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Design and Detailing of G+8 Shear Walled RCC Framed Structure

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Abstract - This paper presents the design and detailing of a G+8 reinforced cement concrete (RCC) framed structure with and without shear walls using STAAD Pro software. The structure is located in Delhi, India, with a height of 27 meters, using concrete grade M25 and steel grade Fe415. The study focuses on the comparative performance of the structure under lateral loads due to seismic activity in Delhi's seismic zone (Zone IV). A comparative analysis is performed with respect to base shear, deflection, and risk assessment using both tabular and graphical representations.

Key Words: Size G+8 RCC Structure, Shear Walls, STAAD Pro, Seismic Analysis, Base Shear, Structural Performance, Risk Assessment.

1. INTRODUCTION

Earthquake Zoning of India

India has a history of major earthquakes. The main reason for the high frequency of earthquakes is that the Indian plate is moving towards Asia at a rate of 47 millimetres per year. Geographical analysis of India shows that about 54% of the land is vulnerable to earthquakes. According to World Bank and United Nations reports, about 200 million urban dwellers in India are expected to be affected by storms and earthquakes by 2050. The latest version of the seismic zoning map of India given in the Indian Seismic Design Code [IS 1893 (Part 1) 2002] has divided India into four seismic levels based on regional factors. In other words, the seismic zoning map of India divides India into 4 seismic zones (Zones II, III, IV and V) as opposed to the earlier version where the seismic zoning of India had V to VI zones. According to the current zoning map, Zone V has the highest level of seismic activity, while Zone II has the lowest.

This Delhi, being in Seismic Zone IV, is prone to moderate to high seismic activity. The structural design of high-rise buildings needs to address the safety concerns caused by seismic forces. Shear walls are used to provide additional stiffness to resist lateral forces, improving the overall stability of the building. In this study, the structure is analysed with and without shear walls to understand the effect of these elements on the stability of an RCC framed structure.

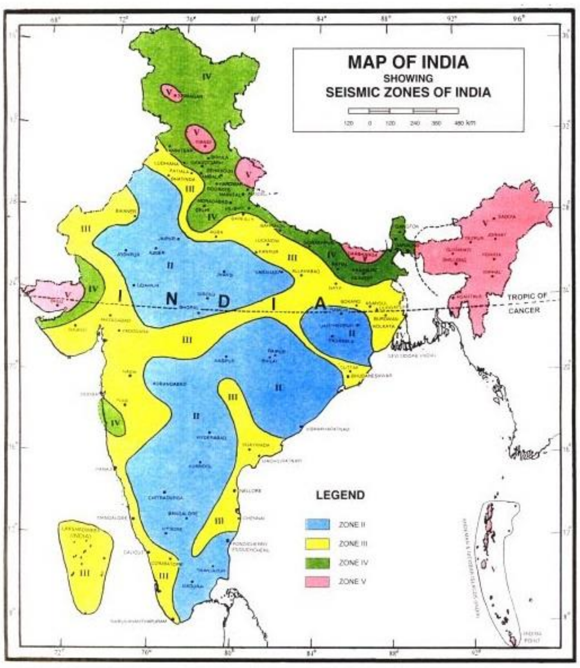

Figure-1: Seismic Zones of India

2. BUILDING CONFIGURATION AND DESIGN PARAMETERS

2.1 Shear Wall

Shear walls are designed to resist wind and seismic loads. Shear walls are designed by the International Building Code and the International Residential Code. The plane of the wall is parallel to the shear walls. The shear walls and other vertical elements of the system are resistible because of the Collectors. Shear walls used in the study analysis consists of reinforced concrete walls.

2.2 Building Details

- **Number of Stories**: G+8 (Ground floor + 8 floors)
- **Height**: 27 meters
- **Location**: Delhi, India
- **Seismic Zone**: IV (IS 1893:2016)
- **Soil Type**: Medium soil (Type II as per IS Code)
- **Storey Height**: 3 meters

2.2 Material Properties

- **Concrete Grade**: M25
- **Steel Grade**: Fe415
- **Density of Concrete**: 25 kN/m^3
- **Density of Masonry**: 20 kN/m^3

2.3 Design Parameters

- **Minimum Base Shear**: 933.07 kN
- **Design Base Shear**: 4373.8 kN
- **Importance Factor**: 1.2 (IS 1893:2016)
- **Response Reduction Factor (R)**: 5 (with shear walls), 3 (without shear walls)

2.4 Software Used

- **Structural Analysis and Design**: STAAD Pro
- **Design Codes**: IS 456:2000, IS 1893:2016, IS 875 (Part I & II)

3. STRUCTURAL MODELLING

3.1 Modelling in STAAD Pro

The structure was modelled and analyzed using STAAD Pro, considering different load combinations for both gravity and seismic loads as per IS 1893:2016. Two different models were created:

1. **Model 1**: RCC framed structure without shear walls.
2. **Model 2**: RCC framed structure with shear walls.

3.2 Load Combinations

- **Dead Load (DL)**
- **Live Load (LL)**
- **Seismic Load (EQ)**

Load Combinations: The following load combinations were used for the analysis as per IS 456:2000:

- 1.5 (DL + LL)
- 1.2 (DL + LL ± EQ)
- 1.5 (DL ± EQ)
- 0.9 DL ± 1.5 EQ

4. ANALYSIS RESULTS

4.1 Base Shear Comparison

The base shear values were computed for both models. The results are summarized as

Table -1: Minimum Base Shear and Design Base Shear with and without Shear Walls

Model	**Minimum Base Shear (kN)**	**Design Base Shear (kN)**
Without Shear Walls	933.07	2500.4
With Shear Walls	933.07	4373.8

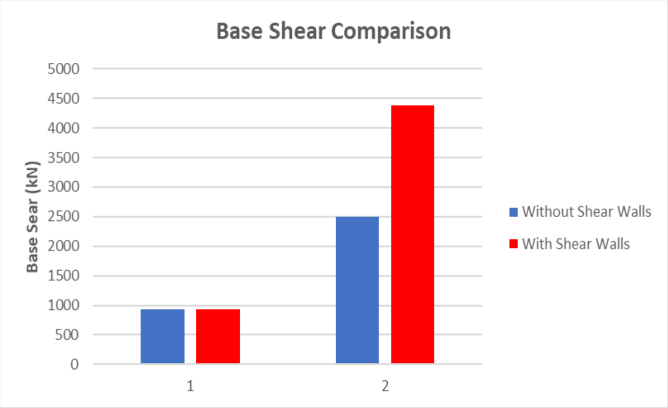

Figure-2: Base Shear Comparison Bar Chart

4.2 Lateral Displacement

Lateral displacement was analyzed for both models to assess the effectiveness of shear walls in controlling the deflection.

Table -2: Displacement with and without Shear Walls with respect to Storey Level

Storey Level	**Displacement (mm) Without Shear Walls**	**Displacement (mm) With Shear Walls**
Ground	0.0	0.0
1	15.2	5.8
2	28.4	10.2
3	39.5	13.9
8	85.6	32.4

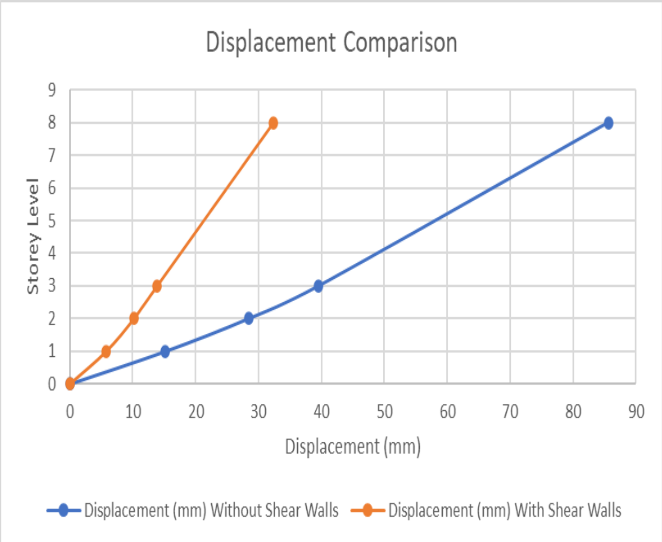

Figure-3: Displacement Comparison Graph

4.3 Drift Analysis

The inter-storey drift was calculated, and the results show that the structure with shear walls has significantly reduced drift, well within the permissible limits as per IS 1893:2016.

Table -3: Drift with and without Shear Walls with respect to Storey Level

Storey Level	Drift Without Shear Walls (%)	Drift With Shear Walls (%)
1	0.32	0.12
2	0.42	0.15
8	0.52	0.19

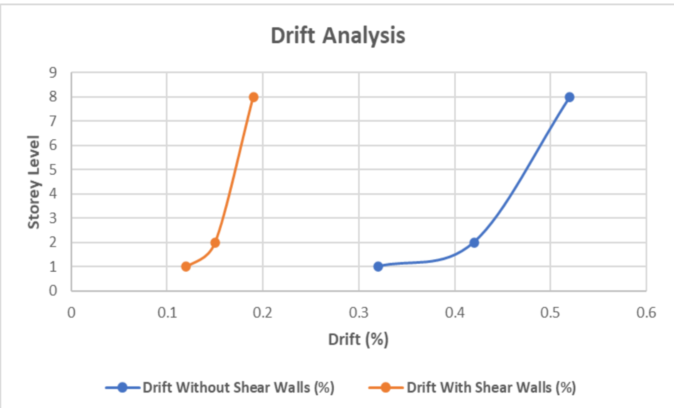

Figure-4: Drift Analysis Comparison Graph

5. STRUCTURAL DETAILING

5.1 Columns and Beams

- **Columns:** Column dimensions of 600 mm x 600 mm were used throughout the structure. Longitudinal reinforcement was designed considering IS 456:2000 requirements, with minimum steel percentage of 1% and maximum of 4%.

- **Beams:** Beams of cross-section 300 mm x 450 mm were designed. Shear reinforcement was provided as per IS 13920 for earthquake resistance.

5.2 Shear Walls

- **Shear Wall Dimensions:** 200 mm thick shear walls were provided along the perimeter.

- **Reinforcement:** Horizontal and vertical reinforcement with 12 mm diameter bars at 150 mm c/c was provided.

6. RISK ASSESSMENT

6.1 Risk with and without Shear Walls

The risk assessment of the building was carried out considering the vulnerability of structures during seismic events.

- **Without Shear Walls:** The structure without shear walls exhibited higher deflections and larger base shear, increasing the risk of failure under seismic loads.

- **With Shear Walls:** The structure with shear walls performed better, showing reduced displacement and drift, thus reducing the risk.

6.2 Graphical Representation

- **Risk Probability:** A risk probability of structural failure was evaluated using fragility curves for both models.

Table -4: Probability of Failure with and without Shear Walls

Model	Probability of Failure (%)
Without Shear Walls	15.4
With Shear Walls	5.2

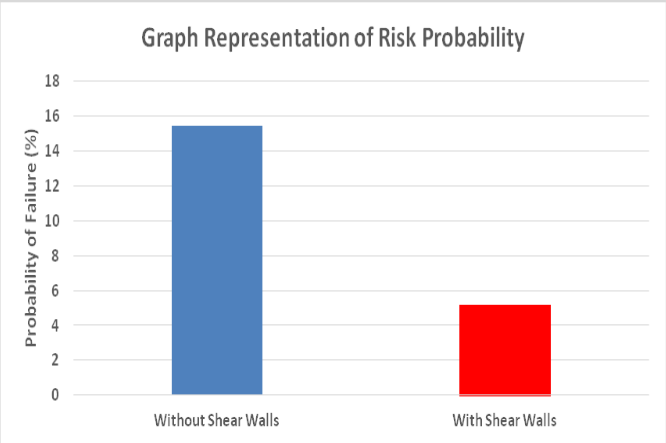

Figure-5: Risk Probability Comparison Bar Chart

7. Conclusions

The design and analysis of a G+8 RCC framed structure with and without shear walls reveal significant differences in seismic performance. The inclusion of shear walls reduces lateral displacement, drift, and overall risk of structural failure. Key conclusions are:

1. **Base Shear**: The presence of shear walls increases the base shear, indicating improved resistance to lateral forces.

2. **Displacement and Drift**: Shear walls significantly reduce lateral displacement and inter-storey drift.

3. **Risk Reduction**: The probability of failure is reduced by incorporating shear walls, leading to enhanced structural safety.

7.1 Recommendations

- Shear walls are recommended for structures in high seismic zones to improve stability and reduce the risk of failure.

- Further studies can be conducted using other grades of concrete and different soil types to generalize the findings.

8. References

- IS 456:2000, "Code of Practice for Plain and Reinforced Concrete," Bureau of Indian Standards.

- IS 1893 (Part 1):2016, "Criteria for Earthquake Resistant Design of Structures," Bureau of Indian Standards.

- STAAD Pro User Manual, Bentley Systems.

- IS 13920:2016, "Ductile Design and Detailing of Reinforced Concrete Structures Subjected to Seismic Forces," Bureau of Indian Standards.

9. Biographies

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