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Seismic Analysis of Multi-Storied Buildings with Even and Uneven Story Heights Under Symmetric and Unsymmetric Configurations

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Abstract
Seismic behavior for 15-story reinforced-concrete frame structures was examined on a variety of configuration geometries. The two buildings included in this study were G + 15 RCC frames One frame had a symmetrical floor plan and equal (even) story heights; the other frame had an unsymmetrical floor plan (unsymmetrical plan or irregular story heights) and was studied in ETABS 2018 using the Response Spectrum Method, per IS 1893:2016 (Zone IV). A comparison of key response characteristics, including total base shear, maximum displacement between stories, story shear and stiffness, in each direction X and Y, was conducted. The results indicated that the symmetrical, equal-height model exhibited the most beneficial seismic behavior. There is a more even distribution of drift, the torsional responses were minimal, and there is a more uniform distribution of overall stiffness and strength. The comparison of the results from the symmetric model and the unsymmetrical model showed exhibited poor responses to an earthquake. Our study found that the irregular case had increases in top-floor displacement of approximately 4-5% and increases in peak story drift of approximately 12% increases, when compared to the regular case. Thus, validating the use of response-spectrum analysis for comparative seismic evaluations of structures.

Keywords: Seismic Analysis, RCC Framed Buildings, Even and Uneven Storey Heights, Symmetric Design, Unsymmetric Design

Introduction
Seismic analysis is at the very core of structural engineering as it relates to multi-story structures, which are generally required to be extremely resilient in order to be structurally safe from earthquakes. Earthquakes represent a complex and dynamic process that is affected by numerous variables, including the geometric shape and material composition of the structure as well as the integrity of the structure's foundation. In addition to investigating the overall behaviour of the structure under the effects of an earthquake, seismic analysis also studies the influence of various structural configurations (such as symmetric vs. unsymmetric, even vs. uneven floor height) on the way a structure responds to seismic forces [1]. Many of the structural irregularities mentioned above can produce undesirable and magnified responses to earthquake-induced loading conditions for a structure. A symmetrical structure with equal floor height is considered to be the most desirable from a seismic standpoint [2]. The reason for this is due to the fact that the center of stiffness and the center of mass align in symmetrical structures therefore, seismic force is evenly distributed throughout the structure [3]. Due to the uniform distribution of seismic forces within a symmetrical structure, there is less of a tendency for stress concentrations to occur within specific structural elements, and there is less likelihood of torsion occurring.

Literature Reviews
Literature Survey
Seismic behavior of Reinforced Cement Concrete (RCC) framed buildings is an important topic of investigation in

structural engineering, especially in seismic hazard areas. Research in previous studies has evaluated the effects of building configuration, plan symmetry, and structural irregularity on the seismic response of RCC-framed buildings. Nikesh B. Lothe et al. (2023); this study evaluated the efficacy of various seismic design methods for ensuring the safety and durability of RCC-framed buildings in seismic activity by employing the Time History Method [1].

Ishaan Trikha et al. (2025); the study investigated two G+5-story RCC-framed buildings with regular rectangular floor plans (symmetrical) and L-shaped floor plans (asymmetrical) [2]. The study demonstrated that plan asymmetry enhances lateral seismic response; however, all of the critical parameters for the G+5 story RCC-framed building remain within permissible limits. Nabin Khanal et al. (2025); the study evaluated two G+4 (ground + four stories) reinforced cement concrete framed buildings in seismic zone IV, one with symmetrical design and another with asymmetrical designs [3]. Vikash Sangadiya et al. (2024); used STAAD Pro to analyze and design a hospital building. The study reported results for bending moment and displacements [4]. A comparison of the largest displacement and highest story drift was made among a group of three severely irregularly constructed buildings, including a T-shaped building. The objective as seismic demands of regular & irregular RCC studied using NLTHA was achieved. The impact of base isolators on symmetric & asymmetric buildings was demonstrated. Structural response evaluated under dynamic loads (Bhuj earthquake data). Kiran Devi et al. (2023); analyzed base shear increased as the seismic zone changed from Zone III to Zone V, showing that those areas experience stronger earthquakes [5]. The study objective was to compare the percentage of longitudinal steel, reinforcement details, and design base shear of a G+8-story reinforced concrete building across various seismic zones. The study results support the objective of showing how these factors vary with seismic intensity. Umer Fayaz et al. (2023); analyzed a hypothetical G+5 story reinforced concrete building subjected to seismic, wind, and live loads through ETABS [6]. The study objective was to evaluate a multi-story building subjected to earthquake-induced forces. Apurva M. Dhasade et al. (2022); provided a direct method of supporting the objective of analyzing structural performance under seismic loading [7]. The paper compares a conventional structure and a floating column structure, supporting studies such as analyzing story displacement, drift, stiffness, member forces, etc. M. T. Raagavi et al. (2021), presented The plan irregularities in buildings cause significant impacts on the seismic performance of buildings caused by the torsional effects and eccentricities [8]. Symmetric structures experienced the maximum base shear and displacement; however, they transferred loads uniformly to enhance safety. L-shaped structures exhibited the worst performance, especially at upper floors. O-shaped and regular structures experienced higher displacement values, while octagonal structures exhibited lower moment and beam end forces.

Literature Summary

• Unsymmetric and irregular buildings are more vulnerable to seismic forces. Several studies consistently found that buildings with irregular plans, such as L-shaped or T-shaped, and those with vertical irregularities like floating columns, experience greater storey displacement and drift compared to symmetric, regular buildings.
• Floating columns increase seismic vulnerability. Buildings with floating columns, which are often used for architectural purposes like creating open spaces, are more susceptible to seismic damage. Taller buildings with floating columns show more drastic changes in seismic response.
• Shear walls are a highly effective seismic strengthening measure. The addition of shear walls significantly improves a building's lateral stiffness and reduces lateral displacement and storey drift. In some cases, a building that would otherwise be unsafe in a high seismic zone becomes safe with the addition of shear walls.

Research Gap

A critical research gap is the limited application of Time History Analysis to evaluate the seismic performance of buildings, despite its recognized accuracy. Specifically, Figure 2: Plan view showing the column grid arrangement of the Unsymmetrical Structure there's a need for more studies using this method to analyze the structural response of tall buildings with varying heights by Response Spectrum Method.

Methodology

Model Development

• G+15 storey RCC framed building model was designed, developed and analyzed by two models using ETABS 2022.
• Model 1
• Floor Height: 3m
• Beam Size: 300mm x 690mm
• Column Size: 690mm x 690mm
• Slab Thickness: 150mm
• Concrete Strength Grade: M30
• Steel Strength Grade: Fe500
• Model 2
• Floor height : 3.3m
• Beam size: 300mm x 690mm
• Column size: 690mm x 690mm
• Slab thickness: 150mm
• Concrete Strength Grade: M30
• Steel Strength Grade: Fe500

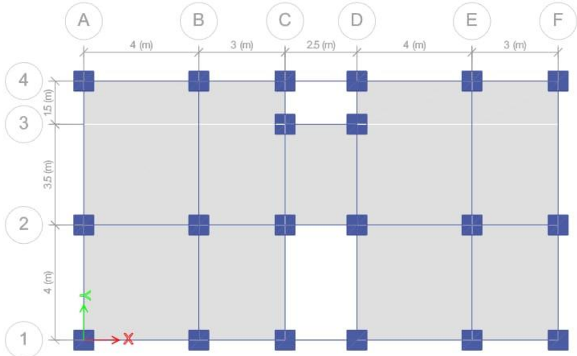

Figure 1: Plan View Showing the Column Grid Arrangement of the Symmetrical Structure

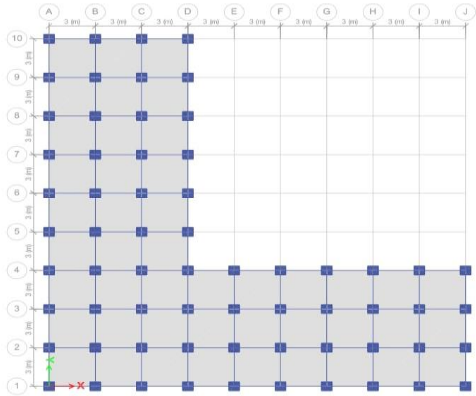

Figure 2: Plan View Showing the Column Grid Arrangement of the Unsymmetrical Structure

Loading Consideration

- Dead Load (DL), and Live Load (LL) applied in accordance with IS 875-1987 (Parts 1&2).
- Wind load (WL) applied in accordance with IS 875-1987 (Parts 3).
- Snow load applied in accordance with IS 875-1987 (Parts 4).
- Seismic loads generated using Equivalent Static method in accordance with IS 1893-2016.
- Zone: IV (Factor = 0.24)
- Importance factor(I): 1.0
- Response reduction factor: 5.0(SMRF)
- Soil Type: Medium (Type II)
- Damping: 5%
- Seismic loads applied in both X and Y directions (EQX & EQY).

Load Combinations

Load combinations defined in accordance with IS 1893 and IS 875(Part 5). For analytical purposes, focus was placed upon unfactored load combinations.

Result and Discussion

A comparative linear static seismic analysis was done in ETABS to compare the seismic performance of symmetric and unsymmetric reinforced concrete structures. The study was done based on the response spectrum method as outlined in IS 1893:2016. Four primary response parameters were examined for the evaluation of seismic behavior in the four storeys of the symmetric model and three storeys of the unsymmetric model: base shear, storey shear, storey drift, and storey displacement caused by the seismic loading in both the x- and y-directions (EQX and EQY).

Story Displacement

Maximum lateral displacement occurred at the top storey level with some variance between the two different models (symmetric and unsymmetric) in addition to the differences noted when comparing the three storeys of the unsymmetric model to the four storey levels of the symmetric model for longitudinal response spectrum loading.

Displacement in mm		
Storey	*Model 1*	*Model 2*
15	30.24	31.662
14	29.176	30.562
13	27.955	29.313
12	26.57	27.9
11	25.033	26.329
10	23.36	24.612
9	21.568	22.764
8	19.673	20.802
7	17.693	18.74
6	15.641	16.596
5	13.533	14.384
4	11.384	12.122
3	9.214	9.829
2	7.044	7.525
1	4.905	5.239
Ground	2.848	3.018
Plinth	1.012	1.007
Footing	0	0

Table 1: Story Displacement Values Under Symmetric and Unsymmetric Buildings

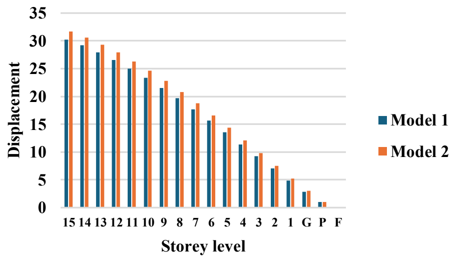

Figure 3: Displacement Along Longitudinal Direction

The unsymmetric model produced slightly larger lateral displacements than did the symmetric model. Top-storey displacement increased by 4.7%, to 31.662 mm (versus 30.24 mm) for the asymmetric model as opposed to the symmetric model for this loading case.

Story Drift

Storey drift represents another measure of storey-by-storey deformation resulting from seismic action. As expected, storey drifts tend to increase with increasing storey height; however, all measured drift values are less than those permitted in IS 1893:2016. Buildings with non-uniform storey heights or unsymmetrical configurations have higher drift requirements than do buildings with uniform storey heights and symmetrical configurations.

Story Drift in mm		
Storey	*Model 1*	*Model 2*
15	0.00024	0.000346
14	0.000294	0.000399
13	0.000352	0.000456
12	0.000405	0.000509
11	0.000452	0.000555
10	0.000492	0.000595
9	0.000527	0.000627
8	0.000556	0.000653
7	0.00058	0.000673
6	0.0006	0.000688
5	0.000614	0.000699
4	0.000624	0.000704
3	0.000628	0.000703
2	0.000626	0.000695
1	0.000612	0.000674
Ground	0.000568	0.000611
Plinth	0.000336	0.000336
Footing	0	0

Table 2: Story Drift Values Under Symmetric and Unsymmetric Buildings

The unsymmetry appears most pronounced in the middle of the building, which would indicate a greater effect of torsion on storey drift. The drift ratio for the unsymmetric configuration is approximately 12.1% larger than that of the symmetric configuration.

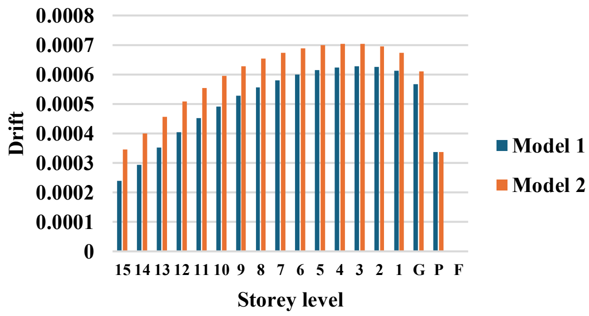

Figure 4: Drift Along Transverse Direction

Story Shear

Storey shears provide a representation of how seismic force is distributed through the building. The largest shear force occurs at the lowest level of the building and decreases as you move up through the building. For the unsymmetric models, the distribution of stiffness is uneven, therefore the unsymmetrical models produce larger shear forces in the lower storeys. This phenomenon occurred consistently through all the storeys of each model.

Story Shear in kN		
Storey	***Model 1***	***Model 2***
15	168.9757	437.6926
14	366.3729	963.0927
13	541.6589	1424.4725
12	695.1225	1821.6637
11	830.2823	2165.3848
10	950.706	2467.8929
9	1058.6594	2737.8946
S8	1156.0319	2981.981
7	1245.2117	3206.8574
6	1328.3471	3417.9873
5	1406.1503	3617.2831
4	1478.0335	3803.9529
3	1543.1581	3976.7374
2	1600.4505	4132.5446
1	1647.2735	4261.9838
Ground	1679.0114	4349.0962
Plinth	1687.9278	4371.7128
Footing	0	0

Table 3: Story Shear Values Under Symmetric and Unsymmetric Buildings

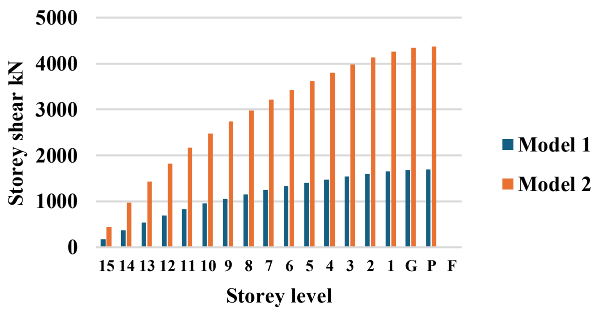

Figure 5: Storey Shear Along Longitudinal Direction

Base Shear

The base shear is defined as the total horizontal seismic load that is transferred from the structural system above the foundation during an earthquake. It is an important factor for evaluating the total horizontal forces acting on a structural system.

Model	Base Shear in Kn	
	EQX	*EQY*
Model 1	1687.9278	1687.9278
Model 2	4371.7128	4371.7128

Table 4: Base Shear Values Under Symmetric and Unsymmetric Buildings

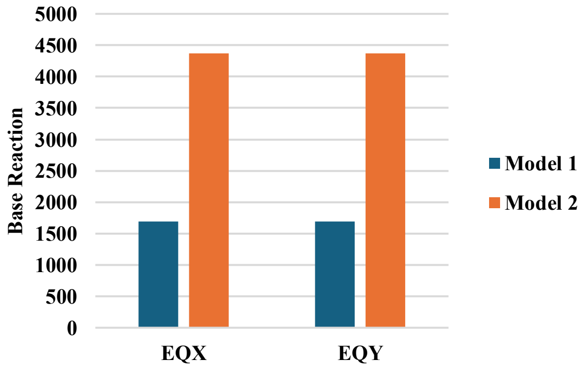

Figure 6: Base Shear of Models

Summary of Findings

Uniformly configured structures with symmetrical configurations perform better under seismic loads than do structures that have uneven storey heights and/or unsymmetrical configurations because they distribute seismic force and deformations more uniformly. Structures with uneven storey heights and unsymmetrical configurations will experience greater lateral displacements, greater storey drift, and greater torsional effects than will structures with uniformly configured and symmetrical configurations. The response spectrum method is effective in representing the modal behavior of structures and provides a suitable basis for comparing the seismic response of different structural configurations.

Conclusion

Using the ETABS software, investigated the response spectrum methodology as well as the static analysis approach for two distinct G + 15 building models. In evaluating the relative merits of each of the structural configurations analyzed, comparisons were made based upon key response parameters derived from the analyses; specifically, the responses included: Storey Displacement, Storey Drift, Storey Stiffness, Fundamental Time Period, and Base Shear. From the data collected, the conclude that: In both structural configurations evaluated, the lateral displacement increased progressively from the base of the structure to the top of the structure indicating an approximate linear relationship consistent with a static analysis. While plan unsymmetry can influence seismic behavior, the magnitude of this impact will be relatively small when considering high-rise structures in the context of seismic analysis. As such, it is extremely important to consider structural configuration early in the planning stages of construction, especially for structures sensitive to performance and located in areas subject to high levels of seismic activity.

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Author Contributions

Dr. Aasif M. Baig : Conceptualization, supervision, methodology, review, editing, and validation.

Mr. Sagar Ashok Tandekar : Data collection, modeling in ETABS, formal analysis, interpretation of results, manuscript drafting, and visualization.

Both authors read and approved the final manuscript.

References

1. Lothe, N. B., Bhadke, S. K., & Baig, A. M. (2024, December). Comparative study of even and uneven story height of high-rise structure by using time history analysis. In AIP Conference Proceedings (Vol. 3188, No. 1, p. 070010). AIP Publishing LLC.
2. Ishaan Trikha, (2025). "Comparative Seismic Analysis of Symmetric and Asymmetric RCC Buildings Using ETABS

Under Equivalent Static Method", International Journal for Research in Applied Science and Engineering Technology (IJRASET),.

3. Khanal, N. (2025). Seismic Analysis of Multi-Story RCC Framed Buildings with Symmetric and Asymmetric Design.
4. Vikash Kumar Sangadiya, Vinod Kumar Modi, "Evaluation of Seismic Demands in Symmetrical and Asymmetrical RCC Buildings with Rubber Base Isolator",India International Research Journal of Engineering and Technology (IRJET), 2024.
5. Kiran Devi, Subhankar Petal, (2023). "A Comparative Study on Seismic Analysis of Multistorey Buildings in Different Seismic Zones", Journal of Smart Buildings and Construction Technology,.
6. Fayaz, U. B., & Singh, B. (2023). A Study of Seismic Analysis of Building Using ETABS. International Journal of Innovative Research in Engineering and Management (IJIREM), 10(06), 11-15.
7. Apurva M. Dhasade, Krupanjali S. Bhange, Pratiksha P. Jadhav, Shweta S. Patil, Pooja L. Rathod, "Seismic Analysis of Multi-Storied Buildings with Floating Columns", International Journal of Creative Research Thoughts (IJCRT), 2022.
8. M. T. Raagavi , Dr. S. Sidhardhan. (2021). "Analytical Study on Seismic Performance of Plan Irregular Structures", Journal of Emerging Technologies and Innovative Research (JETIR).