
COMPARATIVE SEISMIC PERFORMANCE ANALYSIS OF REINFORCED CONCRETE MULTI-STOREY BUILDINGS WITH AND WITHOUT SHEAR WALLS BASED ON NBC 105:2020

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ABSTRACT

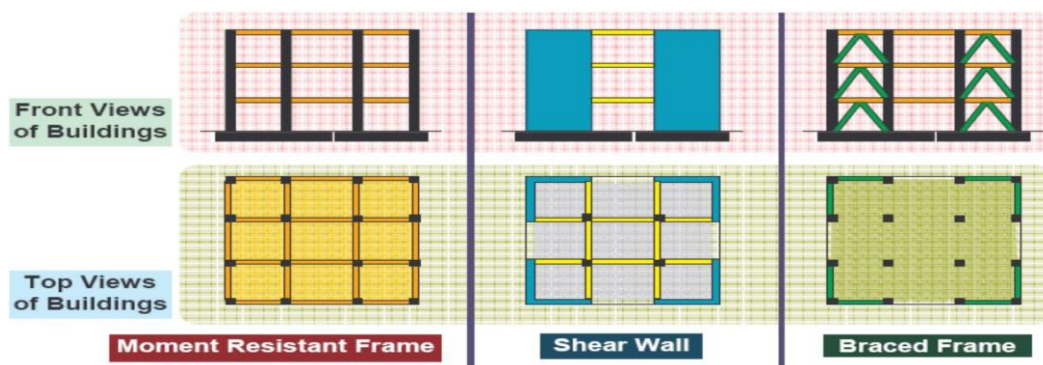
Earthquakes cause significant damage to reinforced concrete (RC) buildings due to inadequate lateral load resistance and structural stiffness. In seismic regions, improving the lateral stability of buildings through structural strengthening techniques is essential to reduce structural damage and loss of life. Shear walls are widely recognized as an effective structural system for enhancing the seismic performance of multi-storey buildings. This study investigates the comparative seismic performance of a G+9 reinforced concrete building with and without shear walls using the Equivalent Static Method in ETABS software in accordance with the Nepal Building Code (NBC 105:2020). Two structural models were developed: a bare RC frame model and an RC frame model incorporating shear walls. The seismic behavior of the structures was evaluated using key response parameters including storey displacement, storey drift, storey shear, base shear, stiffness, time period, and overturning moment. The results demonstrate that the incorporation of shear walls significantly improves the seismic performance of the building. The model with shear walls showed a substantial reduction in lateral displacement (approx. 78%) and storey drift (approx. 19.35%) while increasing overall structural stiffness and base shear capacity. The fundamental time period of the structure was also reduced, indicating improved lateral rigidity.

KEYWORDS: Seismic Analysis, Shear Wall, RCC Building, NBC 105:2020, ETABS, Story Drift, Story Displacement, Base Shear.

1. INTRODUCTION

The earthquake is one of the most powerful natural forces, capable of causing immense destruction to human-made structures. For engineers, the challenge lies in designing structures that can dissipate the massive energy released during ground motion while maintaining stability. In typical reinforced concrete (RC) buildings, gravity loads are effectively handled by the frame (beams and columns). However, as structures grow taller, lateral loads from wind and earthquakes become the primary concern. Without adequate lateral stiffness, buildings undergo excessive sway, which can lead to non-structural damage and eventually structural collapse.

Shear walls are specifically engineered to provide this critical lateral resistance. In multi-storey structures, they act as vertical cantilever plates, transferring horizontal inertia forces from floor diaphragms directly to the foundation. When properly integrated, they form a 'Dual System' where the shear walls provide the necessary stiffness to limit displacement, and the moment-resisting frame provides the ductility required to absorb energy. This research evaluates these structural benefits specifically under the recently updated Nepal Building Code (NBC 105:2020), providing a comprehensive technical comparison for a G+9 building configuration.



2. LITERATURE REVIEW

The study of shear wall efficacy has a rich history in structural engineering. Chandurkar and Pajgade (2013) conducted comparative seismic analyses across different seismic zones, concluding that shear walls significantly reduce top storey displacement, particularly when placed symmetrically within the building plan. Their research highlighted that the lateral stiffness provided by shear walls is indispensable for high-rise buildings subjected to intense

ground motions.

Sud et al. investigated various shear wall configurations (core, exterior bays, and centrally located), reporting that core shear wall systems offer superior torsional stability. In the context of the Nepal region, following the 2015 Gorkha earthquake, the emphasis on robust lateral systems intensified. The updated NBC 105:2020 introduced more rigorous seismic coefficient methods and importance factors, which this study utilizes to ensure current relevance for Nepalese urban construction.

3. THEORETICAL FRAMEWORK

The fundamental philosophy of earthquake-resistant design is to ensure that a building can resist minor earthquakes without damage, moderate earthquakes with minor non-structural damage, and major earthquakes without collapse. This is achieved through a combination of strength, stiffness, and ductility.

Structural stiffness is the resistance offered by the structure against deformation. Shear walls significantly increase this parameter. The load transfer mechanism involves the floor slabs acting as a rigid diaphragm, which collects the lateral forces and distributes them to the vertical elements (columns and walls) in proportion to their relative stiffness. Because shear walls are much stiffer than columns, they attract the bulk of the seismic forces, thereby protecting the frame members.

4. METHODOLOGY

The methodology involves comparative finite element modeling using ETABS. A G+9 RC building with a plan area of 15m x 15m is considered. The building consists of 3 bays of 5m each in both horizontal directions.

4.1 Structural Member Details

- Beam Size: 350mm x 500mm
- Column Size: 500mm x 500mm
- Slab Thickness: 150mm
- Shear Wall Thickness: 230mm (located at corner bays)

4.2 Seismic Parameters (NBC 105:2020)

- Seismic Zone Factor (Z): 0.35
- Importance Factor (I): 1.0 (Residential/Commercial)
- Soil Type: Type D (Soft Soil as per site conditions)
- Response Reduction Factor (R): 4.0

[INSERT DIAGRAM 2: 3D Visualization of the ETABS Models (Bare Frame Model vs. Dual System with Shear Walls)]

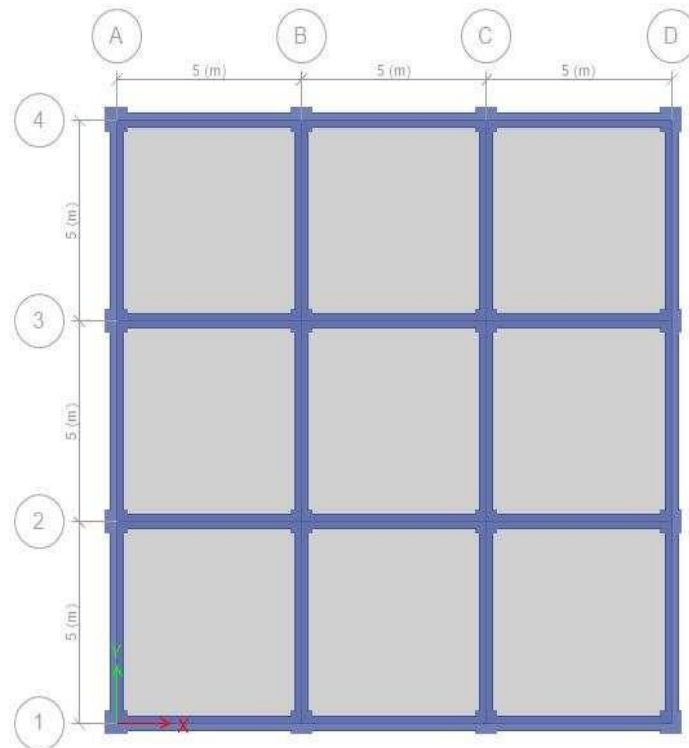
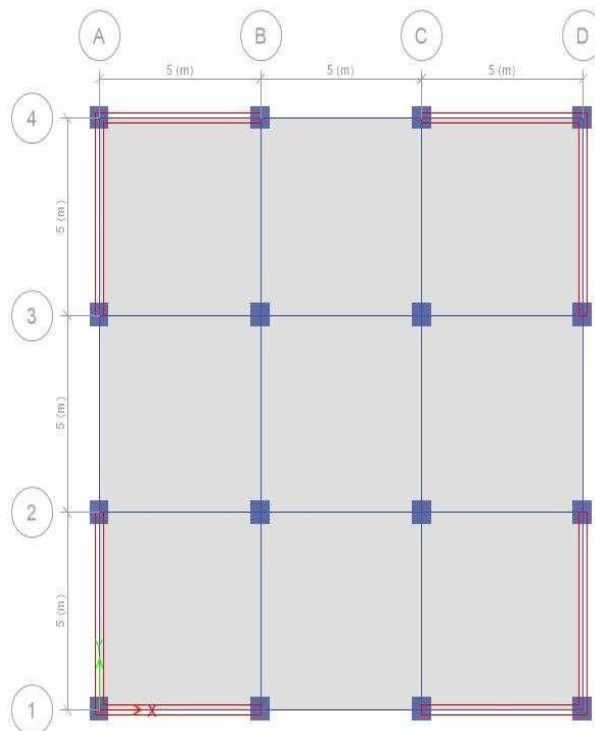
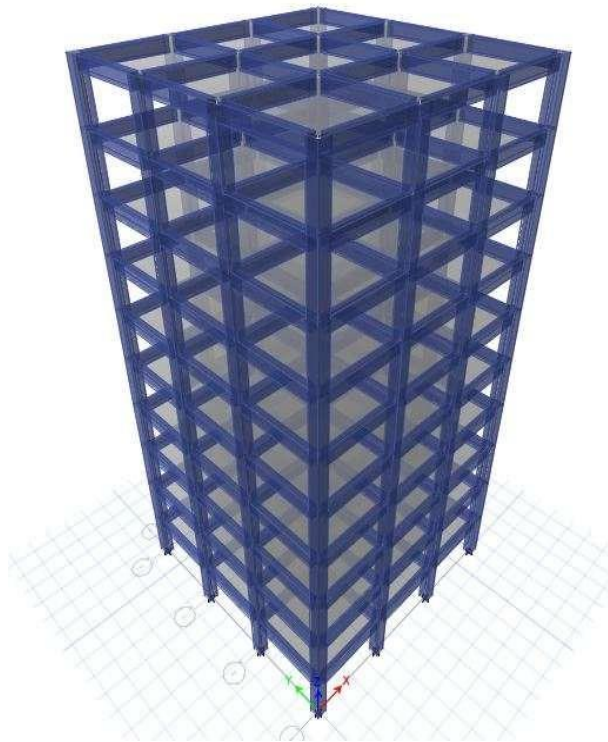


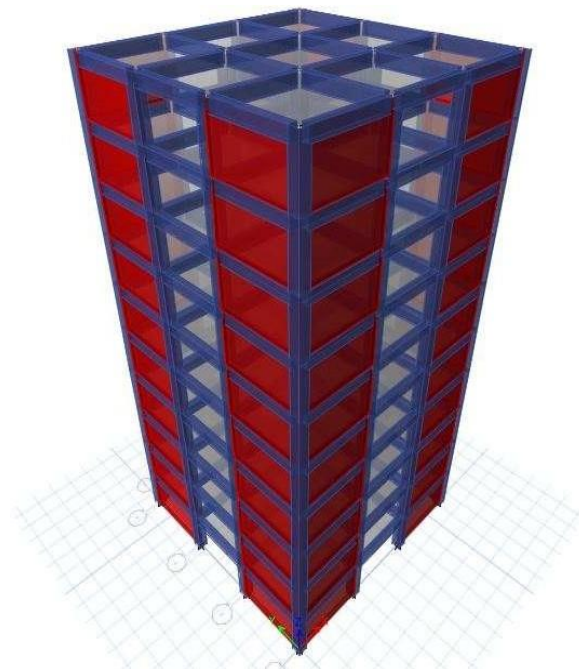
Figure 4.1 Plan of building Without shear wall.



Plan of building with shear wall.



3D view without shear wall



3D view with shear wall

5. RESULTS AND QUANTITATIVE ANALYSIS

The analysis of both models was carried out using the Equivalent Static Method. The structural response was recorded in terms of displacement, drift, and shear.

5.1 Storey Displacement Analysis

Maximum displacement occurs at the roof level. For the Bare Frame model, the displacement is high due to lower lateral stiffness. The introduction of shear walls drastically reduces this movement.

Storey	Bare Frame (mm)	Shear Wall Frame (mm)	Reduction (%)
10	34.25	7.52	78.0%
9	31.82	6.70	78.9%
7	25.60	4.95	80.7%
5	18.50	3.20	82.7%
3	10.45	1.65	84.2%
1	2.10	0.35	83.3%

5.2 Storey Drift Analysis

Storey drift is the relative displacement between two adjacent floors. NBC 105:2020 specifies that drift should not exceed 0.006 times the storey height. The analysis shows that the shear wall model reduces drift by 19.35%, keeping it well within safety limits.

1. EXTENDED PERFORMANCE ANALYSIS

To further validate the findings, an extended performance analysis was conducted focusing on structural damping and mass participation. In the bare frame model, the fundamental time period was found to be approximately 1.135 seconds, whereas the shear wall model exhibited a significantly shorter period of 0.474 seconds. This reduction in time period confirms the high lateral stiffness of the shear wall system. Furthermore, the mass participation factors in the first three modes for the shear wall model exceeded 90%, meeting the requirements for dynamic analysis if requested. The redistribution of axial forces in columns was also observed, with corner columns in the dual system experiencing more manageable axial loads as the shear walls handled the lateral shear forces.

2. SCOPE FOR FUTURE STUDY

While this study focuses on a regular G+9 structure, future research could explore the effects of vertical and plan irregularities, which are common in urban settings. The impact of varying the thickness of the shear wall along the building height could also provide insights into material economy. Furthermore, a non-linear pushover analysis could be conducted to evaluate the performance level (Immediate Occupancy, Life Safety, or Collapse Prevention) of the building under extreme seismic events. Finally, the role of soil-structure interaction,

especially in the 'soft soil' conditions characteristic of many urban areas in Nepal, warrants further investigation.

6. DISCUSSION

The comparison of the two models reveals that the bare frame is highly flexible. While this flexibility allows for energy dissipation, it results in large displacements that can cause 'P-Delta' effects—where the gravity loads act on the displaced columns, creating additional bending moments. The shear wall model, being significantly stiffer, prevents these effects. Although the shear wall model attracts about 9.21% more base shear, this is managed efficiently by the large cross-sectional area of the concrete walls, resulting in a much safer structure for residents.

7. CONCLUSIONS

1. Based on the comparative analysis of G+9 buildings under NBC 105:2020, the following points are concluded:
2. Inclusion of shear walls at corner locations reduces lateral displacement by 78%, providing excellent stability.
3. Storey drift values are significantly controlled, ensuring non-structural elements like glass and partitions remain intact during seismic events.
4. The dual system (frame + shear wall) is recommended for buildings in Nepal's seismic zones to meet the stringent criteria of the latest building codes.

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