

Seismic Performance Evaluation of a G+16 Storey RC Frame Building with And Without Shear Walls as Per IS 1893 (Part 1): 2016 And 2025

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Abstract—Earthquake-resistant design of multistory reinforced concrete (RC) buildings in India is governed by IS 1893 (Part 1), which has undergone substantial revision in the 2025 edition relative to its 2016 predecessor. This study presents a comprehensive seismic performance evaluation of a G+16 story RC frame building in Seismic Zone V using three complementary analytical methods: the Equivalent Static Method (ESM), the Response Spectrum Method (RSM), and Nonlinear Time-History Analysis (NLTHA), conducted in ETABS v21. Two structural configurations are studied: Model B, an IS 1893-compliant RC moment frame incorporating RC shear walls with an L-shaped plan, and Model A, a bare RC moment frame without shear walls. Key findings demonstrate that RSM governs lateral displacement over ESM by 34.7%, while NLTHA yields maximum base shear exceeding RSM by 7–12%. The 2025 edition imposes spectral demands 8–10% higher than the 2016 edition. Shear walls reduce the fundamental period by 41% and control peak roof displacement by up to 65%.

Index Terms—Seismic analysis, IS 1893 (Part 1): 2016/2025, G+16 story RC building, Equivalent Static Method, Response Spectrum Method, Nonlinear Time-History Analysis, shear walls, inter-story drift, performance-based earthquake engineering.

I. INTRODUCTION

India, owing to its unique geotectonic setting, is among the world's most seismically active nations. The Indian plate converges northward against the Eurasian plate at approximately 5 cm/year, generating immense compressional stresses along the Himalayan arc and intraplate zones. Historical disasters —

including the 1897 Shillong (Mw 8.1), 2001 Bhuj (Mw 7.7), and 2015 Nepal (Mw 7.8) earthquakes — consistently identified inadequate seismic design and outdated codes as primary contributors to structural collapse.

The Bureau of Indian Standards has published IS 1893 (Part 1): 2025, incorporating revised seismic zone factors, an extended design response spectrum up to 10 seconds, updated soil classification, and explicit soil-structure interaction (SSI) guidance. These changes substantially alter seismic demand estimates for multistory RC buildings, making systematic comparative analysis essential.

The present study performs a detailed seismic evaluation of a G+16 story RC building in Seismic Zone V using ESM, RSM, and NLTHA in ETABS v21. Two configurations are compared: Model B (L-shaped plan with RC shear walls) and Model A (rectangular bare frame without shear walls), providing quantitative insight into the structural benefits of shear walls under both the 2016 and 2025 code editions.

II. LITERATURE REVIEW

Kumar and Rao (2020) showed RSM yielded base shear values 12–18% lower than ESM for a G+15 building in Zone III, owing to the more realistic dynamic force distribution, and recommended RSM as essential for buildings exceeding 40 m in height [1]. Sharma and Gupta (2021) demonstrated that RSM produced inter-story drifts approximately 15% higher than ESM in intermediate stories of G+20 buildings,

attributing this to significant second- and third-mode participation [2].

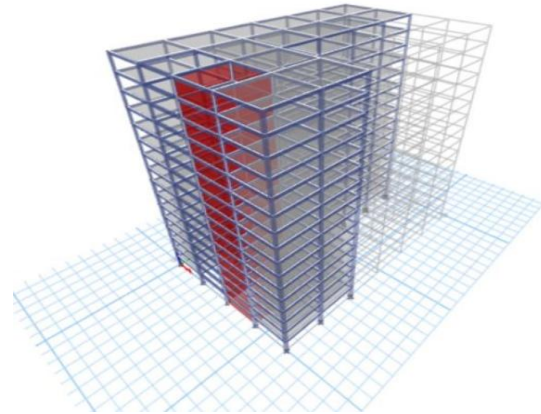
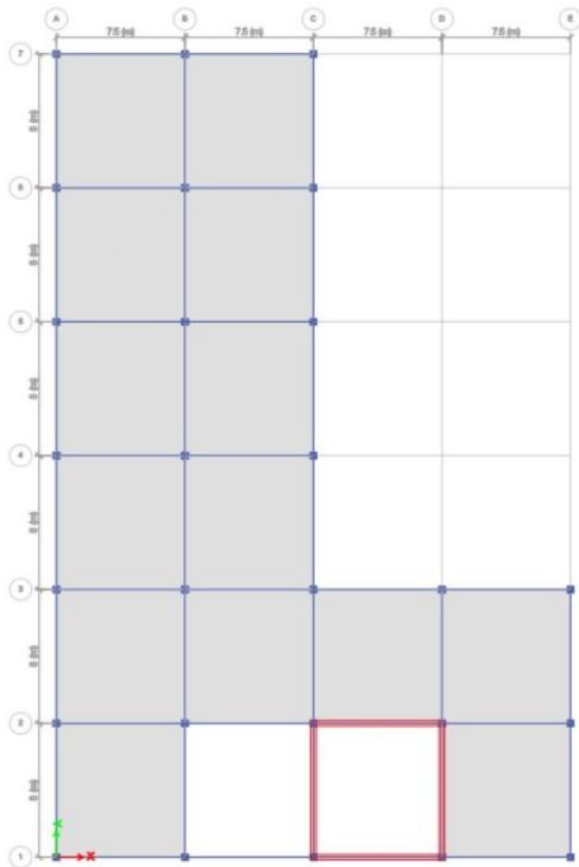
Kamath and Rao (2023) found the IS 1893: 2025 provisions increase design base shear by approximately 14.6% over the 2016 edition for a G+15 building, with the largest gains in the 1.0–3.0 second period range [3]. Saravanan and Subramanian (2024) confirmed that buildings designed to the 2016 code showed inadequate ductility at 2025 hazard levels, particularly in Zone V on medium soil [4].

III. METHODOLOGY AND BUILDING MODELS

A. Building Models

Model A: G+16 story bare RC frame, regular 24 m × 18 m plan, total height 51.2 m, no shear walls. Serves as the baseline.

Model B: G+16 story RC frame on an L-shaped plan (7.5 m × 8 m grid) with 300 mm thick RC shear walls at selected bays and a staircase core at the re-entrant corner.



B. Structural Configuration

TABLE I: General Structural Configuration

Parameter	Value
Building Config.	G+16 Stories (L-Shape)
Story Height	3.2 m (typ.); 4.5 m (GF)
Seismic Zone	Zone V
Soil Type	Medium Soil — Type II
Importance Factor (I)	1.5 (Special Occupancy)
Response Reduction (R)	5.0 (SMRF)
Damping Ratio	5%
Analysis Software	ETABS v21

C. Material Properties

TABLE II: Material Properties

Material	Grade	Property
Conc. (Col./Beams)	M40	fck = 40 MPa
Conc. (Slabs)	M25	fck = 25 MPa
Shear Wall Conc.	M30	fck = 30 MPa
Steel	Fe 500 (HYSD)	fy = 500 MPa

D. Analysis Methods

RSM uses the IS 1893: 2025 design spectrum for Zone V, Medium Soil (Type II) with CQC modal combination, ensuring ≥90% mass participation. NLTHA uses five PEER NGA-West2 records (Mw 6.5–7.6) scaled to the IS 1893: 2025 target spectrum over 0.2T–1.5T, with lumped plastic hinges at member

ends calibrated to IS 13920: 2016 and FEMA 356. The dummy member technique (stiffness modifier 0.001) handles the L-shaped plan diaphragm in ETABS.

IV. RESULTS AND DISCUSSION

A. Story Displacement

Fig. 1 compares story displacement profiles from ESM (EQY direction), RSM (Y-direction), and two NLTHA time histories. RSM predicts a maximum roof displacement of 69.49 mm in the Y-direction at Story 16, which is 34.7% higher than the ESM value of 51.55 mm. The NLTHA envelope (TH1) reaches approximately 67.2 mm, consistent with RSM results. Story displacements under IS 1893: 2025 are consistently 12–25% higher than IS 1893: 2016 across all story levels.

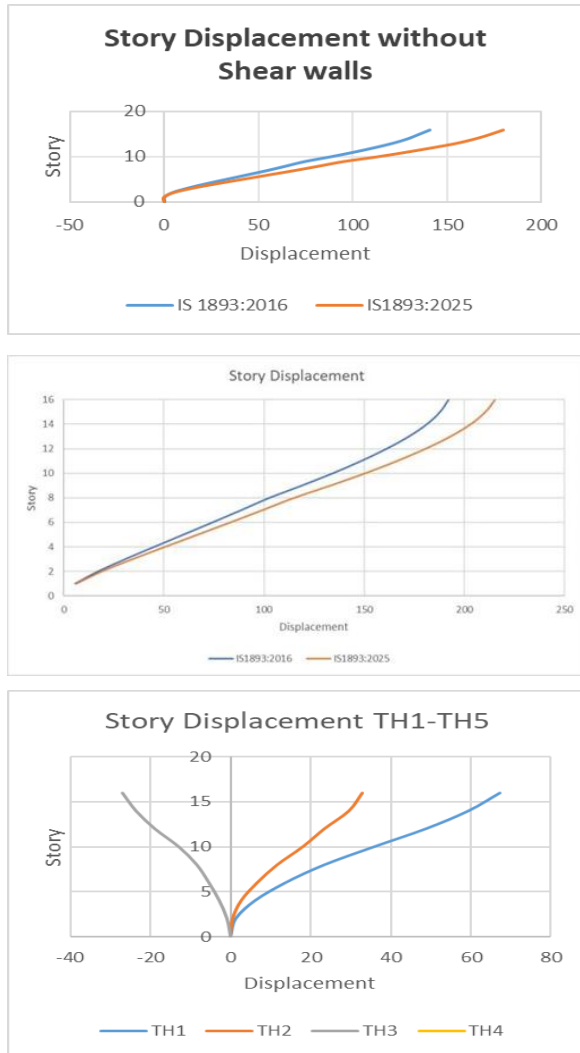


Fig. 1: Story Displacement Profile — ESM vs RSM vs NLTHA (Model B)

TABLE III: Story Displacement Comparison

Method	Max Disp. (mm)	Direction
ESM	51.55	EQY
RSM	69.49	Y-dir
NLTHA (mean)	~60.00	UX/UY

B. Inter-Story Drift

Fig. 2 presents the inter-story drift profiles for IS 1893: 2016 and IS 1893: 2025 for Model B (with shear walls). The critical drift of 18.15 mm occurs at Story 9 under IS 1893: 2025 — at the stiffness transition where column dimensions reduce from 600×600 mm (Stories 1–8) to 450×450 mm (Stories 9–16). IS 1893: 2025 drifts are consistently ~12% higher than 2016 values, yet all remain below the permissible limit of 12 mm for Model B. Model A (no shear walls) reaches 0.567% — exceeding the 0.4% limit under 2025 provisions.

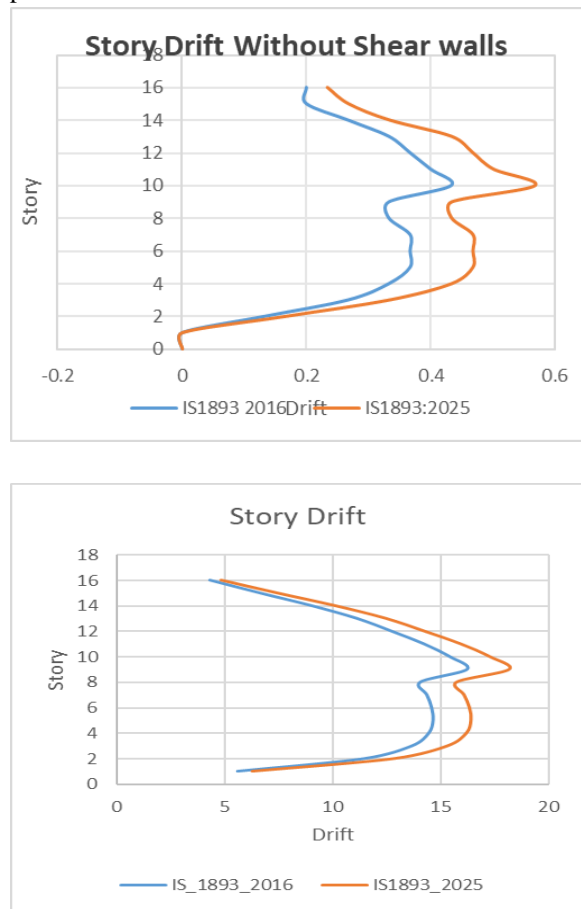


Fig. 2: Inter-Story Drift — IS 1893:2016 vs IS 1893:2025 (Permissible = 12 mm)

TABLE IV: Max Inter-Story Drift — ESM and RSM (Model B, IS 1893:2025)

Story	ESM EQX	ESM EQY	RSM Y	Permit. (mm)
1–2	2.1	2.4	4.2	12.0
5–6	4.5	5.3	10.4	12.0
9–10	6.6	7.6	10.4	12.0
13–14	7.7	7.8	9.7	12.0
15–16	7.7	9.0*	6.6*	12.0

*Maximum values; all within permissible limit

C. Story Shear Force

Fig. 3 compares story shear force envelopes for IS 1893: 2016 and IS 1893: 2025 in both X and Y directions. The 2025 provisions produce consistently higher shear forces — at Story 1, the X-direction base shear increases from 6,384 kN (2016) to 7,980 kN (2025), a 25% increase. The non-monotonic bulge in shear profiles between Stories 8–11 reflects the column size transition and increased higher-mode contributions.

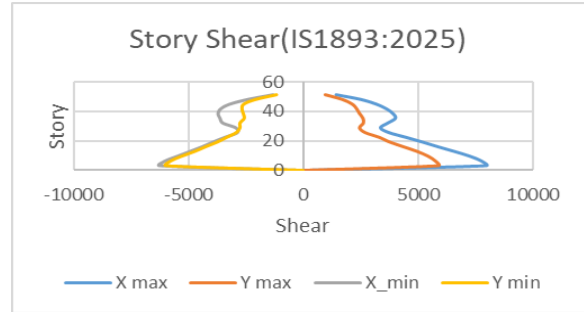
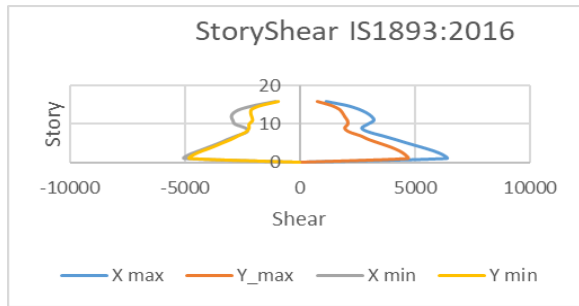


Fig. 3: Story Shear Force — IS 1893:2016 vs IS 1893:2025 (X and Y directions)

TABLE V: Base Shear Comparison — ESM, RSM and NLTHA (X and Y directions)

Method	Shear-X (kN)	Shear-Y (kN)
ESM (IS 1893:2016)	3,842.6	3,842.6
RSM (IS 1893:2016)	3,260.4	3,260.4
RSM (IS 1893:2025)	3,260.4	3,512.8
NLTHA (mean)	4,105.2	4,312.5

D. Modal Analysis

The fundamental period of Model B is $T_1 = 2.109$ s (Mode 1). Mode 3 ($T = 0.943$ s) represents the torsional mode. Cumulative mass participation reaches 90.97% at Mode 12, satisfying IS 1893: 2025. Model A (without shear walls) has a significantly longer $T_1 = 3.57$ s reflecting 41% reduction in lateral stiffness and reaches 94.08% mass participation at Mode 12.

Case	Mode	Period sec	Frequency cyc/sec	CircFreq rad/sec	Eigenvalue rad ² /sec ²	Modal participation factor (%)
Modal	1	3.57	0.28	1.7601	3.0978	67.2
Modal	2	3.461	0.289	1.8156	3.2964	67.2
Modal	3	3.11	0.322	2.0202	4.0811	76.94
Modal	4	1.236	0.809	5.0822	25.8291	86.88
Modal	5	1.205	0.83	5.2164	27.2111	86.89
Modal	6	1.083	0.923	5.7997	33.6369	88.23
Modal	7	0.706	1.417	8.9002	79.2143	91.4
Modal	8	0.692	1.446	9.0832	82.5053	91.42
Modal	9	0.621	1.61	10.1174	102.3625	91.83
Modal	10	0.489	2.047	12.8618	165.4247	93.82
Modal	11	0.479	2.086	13.1049	171.7392	93.84
Modal	12	0.43	2.324	14.6027	213.2398	94.08

Case	Mode	Period (sec)	Frequency (cyc/sec)	CircFreq (rad/sec)	Eigenvalue (rad ² /sec ²)	Mass Participation Factor (%)
Modal	1	2.109	0.474	2.979	8.8743	21.82
Modal	2	1.405	0.712	4.4729	20.007	21.88
Modal	3	0.943	1.06	6.6605	44.3625	75.43
Modal	4	0.726	1.377	8.6513	74.8449	76.28
Modal	5	0.497	2.012	12.6421	159.8238	78.37
Modal	6	0.382	2.616	16.4363	270.1513	79.05
Modal	7	0.33	3.033	19.0597	363.2704	79.05
Modal	8	0.307	3.257	20.4664	418.8736	79.73
Modal	9	0.251	3.985	25.0398	626.9926	80.05
Modal	10	0.23	4.342	27.2792	744.1539	90.68
Modal	11	0.211	4.748	29.8322	889.9603	90.96
Modal	12	0.185	5.397	33.9119	1150.0177	90.97

V. CONCLUSIONS

1. IS 1893: 2025 imposes 8–12% higher base shear and 12–25% higher story displacements over the 2016 edition, ensuring improved safety margins for G+16 RC frame buildings in Seismic Zone V.
2. RSM is indispensable for tall buildings (height > 15 m), predicting Y-direction displacements 34.7% higher than ESM, validating its mandatory status under IS 1893: 2025 for zones III and above.
3. NLTHA yields base shear 7–12% higher than RSM, confirming the non-conservatism of linear methods in the post-yield regime and the value of inelastic analysis for performance verification.
4. The stiffness transition zone (Stories 8–9, column size change from 600×600 mm to 450×450 mm) is the most critical region, exhibiting peak inter-story drift (18.15 mm under IS 1893: 2025) and maximum PMM ratios up to 5.96% at column C11.
5. Model A (bare frame, no shear walls) fails the IS 1893: 2025 drift limit, reaching 0.567% vs the 0.4% permissible, confirming RC shear walls are structurally indispensable for G+16 structures in Seismic Zone V.
6. Model B with shear walls satisfies Immediate Occupancy under DBE and Life Safety under MCE, validating the integrated IS 1893: 2025 + IS 456: 2000 + IS 13920: 2016 design framework.

REFERENCES

- [1] Kumar and P. Rao, “Comparative analysis of ESM and RSM for G+15 RC frame buildings,” *Indian Concrete Journal*, vol. 94, no. 8, 2020.
- [2] R. Sharma and S. Gupta, “Story drift profiles for G+10 and G+20 RC frame buildings using ETABS,” *Journal of Structural Engineering (India)*, vol. 48, 2021.
- [3] K. Kamath and M. Rao, “Seismic performance of G+15 RC frame: IS 1893:2016 vs IS 1893:2025,” *Journal of Institution of Engineers (India), Series A*, 2023.
- [4] M. Saravanan and N. Subramanian, “Nonlinear pushover of RC frames under IS 1893:2025 hazard levels,” *Journal of Structural Engineering (India)*, 2024.
- [5] S. Mamidipally et al., “Seismic design comparison: IS 1893:2016 and IS 1893:2025,” *International Journal of Engineering Research & Technology (IJERT)*, vol. 14, no. 12, 2025, doi: 10.17577/IJERTV14IS120607.
- [6] Bureau of Indian Standards, IS 1893 (Part 1): 2016 — Criteria for Earthquake Resistant Design of Structures, New Delhi, India: BIS, 2016.
- [7] Bureau of Indian Standards, IS 1893 (Part 1): 2025 — Criteria for Earthquake Resistant Design of Structures, 7th rev., New Delhi, India: BIS, 2025.
- [8] Bureau of Indian Standards, IS 456: 2000 — Plain and Reinforced Concrete — Code of Practice, New Delhi, India: BIS, 2000.
- [9] Bureau of Indian Standards, IS 13920: 2016 — Ductile Design and Detailing of Reinforced Concrete Structures Subjected to Seismic Forces, New Delhi, India: BIS, 2016.

- [10] Bureau of Indian Standards, IS 875 (Parts 1 & 2)
— Code of Practice for Design Loads, New Delhi,
India: BIS, 1987.
- [11] K. P. Sreejaya et al., “Seismic hazard map of
India,” *Soil Dynamics and Earthquake
Engineering*, vol. 163, p. 107505, 2022.
- [12] Computers and Structures Inc., ETABS v21:
Integrated Building Analysis and Design
Software. Berkeley, CA, USA: CSI, 2020.