

Comparative Study of Old Earthquake IS Codes (IS:1893-2002, IS:1893-2016) & Draft Code (IS:1893-2023) Using Multi-Storey RCC Building Analysis

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Abstract: This paper presents a comparative study of seismic design provisions as per Indian Standards IS 1893:2002, IS 1893:2016, and the draft IS 1893:2023. A G+14 RCC building was modeled and analysed using ETABS software under the respective codes. The comparison focuses on key seismic parameters—base shear, storey displacement, and storey drift. Results show that the 2023 draft code introduces a performance-based approach, with revised seismic zoning, updated response spectra, and improved site classification. These revisions enhance building safety and align Indian practices with international standards.

Keywords: IS 1893, Seismic Analysis, RCC Building, ETABS, Base Shear, Storey Drift, Response Spectrum.

III. INTRODUCTION

Earthquakes cause lateral and dynamic forces that critically affect the stability of structures. The Indian seismic design code IS 1893 provides guidelines for designing earthquake-resistant buildings. Over time, IS 1893 has undergone several revisions—2002, 2016, and the latest draft 2023—to incorporate advancements in structural dynamics, soil behaviour, and probabilistic hazard assessment. This paper investigates how these updates influence the seismic response of multi-storey reinforced concrete (RCC) buildings.

The 2002 code was largely empirical, focusing on simplified base shear calculations. The 2016 version improved precision by introducing updated dynamic analysis procedures, revised spectra, and clear limits for drift and irregularities. The 2023 draft represents a shift toward performance-based design with probabilistic earthquake hazard assessment (PEHA), multiple return periods, and detailed soil classifications.

II. COMPARISON OF IS 1893:2002, IS 1893:2016, And DRAFT IS 1893:2023

Parameter	IS 1893:2002	IS 1893:2016	Draft IS 1893:2023
Seismic Zoning	India divided into 4 Zones (II, III, IV, V) based on regional seismicity.	Same 4 Zones (II–V) retained; improved clarity in definitions and response estimation.	Extended to 6 Zones (II–VI) for finer regional differentiation based on seismic hazard.
Zone Factor (Z)	$Z = 0.10, 0.16, 0.24, 0.36$ for Zones II–V (based on 475-year return period).	Same Z values retained; clarified use of $Z/2$ for Design Basis Earthquake (DBE).	Z linked to Return Periods (73–9975 years); zone factors range from 0.0375–1.1250 depending on zone and return period.
Design Philosophy	Simplified, life-safety-based design approach.	Refined life-safety design with better dynamic analysis guidance.	Performance-based and reliability-based design introduced; multiple hazard levels considered.
Importance Factor (I)	Introduced two categories: Ordinary ($I=1.0$) and Important ($I=1.5$).	Three categories: Ordinary ($I=1.0$), Public assembly ($I=1.2$), Critical ($I=1.5$).	Relates design to return period instead of I-value; $I = 1.0$ retained for most cases; higher hazard level replaces $I > 1$.

Response Reduction Factor ®	OMRF = 3, SMRF = 5; simple categorization.	Same values; clarified ductility and redundancy requirements; SMRF mandatory in higher zones.	Broadened classification: R = 3.0–6.0 depending on system; dual systems & advanced frames included (EBF = 5.5, Dual = 6.0).
Soil Classification and Site Factors	3 soil types: Rock/Hard, Medium, Soft; limited guidance.	Retained 3 types; refined design spectrum plateau ranges.	Refined soil classes based on shear wave velocity (V_s); site-specific spectra mandatory for tall/critical structures.
Fundamental Natural Period (T)	Empirical formulas based on height; no infill consideration.	Refined equations; included infilled frames.	Same form, but refined coefficients; validation of analytical vs empirical periods; 3D dynamic analysis mandatory.
Dynamic Analysis Requirement	Static method default; dynamic analysis only for tall/irregular (>40 m, Zones IV & V).	Dynamic analysis mandatory for medium & high-rise; static limited to regular <15 m in Zone II.	Dynamic analysis mandatory for all important/large buildings; static only for very small regular structures in low zones; site-specific spectra required.
Return Periods for Design	Fixed at 475 years for design earthquake.	Same (475 years).	Variable: 73–9975 years depending on structure category (Normal, Important, Critical, Special).
Overall Approach	Prescriptive and simplified.	Improved precision and ductility-based design.	Advanced, performance- and resilience-oriented, harmonized with global standards (ASCE 7, Eurocode 8).

III. OBJECTIVES OF THE STUDY

1. To study and compare IS 1893:2002, IS 1893:2016, and Draft IS 1893:2023 with respect to key seismic design parameters including Zone Factor (Z), Importance Factor (I), and Response Reduction Factor (R).
2. To model and analyze the seismic response of a G+14 RCC building using ETABS software according to the provisions of the three code versions.
3. To compare seismic performance parameters such as base shear, maximum storey displacement, and storey drift obtained from the different code versions.
4. To draw conclusions and provide recommendations based on the comparative analysis of results from the three IS 1893 versions.

IV. LITERATURE REVIEW

Several researchers have carried out comparative studies on the evolution of the Indian seismic design codes (IS 1893:2002, IS 1893:2016, and draft versions). The key findings from previous studies are summarized below:

Ravikant Singh et al. (2020): Conducted a comparative study of seismic loads on multi-storey RC buildings using IS 1893:2002 and IS 1893:2016. The study found that buildings designed as per the older 2002 code were more vulnerable to earthquake forces. The updated 2016 code provided safer and more realistic load estimations.

Rita Debnath et al. (2017): Compared the seismic provisions of IS 1893:2002 and the draft IS 1893:2016. The study identified key changes related to building irregularities, effects of masonry walls, and simplified design procedures. Results were presented in tabular and graphical form.

Vikas Siddesh et al. (2019): Analyzed a 12-storey high-rise RC building with raft foundation using ETABS and SAFE under IS 1893:2002 and IS 1893:2016. The study showed noticeable variation in seismic response and foundation behavior, emphasizing the need for code-specific analysis in design.

Ajay Kumar et al. (2017): Performed a comparative analysis of static (IS 1893:2002) and dynamic (IS 1893:2016) design methods for design buildings in Zone V. The dynamic method per IS 1893:2016 led to a slightly higher construction cost (around 1.06–1.1 times) but ensured improved safety and performance.

Pooja Manoj Kale et al. (2019): Studied the seismic performance of 12- and 16-storey RCC buildings as per IS 1893:2016, IS 16700:2017, and IS 1893:2002.



The research concluded that newer codes improve performance in all seismic zones and that the response spectrum method provides more accurate results than the static method.

Jain, S. K. et al. (2016): Provided worked examples and practical applications of IS 1893:2016. The study discussed concepts like torsion, liquefaction, and anchorage design with step-by-step calculations, helping engineers understand new provisions.

Mayur et al. (2018): Presented a tabular comparison of IS 1893:2002 and IS 1893:2016. The study summarized key revisions in seismic zone factors, importance factors, soil classification, response spectrum, and load combinations, aiding easy code comparison.

Cinitha, P. K. et al. (2015): Evaluated the performance of a 6-storey RCC frame under different versions of IS 1893. The researchers proposed a simple formula for a global damage index and demonstrated how code changes affected structural vulnerability.

Jitendra Gudainiyam et al. (2018): Investigated torsional irregularities in RC buildings as per IS 1893:2002 and IS 1893:2016.

The updated 2016 code provided clearer and more detailed criteria for torsional irregularities, resulting in safer structural designs.

Deepika Rani, K. et al. (2018): Studied the effect of plan shape on seismic response in G+15 RC buildings. The study showed that irregular building shapes experienced higher seismic vulnerability compared to regular configurations.

V. METHODOLOGY

This chapter outlines the methodology adopted for the seismic analysis of a reinforced cement concrete (RCC) building using ETABS software. The study involves the modeling, material definition, load application, and seismic analysis of a G+14 storey RCC building as per the provisions of IS 1893 (Part 1): 2002, IS 1893 (Part 1): 2016, and the Draft IS 1893 (Part 1): 2023. Comparative analysis has been carried out to evaluate the influence of successive code revisions on key seismic parameters such as base shear, storey displacement, and storey drift.

A. Building Modeling

The first step involves the creation of a three-dimensional (3D) analytical model of the RCC building using ETABS software. The geometry of the structure, including the overall height, number of storeys, column-beam layout, and slab configuration, was accurately defined in accordance with architectural and structural drawings.

Structural components such as beams, columns, and slabs were modeled at their respective positions. Proper grids, reference lines, and levels were established to ensure accuracy and consistency in the digital representation of the building.

B. Key Parameters of the Model

The analysis was conducted in accordance with the provisions of IS 1893 (Part 1): 2002, IS 1893 (Part 1): 2016, and the Draft IS 1893 (Part 1): 2023. Seismic loads were computed and distributed along the height of the structure as per respective code guidelines.

A G+14 RCC building of symmetrical rectangular plan was considered for this study. The fundamental parameters of the model are summarized below:

Parameter	Specification
Number of Storeys	G + 14
Building Height	45.0 m
Plan Shape	Rectangular
Floor-to-Floor Height	3.0 m
Beam Size	300 mm × 600 mm
Column Size	750 mm × 750 mm
Slab Thickness	150 mm
Spacing in X-Direction	4.0 m
Spacing in Y-Direction	4.0 m

C. Definition and Assignment of Materials

All materials were defined in ETABS as per the standard specifications given in IS 456:2000 and assigned to the relevant structural elements.

i) Concrete

- Grade: M30
- Unit Weight: 25 kN/m³
- Poisson's Ratio: 0.20
- Modulus of Elasticity (E): As per IS 456:2000

ii) Reinforcement Steel

- Grade: Fe 500
- Unit Weight: 78.5 kN/m³
- Poisson's Ratio: 0.30
- Modulus of Elasticity (E): 2×10^5 MPa

iii) Assignment of Materials**Structural Member Material Specification**

Columns	M30 Concrete with Fe 500 Steel
Beams	M30 Concrete with Fe 500 Steel
Slabs	M30 Concrete with thickness of 150 mm

D. Load Definition and Application

All loads were defined and applied as per the relevant Indian Standard codes, namely IS 875 (Part 1 & Part 2) and IS 1893 (Part 1).

Load Type	Description
Dead Load	Self-weight of structural elements, finishes, and walls (IS 875 Part 1)
Live Load	As per IS 875 Part 2 (2 kN/m ² typical)
Seismic Load	As per Response Spectrum Method defined in IS 1893 (2002, 2016, and Draft 2023)
Load Combinations	As per IS 456 and IS 1893 provisions

E. Earthquake Loads as per IS 1893:2002

Parameter	Value / Description
Earthquake Zone	Zone V (Most Vulnerable)
Zone Factor (Z)	0.36
Importance Factor (I)	1.0
Response Reduction Factor (R)	5 (SMRF)
Soil Type	Medium
Damping	5%

F. Earthquake Loads as per IS 1893:2016

Parameter	Value / Description
Earthquake Zone	Zone V (Most Vulnerable)
Zone Factor (Z)	0.36
Importance Factor (I)	1.2
Response Reduction Factor (R)	5 (SMRF)
Soil Type	Medium
Damping	5%

G. Earthquake Loads as per Draft IS 1893:2023

Parameter	Value / Description
Earthquake Zone	Zone VI (Most Vulnerable)
Zone Factor (Z)	0.60
Importance Factor (I)	1.0
Response Reduction Factor (R)	5 (SMRF)
Site Class	B
Damping	5%

H. Analysis Procedure

The seismic analysis was carried out using the **Response Spectrum Method** to evaluate the building’s dynamic response. Separate analytical models were developed for each code version, and the building was analyzed under respective seismic provisions. The output results were then compared to study the effect of evolving seismic code requirements on building performance.

I. Output Parameters for Comparison

After completing the analysis, the following output parameters were extracted for comparative evaluation:

Parameter	Purpose
Base Shear	To evaluate the total lateral seismic force transmitted to the foundation
Storey Displacement	To assess the overall lateral deformation of each storey
Storey Drift	To verify compliance with permissible drift limits as per respective codes

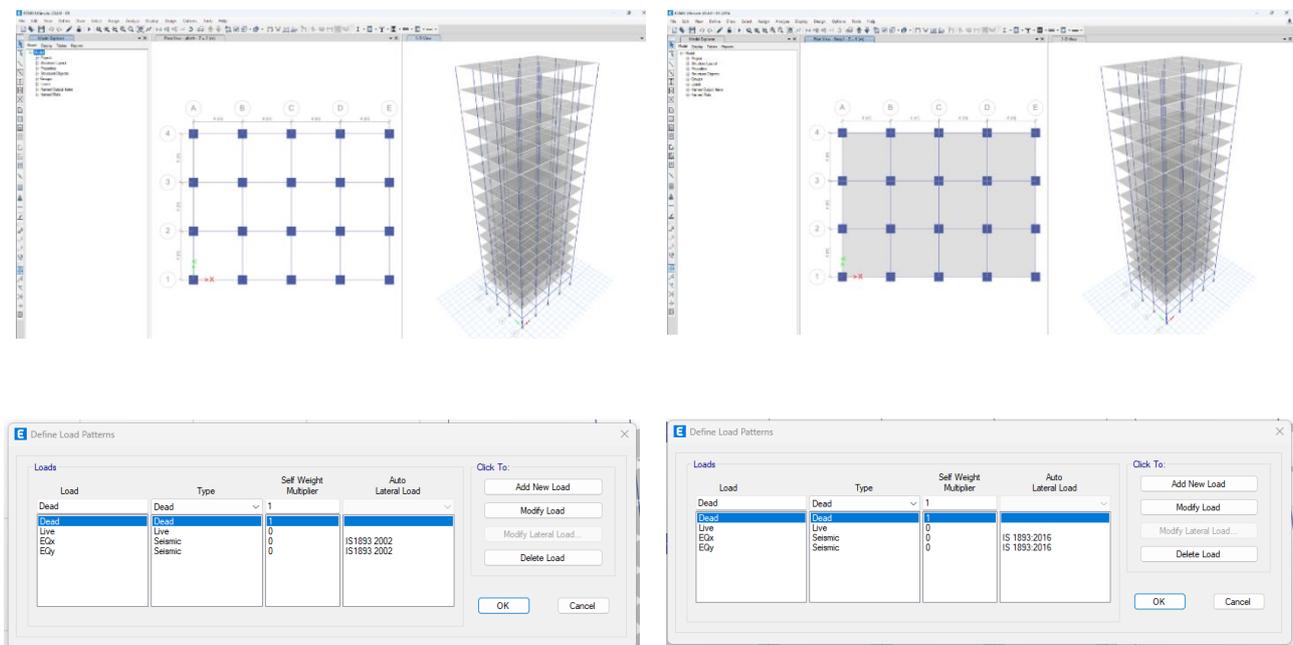


Figure 1.0: Etabs Modeling-IS 1893 2002 & 2016

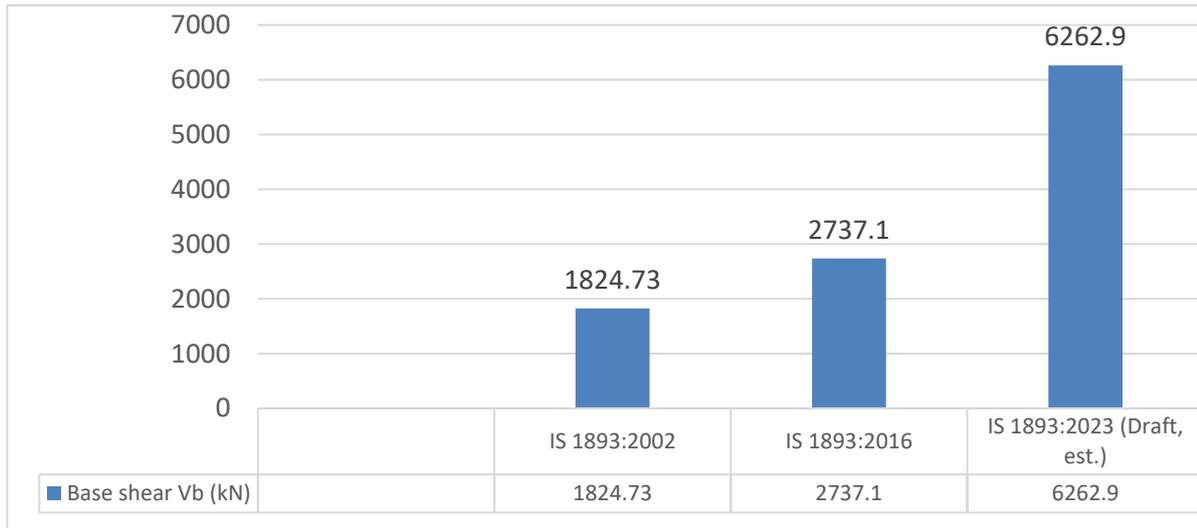
VI. RESULTS & COMPARISON

Comparison of Base Shear -X-Direction (IS 1893:2002, 2016 & Draft 2023)

Table 1.1: Base shear values

Code / Year (Reference)	Base shear Vb (kN)	Seismic weight W(kN)	Horizontal coeff. Ah=Vb/W (decimal)	Ah (%)
IS 1893:2002	1824.73	61042.00	0.02989	2.989%
IS 1893:2016	2737.10	61042.00	0.04484	4.484%
IS 1893:2023 (Draft, est.)	6262.90	61042.00	0.10259	10.259%

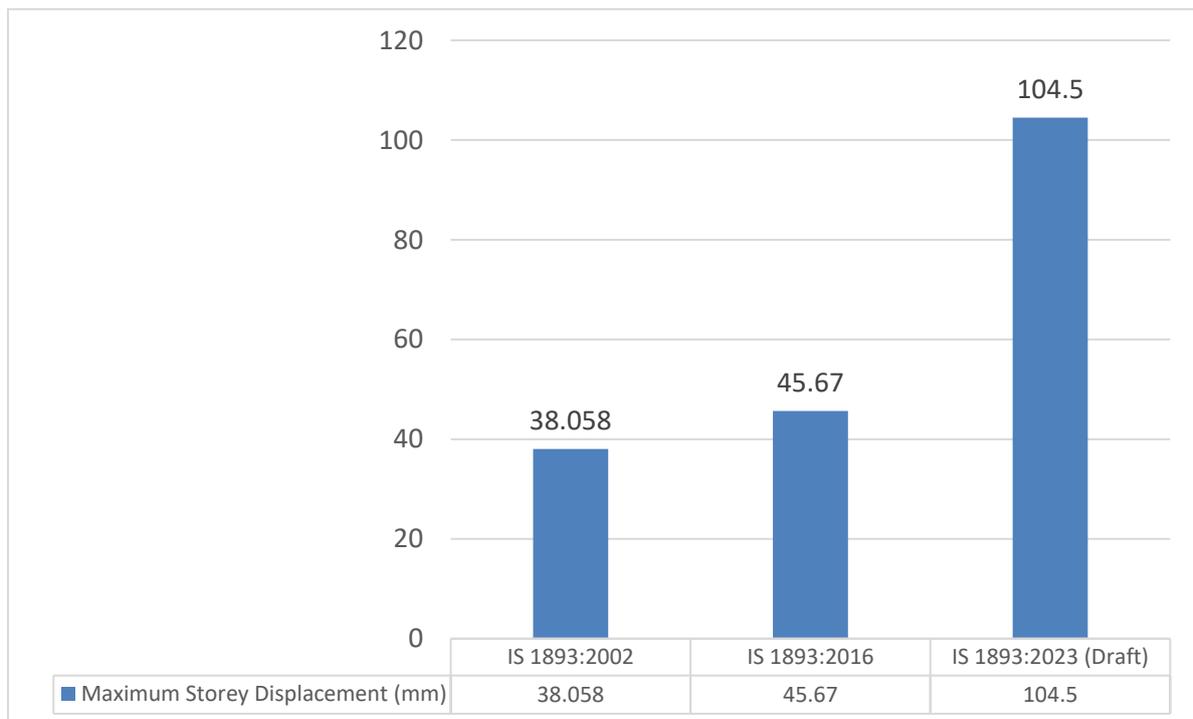
The comparison of base shear and horizontal acceleration coefficients (Ah) as per IS 1893:2002, IS 1893:2016, and the draft IS 1893:2023 reflects the evolution of India’s seismic design approach. The base shear increases from 1824.73 kN (2002) to 2737.10 kN (2016) and 6262.90 kN (2023 draft), while Ah rises from 0.02989 to 0.04484 and 0.10259, respectively. This indicates a steady increase in seismic demand, enhancing safety and resilience. The 2016 code shows about a 50% rise in Ah over 2002, and the 2023 draft a 243% increase over 2002. The latest draft incorporates probabilistic hazard assessment, improved soil classification, and updated load combinations, reflecting a shift toward performance-based, realistic earthquake design for modern multi-storey buildings.



Comparison of maximum storey displacement (IS 1893:2002, 2016 & Draft 2023)

Table 1.2: Maximum storey displacement

Code Version	Maximum Storey Displacement (mm)	% Increase from Previous	% Increase from IS 1893:2002
IS 1893:2002	38.058	–	–
IS 1893:2016	45.670	+20.0%	+20.0%
IS 1893:2023 (Draft)	104.50	+128.8%	+174.6%



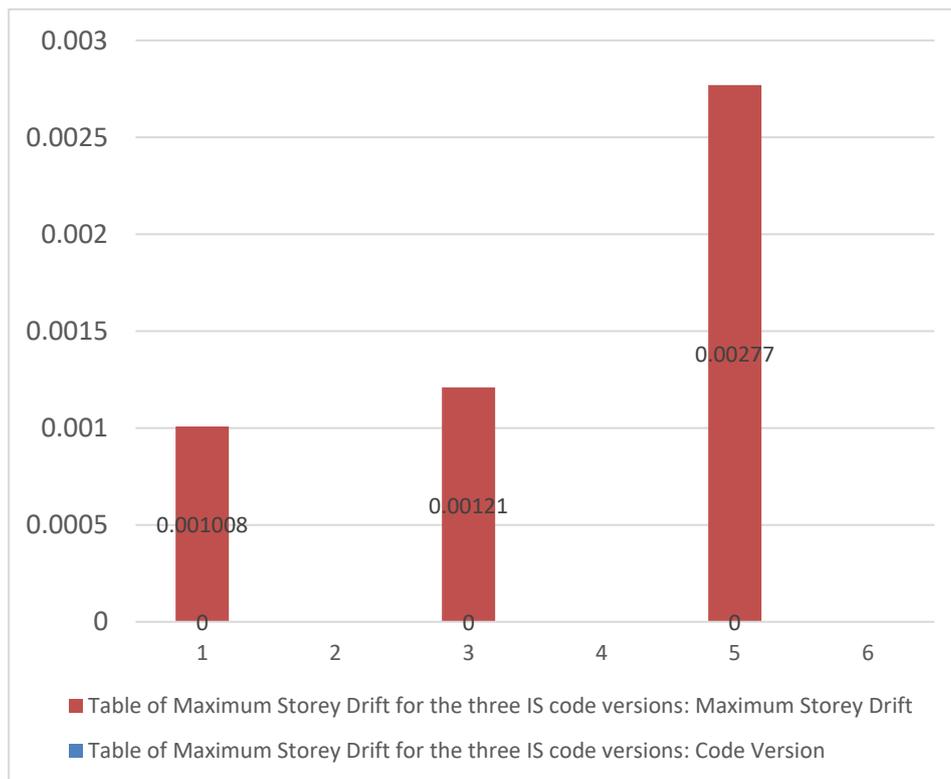
The comparison of maximum storey displacement values under IS 1893:2002, IS 1893:2016, and the draft IS 1893:2023 shows the evolving flexibility and performance requirements in seismic design. Displacement increases from 38.058 mm (2002) to 45.670 mm (2016) — a 20% rise due to updated response spectra and design parameters. The 2023 draft shows a sharp increase to 104.5 mm, about 129% higher than 2016 and 175% above 2002, indicating a shift toward performance-

based design that emphasizes controlled deformation and energy dissipation. Incorporation of probabilistic hazard assessment, revised spectra, and soil flexibility in the latest draft allows structures to sustain safe inelastic deformations, enhancing resilience against strong earthquakes.

Comparison of maximum story drift (IS 1893:2002, 2016 & Draft 2023)

Table 1.3: Maximum Storey Drift

Code Version	Maximum Storey Drift	% Increase from Previous	% Increase from IS 1893:2002
IS 1893:2002	0.001008	–	–
IS 1893:2016	0.00121	+20.0%	+20.0%
IS 1893:2023 (Draft)	0.00277	+128.8%	+174.9%



The comparison of maximum storey drift values as per IS 1893:2002, IS 1893:2016, and the draft IS 1893:2023 shows the evolving flexibility criteria in seismic design. The drift, indicating relative lateral movement between floors, increases from 0.001008 (2002) to 0.00121 (2016) — a 20% rise due to revised seismic coefficients and spectra. The 2023 draft records 0.00277, about 129% higher than 2016 and 175% above 2002, reflecting a shift toward performance-based design that allows controlled inelastic deformation for improved safety. With probabilistic hazard assessment, revised spectra, and soil flexibility included, the latest draft ensures structures are more ductile and resilient, capable of sustaining larger movements without brittle failure.

VII. CONCLUSIONS

The study concludes that:

1. The evolution from IS 1893:2002 → IS 1893:2016 → Draft IS 1893:2023 reflects India’s shift toward modern performance-based seismic design.
2. The base shear, displacement, and storey drift progressively increase in newer codes, signifying stricter seismic safety requirements.
3. The draft IS 1893:2023 incorporates probabilistic hazard mapping, site-specific spectra, soil flexibility, and torsional irregularity effects for more realistic design.



4. Structural engineers must adopt dynamic and nonlinear analysis for better prediction of structural behavior during earthquakes.
5. The transition to performance-based design ensures not only life safety but also functional continuity after major earthquakes.

RECOMMENDATIONS

1. Adopt Updated Codes: Engineers and designers should use the draft IS 1893:2023 provisions for more accurate and reliable seismic design.
2. Advanced Analysis Methods: Incorporate nonlinear time-history analysis and soil–structure interaction studies for realistic modeling.
3. Performance-Based Design: Design structures considering Immediate Occupancy, Life Safety, and Collapse Prevention performance levels.
4. Use of Seismic Control Systems: Employ shear walls, bracing systems, base isolators, and energy dissipation devices to enhance seismic resilience.
5. Future Research: Explore irregular and composite structures, probabilistic hazard assessment, and cost–benefit analysis for sustainable seismic design.

REFERENCES

- [1] Bureau of Indian Standards (2002). IS 1893 (Part 1): Criteria for Earthquake Resistant Design of Structures – General Provisions and Buildings, New Delhi.
- [2] Bureau of Indian Standards (2016). IS 1893 (Part 1): Criteria for Earthquake Resistant Design of Structures – General Provisions and Buildings (Sixth Revision), New Delhi.
- [3] Bureau of Indian Standards (2023, Draft). IS 1893 (Part 1&2): Criteria for Earthquake Resistant Design of Structures – General Provisions and Buildings (Draft for Public Comments), New Delhi.