Design and Detailing of Ground Floor + Eight Floor Shear Walled Reinforced Cement Concrete Framed Structure

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Abstract - This paper examines the design and detailing of a Ground Floor + 8-story Reinforced Cement Concrete (RCC) framed structure located at Okhla NSIC, New Delhi. The structure, with a height of 24 meters, is analyzed with and without shear walls using ETABS software. Key parameters include concrete grade M20, reinforcement grade Fe415, stiff soil type, minimum base shear of 1323.1 kN, and design base shear of 4162.58 kN. The study evaluates seismic performance, risk assessment, and construction methodologies. Tables and graphs illustrate findings on structural performance and safety. The research emphasizes the importance of shear walls in enhancing seismic resistance.

Key Words: Concrete grade M20, Reinforcement grade Fe415, Stiff Soil type, Minimum base shear and design base shear.

1. INTRODUCTION

Earthquake zoning in India refers to the division of the country into regions based on their vulnerability to seismic activity. This classification helps in understanding the potential risk of earthquakes in different areas and guides the development of appropriate construction standards and disaster management strategies.

India's zoning system categorizes the country into four seismic zones: Zone II, Zone III, Zone IV, and Zone V, with Zone II having the lowest seismic risk and Zone V the highest. This classification is based on historical earthquake data, tectonic features, and the intensity of ground shaking experienced in various regions.

Zone V includes areas like the northeastern states, parts of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, and the Andaman and Nicobar Islands, which are highly prone to severe earthquakes. Zones IV and III encompass areas with moderate to significant seismic risk, while Zone II covers regions with relatively low seismic activity. This zoning framework is critical for implementing building codes and ensuring that infrastructure in high-risk areas is designed to withstand potential seismic forces.

Seismic activity poses significant challenges to building stability, particularly in regions like New Delhi, categorized under Seismic Zone IV. Shear walls, as integral components of lateral force-resisting systems, play a critical role in mitigating seismic damage in RCC structures. This study compares the performance of a G+8 RCC framed structure with and without shear walls. Using ETABS software, the paper explores structural behavior, base shear, story drift, and stiffness to assess the impact of shear walls.

2. SHEAR WALLS

Definition: Shear walls are vertical structural elements designed to resist lateral forces caused by wind and earthquakes. They are crucial in high-rise buildings, providing stiffness and stability.

Functions:

- Resist lateral loads.
- Minimize inter-story drift.
- Enhance overall structural rigidity.

Placement: Shear walls are strategically located around staircases, elevator cores, and external walls for optimal performance without compromising architectural design.

3. SEISMIC ZONES OF INDIA

India's seismic zoning is classified into four zones based on earthquake intensity:

- **Zone II**: Low-intensity earthquakes.
- **Zone III**: Moderate-intensity earthquakes.
- **Zone IV**: Severe-intensity earthquakes (e.g., Delhi).

- **Zone V**: Very severe-intensity earthquakes.

New Delhi falls under Zone IV, necessitating robust design measures to ensure safety and compliance with IS 1893:2016.

4. PROJECT DETAILS

Location: Okhla NSIC, New Delhi (Seismic Zone IV).

Structural Details:

- **Height**: 24 meters (G+8 floors).
- **Concrete Grade**: M20.
- **Reinforcement Grade**: Fe415.
- **Soil Type**: Stiff.
- **Base Shear**:
- Minimum: 1323.1 kN.
- Design: 4162.58 kN.

5. METHODOLOGY

5.1 MODELING IN ETABS

Two models are created in ETABS:

1. Without Shear Walls: Standard RCC framed structure.
2. With Shear Walls: RCC framed structure incorporating shear walls.

Steps:

1. Define material properties (M20 concrete, Fe415 steel).
2. Assign geometric properties (beams, columns, slabs).
3. Apply loads:

- Dead loads: Self-weight, floor finishes.
- Live loads: 2.0 kN/m^2.
- Seismic loads: As per IS 1893 (Part 1): 2016.

4. Conduct dynamic analysis using the Response Spectrum Method.

5.2 ANALYSIS PARAMETERS

- **Natural Period**: Calculated for both models.
- **Base Shear**: Comparison of lateral force distribution.
- **Story Drift**: Evaluated against permissible limits.
- **Story Stiffness**: Assessed for resistance to deformation.

6. RESULTS AND DISCUSSION

6.1 SEISMIC PERFORMANCE

- **Natural Period**:
- Without Shear Walls: Higher, indicating lower stiffness.
- With Shear Walls: Lower, indicating higher stiffness.

Model	Natural Period (s)	Base Shear (kN)
Without Shear Walls	1.6	1323.1
With Shear Walls	0.9	4162.58

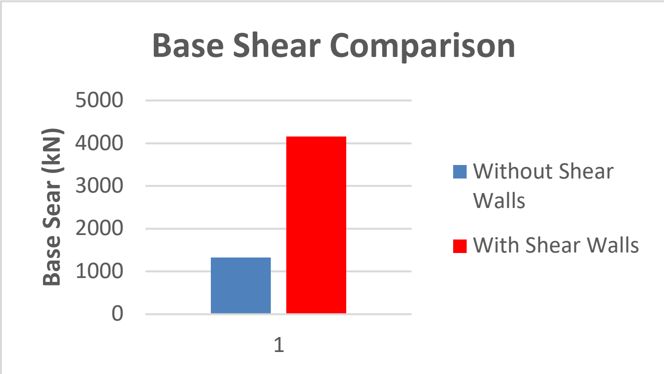

Figure-1: Base Shear Comparison Bar Chart

6.2 Displacement

Assessment of displacement table comparing results with and without shear walls at different story levels is given below.

Story Level	Displacement Without Shear Walls (mm)	Displacement With Shear Walls (mm)
1	12	4
2	20	6
3	28	8
4	32	9
5	35	10
6	36	11
7	37	11.5
8	38	12

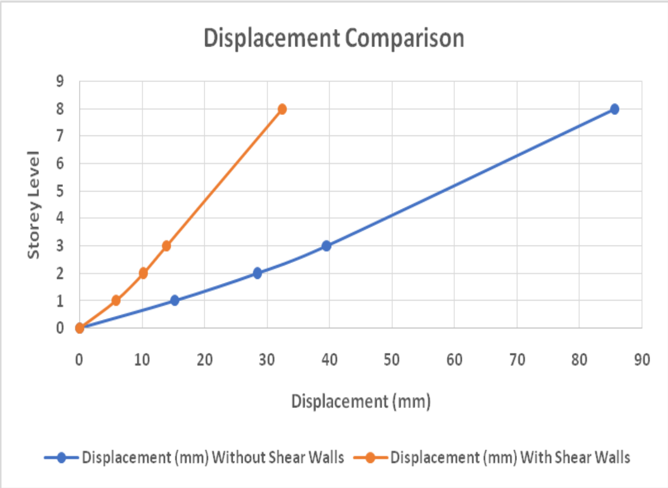

Figure-2: Displacement Comparison Graph

6.3 BASE SHEAR DISTRIBUTION

Shear walls effectively redistribute seismic forces, reducing stress concentrations in columns and beams.

6.4 STORY DRIFT

- Without shear walls: Drift exceeds permissible limits in upper stories.
- With shear walls: Drift remains within safe limits.

Story Level	Drift Without Shear Walls (mm)	Drift With Shear Walls (mm)
1	15	5
5	30	8
8	40	12

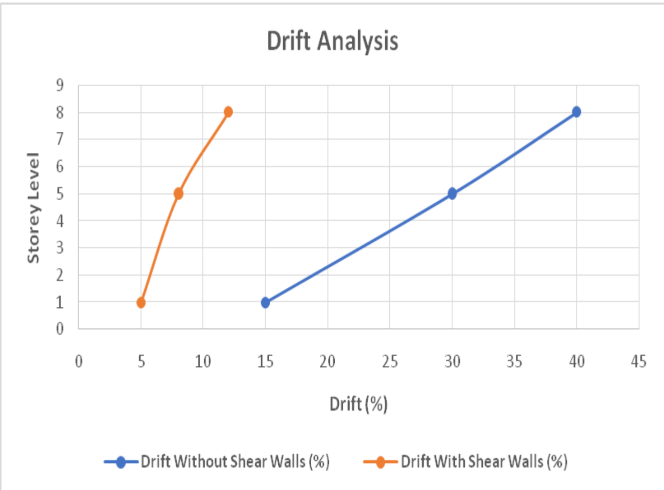

Figure-3: Drift Analysis Comparison Graph

6.5 FAILURE PROBABILITY

The failure probability is assessed based on dynamic response and risk metrics:

Story Level	Failure Probability Without Shear Walls (%)	Failure Probability With Shear Walls (%)
1	10	3
5	20	5
8	35	8

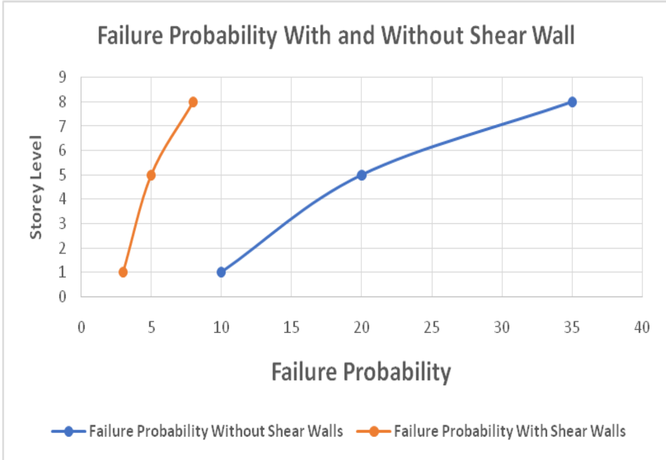

Figure-4: Risk Probability Comparison Graph

6.6 STORY STIFFNESS

Shear walls increase stiffness by approximately 65%, improving resistance to lateral deformation.

6.7 RISK ASSESSMENT

- **Without Shear Walls**: Higher vulnerability to seismic forces.
- **With Shear Walls**: Enhanced safety and reduced risk of failure.

7. CONSTRUCTION METHODOLOGY

7.1FOUNDATION

- Raft foundation designed for stiff soil conditions.
- Shear walls anchored for effective load transfer.

7.2 FRAMING

- RCC beams and columns constructed using M20 concrete and Fe415 steel.
- Shear walls integrated with vertical and horizontal reinforcements.

7.3 SLABS

- Flat slabs reinforced to resist bending and shear forces.

7.4 SHEAR WALL DETAILING

- Vertical reinforcement: 0.25% of the cross-sectional area.
- Horizontal reinforcement: 0.2% of the cross-sectional area.
- Boundary elements: Heavily reinforced to handle concentrated stresses.

8. STRUCTURAL DETAILING

8.1 BEAM - COLUMN JOINTS

- Special confining reinforcement.
- Adequate anchorage to prevent failure.

8.2 SHEAR WALL REINFORCEMENT

- Spacing and placement of bars comply with IS 13920:2016.

9. CONCLUSION

The incorporation of shear walls in RCC structures significantly enhances seismic performance. The study demonstrates that shear walls reduce story drift, increase stiffness, and distribute lateral forces effectively, ensuring safety in Seismic Zone IV. ETABS modeling and analysis validate the advantages of shear walls, making them indispensable for earthquake-resistant designs.

10. REFERENCES

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11. BIOGRAPHIES

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