such as floor displacement, inter-storey drift, lateral force demand at the base, and overturning effects are closely observed and compared. Both a bare frame condition and models incorporating shear walls are included to clearly identify the offering of shear walls to the structural response. The construction is considered placed in a severe earthquake-prone region (Zone V) resting on medium soil conditions as per IS 1893 (Part 1):2016. Calculate the actual seismic response of the structure; both response spectrum analysis along with time history analysis analysis are employed this study.**

***Index Terms*— Location of shear walls, Seismic analysis, Storey drift, Base shear, ETABS.**

I. INTRODUCTION

The load resisting wall are generally used in RCC multi-storey buildings to provide stability against the lateral forces and limit sideways movement caused by wind and earthquakes. Even so, fixing their exact location within a building is a critical design decision. The way a shear wall performs is closely linked to where it is placed, and an unsuitable position can reduce its ability to control lateral forces, even if the wall itself is well designed.

The shear wall main purpose is architectural requirement and structural safe. The shear wall is office flexible space and opening also appropriate plasing of column. It is most important in high rise structure and seismic forces are significant. The structural system has to be anaylase with help of India stand code.

A. Methods of Analysis

The Various Methods for Analysing RCC Buildings

- Linear Static Analysis
- Response Spectrum Analysis
- Time History Analysis
- Pushover Analysis

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II. Literature Review

Tarun Madgendra, A.A.Qureshi, Abhyuday Titiksh [1]-used shear wall systems because the most practical lateral load-resisting mechanisms which is available. This is a research to study and find the most suitable structural layout of a multi-storey building, mainly changing locations of shear walls. As the zone lowers, there is a greater chance of earthquakes. In these situations, using shear walls becomes important in ensuring structural safety.

Shubham R. Kasat, Sanket R. Patil, Akshay S. Raut [2]—studied and analysed 18-storey structure which does not include any shear walls, using the Equivalent static method for earthquake zone 3. The primary aim of this study the overall building response and also the key response limit like storey displacement, storey drift, and base shear. The results reveal that presence of shear wall improves overall structural response under seismic loading. Due to the increased lateral stiffness provided by the shear wall, beams and columns can be designed with smaller and economical sizes, resulting in a more economical structure.

Lakshmi K.O, Prof. Jayasree Ramanujan, Mrs Bindu Sunil [3]- Research was conducted on performance of buildings under lateral forces by comparing key structural components like storey drift and storey shear, overall deflection to columns. The study showed the importance of shear wall locations on these response parameters, which was examined using linear as well as nonlinear analysis methods. To evaluate the expected seismic performance in structure, pushover analysis was performed by estimating strength and deformation demands corresponding to design-level earthquakes."

Y. Verma ,R. Debbarma [4]- "The study examines the seismic response of a RC building incorporating shear walls by including soil–structure interaction. Particular attention is given to clayey soil conditions commonly encountered in practice, including soft, medium, and hard clay. All structural models are analysed in accordance with the provisions of IS 1893:2016. For comparison purposes, a fixed-base G+10 storey reinforced concrete building is also analysed. The results clearly show that neglecting Soil–foundation interaction leads to an overestimation of the structural response under seismic loading."

Abdelhacine Gouasmia Kamel Djeghaba [5]- This study focuses on evaluating the influence of soil–structure interaction on the modal properties and dynamic behaviour of structures. A series of parametric analyses is carried out to examine the effects of soil layer stiffness, depth, and dominant frequency, along with the frequency content of the input ground motion, on overall structural response.

Dr. Abdulamir Atalla Almayah, Rahman G. Taresh [6]- Utilising time-history analysis, multi-storey concrete buildings subjected to seismic activity are examined. For various shear wall locations, base shear and floor displacements are investigated. The use of shear walls in concrete structures enhances their rigidity. The location of shear walls influences how the formation responds to seismic weight. For every building, a comparison of the findings from the static and dynamic analyses has been done.

III. Methodology

A G+13-storey reinforced concrete (RC) building was analysed to examine effect of shear walls location seismic performance. Four analytical structural models are developed with the help of ETABS software. The first model represents a bare moment-resisting frame (MRF), while the remaining models incorporate shear walls located at the building corners, along the mid-sides of the perimeter, and around the central core.

Seismic performance of the building was examined using ETABS as the analytical platform. Both response spectrum analysis, time history analysis were performed provisions of in accordance with IS 1893 (Part 1):2016, thereby capturing the dynamic behaviour of structure during seismic excitation action realistically and reliably. All seismic evaluations in this study were carried out assuming medium soil conditions (Soil Type II), and this assumption was consistently maintained for all structural models considered.

A. Building Description

TABLE I. DESIGN DIMENSIONS AND PARAMETERS

SR.	Specifications	Size
1.	Dimension	25X25 m
2.	X-Axis length	25 m
3.	Y-Axis length	25 m
4.	Height of slab	3.3 m
5.	Ground floor level	3.3 m
6.	Overall height	42 m
7.	thickness of floor slab.	150 mm

8.	Building structural system	OMRF
9.	Soil profile	Medium soil (Soil type II)
10.	Response reduction factor (RF)	5
11.	Important factor	1.2
12.	Zone factor(Z)	0.36
13.	Time-history	0.69
14.	Concrete grade	M40
15.	Grade of steel	Fe 500
16.	Plinth floor level beam dimension	300 mm × 600 mm
17.	Beam cross-section	300 mm x 600 mm
18.	Column dimension	600 mm x 600 mm

(Table I) The present study considers six different RC building models with G+13 storey configuration. Each building model is developed with a constant plan area 625 m² and typical height of slab 3.3m giving an overall building height 42.0m. All structures are modelled as reinforced concrete moment-resisting frame systems. The slab thickness is taken as 150mm while the external and internal wall thicknesses are assumed as 230 mm and 150 mm, respectively. Concrete of M30 grade, fe500 grade of steel are used throughout this analysis. The beam sections are modelled with dimensions of 300 mm(width) × 600 mm(depth), and the column sections are modelled as 600 mm × 600 mm for all stores to maintain uniformity across all models. Loading conditions are assigned in accordance with as per IS 875 (Part 1) for dead loads and as per IS 875 (Part 3) for live loads. The superimposed dead load on the floor slab taken as 1.5 KN/m². The load due to external walls is considered to be 13.0 KN/m², while the internal wall load is taken as 9 kN/m². Imposed load considered as 2 kN/m² is applied Analysis is performed as india standard 1893 (part 1): 2016 for seismic zones. The corresponding zone factors are taken as 0.16 for zone III, 0.24 for zone IV and 0.36 for zone V. The importance factor is taken as 1.2 for all models, and 5.0 is assumed as response reduction factor. Medium soil condition (soil type II) is assumed for all seismic analyses.

B. Using load Combinations

101.1.5(LL+D.L+SDL)
201.(SDL+D.L.+LL)
301. 0.9(D.L+LL+SDL)
102.1.5(SDL+D.L+REX)
202.(SDL+D.L. +LL +REX)
302. 0.9(D.L+LL+REX)
103.1.5(SDL+D.L +REX)
203.(SDL+D.L.+LL -REX)
303. 0.9(D.L+LL-REX)
104.1.5(SDL+D.L +REY)
204.(SDL+D.L.+LL +REY)
304. 0.9(D.L+LL+REY)
105.1.5(SDL+D.L+-REY)
205.(SDL+D.L +LL -REY)
305. 0.9(D.L+LL-REY)
206.1.2(D.L.+SDL+LL+REX)
306. 0.9D.L+0.9SDL+1.5WX
207.1.2(D.L.+SDL+LL-REX)
307. 0.9D.L+0.9SDL-1.5WX
208.1.2(D.L.+SDL+LL+REY)
308. 0.9D.L+0.9SDL+1.5WY
209.1.2(D.L.+SDL+LL-REY)
309. 0.9D.L+0.9SDL-1.5WY

- DL (Dead load)- weight of structural member slab, beam, columns, walls.
- SDL(Super Dead Load)- Floor finishes, services.
- LL(Live Load)- Occupancy load due to people, furniture.
- REX/REY- Earthquake force along principle axes.
- WX/WY- Wind-induced force along principle axes.

- Gravity Load Combination

- 1.5(DL+SDL+LL)-This load combination is used for worst-case gravity loading and ultimate strength design. (DL+SDL+LL)-This load combination is used for the service load combination.
- 0.9(DL+SDL+LL)-This load combination are use for stability or uplift that is critical.
- Seismic load combination (Earthquake + Gravity)
- 1.5(DL+SDL ± REX / REY)-This load combination are use for safety under maximum seismic force.
- (DL+SDL ± REX / REY)-This load combination normal design codition are most commonly governing for the member.
- 0.9(DL+SDL±REX / REY)-Use this combination dead load to help resist overturning, and it is important for shear wall stability.
- Reduced load factor combination (IS 1893)
- 1.2(DL+SDL+LL ± REX / REY)-This load combination use probability that the full live load may not be present during an earthquake. It is important for seismic analysis in ETAB.
- Wind load combinations
- 0.9DL+0.9 SDL ± 1.5 WX / WY – This is the most critical combination for wind to find for overturning and uplift checks.

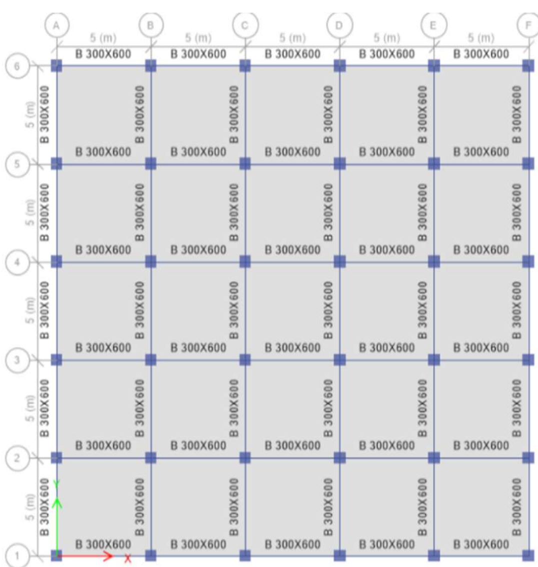
C. Codes and Standards

- Design and Detailing Provisions for Concrete Structures IS 456:2000
- Code provisions for seismic design based on IS 1893 (Part 1): 2016
- Code requirements for seismic ductile detailing of RC structures based on IS 13920:2016
- Indian Standard for Dead Load Determination 875 (Part 1)
- Provisions for Imposed (Live) Loads IS 875 (Part 2)
- Specifications for Wind-Induced Forces on Buildings IS 875 (Part 3)
- Code of Practice for Structural Safety of Tall Buildings IS 16700:2017. Reference [7], [8], [9] & [10]

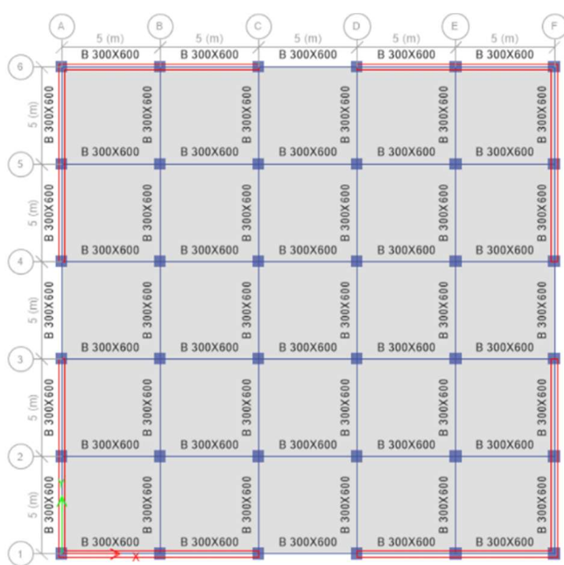
D. Type of Model

In this study, four different models (M) are listed below:
(M1) The building does not include shear walls
(M2) Corner-located shear wall configuration is adopted.
(M3) The building incorporates shear walls at mid-edge locations
(M4) The building incorporates a central core shear wall configuration

IV. ETABS MODELLING



Case 1



Case 2

Figure 1. Model-1 The building does not include shear walls   Figure 2. Model-2 corner-located shear wall configuration is adopted

Case 3

Case 4

Figure 3. Model 3 The building with shear walls at mid-edge locations.

Figure 4. M4 The building with central core shear wall

In this study, the ETAB floor slab is using shell elements with a uniform mesh, and the shear walls are divided into a size of 1 meter by 1 meter. This mesh are help for ensure adequate accuracy in stiffness distribution, stress variation and force transfer between structral element. mesh helps adjoining slabs and shear walls to prevent a break in continuity (Figures 1-4).
In the ETAB modal damping ratio is 5% was rated for reinforced concrete structural RCC, as per IS 1893(Part 1):2016 are granted. Boundary conditions are assigned to all structure member like column, beams, and floor slab are use to help ensure loads are transferred correctly and calculate displacements, drift, base shear and overturning moment.
In the time history analysis, earthquake records representative of seismic conditions commonly observed in Indian high-risk zones were considered. The chosen ground motion was adjusted so that its response closely followed the design spectrum specified for Zone V under medium soil conditions. A sufficiently fine time interval was adopted to ensure that rapid changes in structural response were properly captured during the analysis. The structural behaviour was then assessed by examining key response measures such as floor-wise displacement, inter-storey drift, overall base shear, and the resulting overturning moment.

V. Results and Discussion

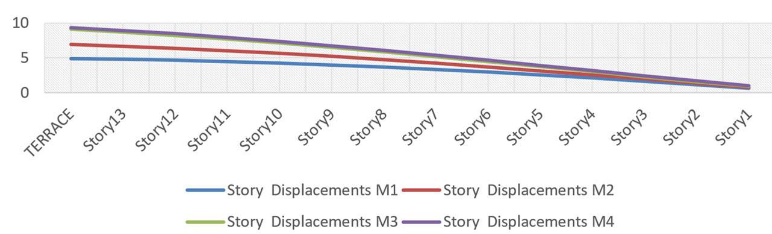


Figure 5. Storey Displacement

Figure 5 graphical representation of the storey displacement graph shows the mamimum dispasment in the floor during earthquake. The no-shear wall m1 model hase hight movement it is more flexiblr wower resistans to sismic force. Overall, although displacement increases towards the top in every model, the increase is more controlled in M4, showing better seismic behaviour. In the core shear wall model show 65% reducction in peak roof displacment.

Figure 6. Storey drift variation

Figure 6 presents the graphical representation of storey drift, illustrating how the difference in lateral displacement between adjacent storeys varies along the overall building height. Model (M1), which does not include shear walls, exhibits considerably higher storey drift. The introduction of shear walls leads to significant decrease in storey drift, with Model M4, incorporating a central core shear wall system, showing the lowest drift values.

Maximum relative storey displacement in the core shear wallconfiguration is reduced by approximately two-thirds compared to the frame-only structural system.

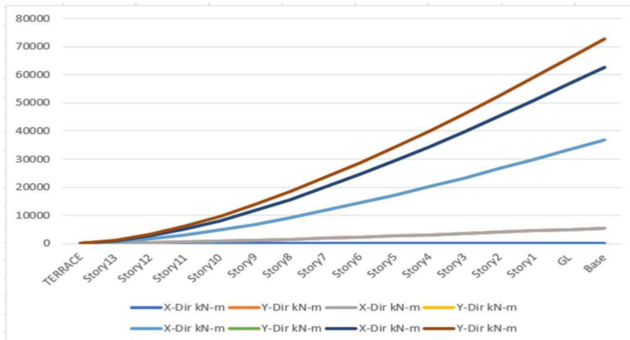


Figure 7. Overturning moment

Figure 7 presents the graphical representation of overturning moment variation. The overturning moment values increase progressively towards the base for all analytical models. However, structures with centrally placed shear walls exhibit improved resistance due to the effective transfer of lateral forces to the foundation. The base shear results indicate that models incorporating shear walls attract higher seismic forces, reflecting increased structural stiffness and enhanced load-resisting capacity. In all case, the corner shear wall are base shear highest it provide best lateral resistance forces.

TABLE II. BASE SHEAR (KN)

Model	EQX(kN)	EQY(kN)
M1	194.74	194.74
M2	1016.00	1016.00
M3	370.79	370.79
M4	854.68	854.68

Table II show the base shear vale of total earthquake forec transferred to the foundation.in the model M1 are in on shear wall the base shear vale is very less it make more flexibel and hight natural time period. This does not necessarily better sismic performanes according to is 1893.

In M2, the shear wall provide at corner of the buildig it highest base shear amoge all case. This case is a strong and efficient lateral load resistig force

In M3 model shear wall are icorporate at mid edge loaction as compare M1 is less than that of M2 and M4. It less effective in mobilistion overall lateral force.

In M4 center core shear wall provide more stiffness distribution, reduces torsional effect and controls storey displacement and drift.

VI. CONCLUSION

In the sismic analysis G+13 building RC strcture with bear frame, hase four modle M1,M2,M3,M4 using ETAB sofware. In all modle are assige the floor, beam, column and storey hight material properties are conditions and reliable comparison. The response analysis was carriey out with the help of india standard 1893 part 1 : 2016 for seismic zone, using medium type of soil condition.

In the model 1 are the most uniform seismic force with inter storey drift and story displacement along the hight if the building. The bare frame model M1 as compared with M2 is reduction storey displasment at upper floor. In the center core shear wall M4 are the most cnsistent improvement in story displacment reduced by 60-70% in bear frame. The maximum story drift in core shear wall are reduces by 65%. In the midedge shear wall provide typically range 30-40% of stiffness is improved as compared to the corener and core shear wall.

In all four model centrally location core shear wall M4 are offere the most effective of stability stiffness and control force demand. This enhance structal safety and efficincy without causing seismic forces.

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