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An Analytical Comparison of Seismic Design Provisions of is 1893:2016 and is 1893:2025 and its Implications on Reinforced Concrete Building Design

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Abstract - **Seismic design codes play a critical role in minimizing structural damage during earthquakes by providing rational procedures for estimating seismic forces. In India, IS 1893 serves as the principal standard for earthquake-resistant design and has recently been revised as IS 1893:2025 to reflect advancements in seismic hazard assessment and design philosophy. The revised code introduces modifications in seismic zoning parameters and response spectrum formulation, particularly influencing structures with longer natural periods.**

This study presents a manual analytical comparison between the seismic force provisions of IS 1893:2016 and IS 1893:2025 for a tall reinforced concrete moment-resisting frame building. The equivalent static method is adopted to compute design seismic forces without the use of numerical analysis software. Key parameters such as natural period, spectral acceleration, design horizontal seismic coefficient, base shear, and storey-wise force distribution are evaluated and compared. The results indicate an increase in seismic demand under IS 1893:2025, highlighting the impact of revised long-period spectral characteristics. The study provides practical insight into the implications of the updated code provisions for seismic design practice in India.

Keywords - IS 1893:2025, seismic analysis, response spectrum, RC buildings, code comparison

I. INTRODUCTION

1.1 General

India is highly vulnerable to earthquakes due to its complex geological and tectonic setting. A large part of the country lies in regions of moderate to severe seismic risk, and past earthquakes have repeatedly demonstrated the susceptibility of the built environment to seismic damage. Reinforced concrete (RC) buildings constitute the majority of residential and commercial structures in India, making their seismic performance a critical concern for public safety and economic stability.

Earthquake-induced damage to RC buildings is largely influenced by the adequacy of seismic design provisions adopted during planning and construction. Improper estimation of seismic forces, lack of ductile detailing, and non-compliance with codal requirements often result in excessive damage or collapse during strong ground motion. Hence, the role of seismic design codes becomes crucial in ensuring structural safety.

1.2 Seismic Design Codes in India

In India, earthquake-resistant design of structures is governed primarily by **IS 1893 (Criteria for Earthquake Resistant Design of Structures)** published by the Bureau of Indian Standards (BIS). Since its first publication in 1962, IS 1893 has undergone multiple revisions to incorporate advancements in earthquake engineering and lessons learned from damaging earthquakes. Major revisions were released in 1970, 1975, 1984, 2002, and 2016. The **IS 1893:2016** edition introduced refined response spectra, improved soil classification, and clearer analytical procedures. However, increasing urbanization, construction of taller and irregular structures, and improved understanding of seismic hazards highlighted the need for further revision of the code.

1.3 IS 1893:2025 and Need for the Study

The recently released **IS 1893:2025** represents a significant update to the seismic design framework in India. The revised code introduces updated seismic zonation, an enhanced probabilistic basis for seismic hazard representation, extension of design response spectra to longer time periods, and increased emphasis on site-specific considerations. These changes are expected to influence the estimation of seismic forces and design requirements for RC buildings. Despite the importance of these updates, there is limited analytical literature explaining the quantitative impact of IS 1893:2025 provisions on structural design. Practicing engineers and students may find it challenging to interpret how the

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revised spectra and parameters affect seismic force calculations when compared to IS 1893:2016.

II. OVERVIEW OF IS 1893:2016 AND IS 1893:2025

2.1 General

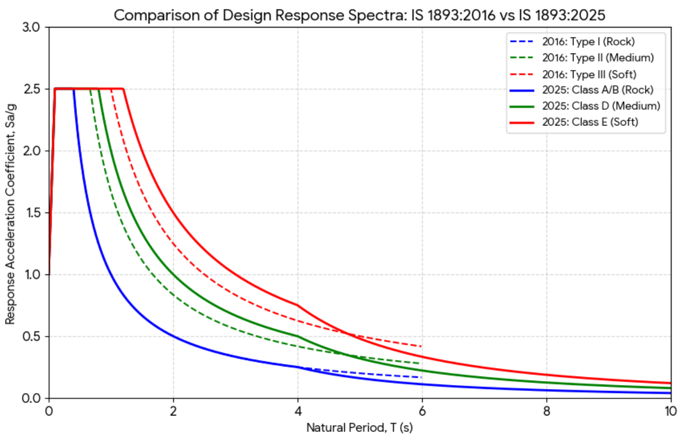
IS 1893, titled "Criteria for Earthquake Resistant Design of Structures", is the principal Indian standard for evaluating seismic forces on structures. The code provides guidelines on seismic zoning, response spectra, importance factors, soil classification, and methods of seismic analysis. Over time, IS 1893 has been revised to incorporate advancements in seismic hazard assessment and structural design philosophy. The **2016 and 2025 editions** represent two key stages in the evolution of seismic design practice in India. While IS 1893:2016 is based on simplified deterministic approaches, IS 1893:2025 introduces refined hazard representation and updated design parameters.

2.2 Seismic Zonation and Hazard Representation

IS 1893:2016 classifies India into four seismic zones, with zone factors representing the expected intensity of ground motion. The zoning approach assumes uniform seismic hazard within each zone and follows a deterministic design philosophy. In contrast, IS 1893:2025 adopts an improved seismic hazard framework based on updated seismic data and probabilistic concepts. The revised code provides better differentiation of regional seismic risk and emphasizes the need for site-specific considerations, particularly for important structures.

2.3 Design Response Spectrum

The design response spectrum in IS 1893:2016 is defined for different soil conditions and is applicable over a limited range of natural periods. This spectral representation is adequate for low- to medium-rise buildings but may not accurately capture seismic demand for taller and more flexible structures. IS 1893:2025 introduces a key modification by extending the design response spectrum to **longer natural periods**, thereby improving the estimation of seismic demand for tall structures. This change represents a major step toward more realistic seismic force evaluation.



2.4 Importance Factor and Soil Effects

IS 1893:2016 assigns importance factors based on the functional use of buildings and classifies soil into broad categories. While this approach is convenient, it provides limited consideration of detailed site effects. The 2025 revision refines the classification of structures based on their post-earthquake importance and places stronger emphasis on soil characteristics and site-specific investigations. This leads to a more rational estimation of seismic demand for critical structures.

III. METHODOLOGY

3.1 General

The objective of this study is to analytically compare the seismic design provisions of **IS 1893:2016** and **IS 1893:2025** and to evaluate their influence on the estimation of seismic forces in reinforced concrete buildings. A **manual calculation-based methodology** is adopted to ensure clarity, transparency, and ease of interpretation. No numerical or finite element software is used in the present study. The methodology involves selecting representative reinforced concrete buildings, identifying relevant seismic design parameters from both code editions, and performing step-by-step seismic force calculations in accordance with codal provisions.

3.2 Selection of Representative Building

To facilitate a meaningful comparison, a typical reinforced concrete moment-resisting frame building is considered. The selected building configuration represents common residential and commercial construction practices in India. The general assumptions adopted for the representative building are:

1. Reinforced concrete moment-resisting frame structure
2. Reinforced concrete moment-resisting frame structure
3. Regular plan and elevation
4. Fixed base condition
5. Uniform storey height
6. Symmetric mass and stiffness distribution

The selected building is assumed to be located in a seismic region where seismic effects govern structural design.

3.3 Assumptions and Design Parameters

For the purpose of analytical comparison, the following assumptions and parameters are considered:

1. Linear elastic behavior of the structure
2. Equivalent static method of seismic analysis..
3. Design seismic forces calculated as per IS 1893:2016 and IS 1893:2025.
4. Same structural geometry, material properties, and gravity loads for both code cases.

Key seismic design parameters such as seismic zone factor, importance factor, response reduction factor, soil type, and damping ratio are selected based on the relevant clauses of the respective codes.

3.4 Analytical Procedure

The seismic force calculations are carried out using the equivalent static method as prescribed in both code editions. The following steps are followed for each case:

1. Determination of the fundamental natural period of the building using codal expressions.
2. Evaluation of the design horizontal seismic coefficient based on seismic zone factor, importance factor, response reduction factor, and spectral acceleration coefficient.
3. Calculation of design base shear acting at the base of the structure.
4. Distribution of base shear along the height of the building to obtain storey-level lateral forces.
5. Comparison of calculated seismic forces obtained using IS 1893:2016 and IS 1893:2025 provisions.

3.5 Comparative Framework

To ensure consistency, all non-seismic parameters are kept constant while varying only the seismic design provisions between the two code editions. The comparison focuses on:

- Design response spectra
- Design horizontal seismic coefficient
- Base shear
- Distribution of lateral forces

The percentage variation in seismic demand due to code revisions is evaluated and discussed.

3.6 Output and Evaluation Criteria

The results of the analytical comparison are presented in the form of tables, equations, and simplified plots. The evaluation criteria include:

- Variation in base shear values
- Influence of revised response spectra
- Implications on structural safety and design conservatism

The findings are interpreted to assess the practical impact of IS 1893:2025 on seismic design practice.

IV. MANUAL SEISMIC DESIGN CALCULATIONS

4.1 General

This chapter presents a detailed **manual calculation of seismic forces** for a representative **high-rise reinforced concrete building** using the provisions of **IS 1893:2016** and **IS 1893:2025**. The equivalent static method is adopted to clearly highlight the influence of revised seismic parameters and response spectrum formulation introduced in IS 1893:2025. Identical building geometry, material properties, and gravity loads are considered for both code editions to ensure a meaningful analytical comparison.

4.2 Description of the Representative Building

To capture the effect of revised long-period spectral ordinates, a tall RC moment-resisting frame building is selected.

Building details:

- Type of structure: RC moment-resisting frame
- Number of storeys: **G + 15 (16 storeys)**
- Storey height: 3.0 m
- Total building height, $h = 48$m
- Plan dimensions: 18 m × 15 m
- Structural system: Special RC moment-resisting frame
- Foundation condition: Fixed base
- Building regularity: Regular in plan and elevation

4.3 Seismic Design Parameters

Common Parameters (Both Codes):

- Importance factor, $I = 1.0$(Residential building)
- Response reduction factor, R = 5.0
- Soil type: Medium soil
- Damping ratio: 5%

Seismic Zone:

The building is assumed to be located in a **high seismic region (Zone V)** to clearly observe the effect of revised hazard representation.

- Zone factor as per IS 1893:2016, Z_{2016} = 0.36
- Revised zone factor as per IS 1893:2025, Z_{2025} = 0.40

4.4 Fundamental Natural Period of the Building

As per IS 1893, the approximate fundamental natural period for RC moment-resisting frame buildings is given by:

$$T=0.075h^{0.75}$$

$$T=0.075(48)^{0.75}$$

$$T = 0.075 \times 18.2 = 1.37 \ sec$$

4.5 Design Response Spectrum

4.5.1 IS 1893:2016 (Medium Soil)

For medium soil and 5% damping, when:

$$0.55<T\leq 4.0 \text{ sec}$$

The design spectral acceleration coefficient is given by:

$$Sa/g = 1.36/ T$$

$$Sa/g = 0.99$$

4.5.1 IS 1893:2025 (Medium Soil)

IS 1893:2025 modifies the descending branch of the response spectrum to better represent long-period ground motion effects. For medium soil and 5% damping, the revised expression is:

The design spectral acceleration coefficient is given by:

$$Sa/g = 1.36/ T^{0.9}$$

$$Sa/g = 1.02$$

4.6 Design Horizontal Seismic Coefficient

The design horizontal seismic coefficient is calculated as

$$Ah= Z/2 * I/R * Sa/g$$

4.6.1 IS 1893:2016

$$Ah=0.0356$$

4.6.2 IS 1893:2025

$$Ah=0.0408$$

4.7 Seismic Weight of the Building

The total seismic weight of the building, including dead load and applicable portion of imposed load, is calculated and assumed as:

$$W=30{,}000 \text{ kN}$$

(This value is kept identical for both cases.)

4.8 Design Base Shear

$$Vb=Ah\times W$$

4.8.1 Design Base Shear as per IS 1893:2016

$$Vb= 0.0356\times 30{,}000$$

$$Vb= 1068 \text{ KN}$$

4.8.2 Base Shear as per IS 1893:2025

$$Vb= 0.0408\times 30{,}000$$

$$Vb= 1224 \text{ KN}$$

4.9 Percentage Increase in Base Shear

$$\% \text{ Increase} = 14.6\%$$

4.10 Distribution of Base Shear

The calculated base shear is distributed along the height of the building using:

$$Qi=\sum Wihi/Wihi\times Vb$$

Storey-wise lateral forces are calculated for both code editions following the same procedure.

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Store No.	Heigh (h_i) (m)	(Q_i) (kN) IS:1893:201	(Q_i) (kN) IS:1893:202
1	4	125.	14
1	4	117.	13
1	4	11	12
1	3	102.	11
1	3	94.	10
1	3	86.	9
1	3	78.	9
	2	70.	8
	2	62.	7
	2	54.	6
	1	47.	5
	1	39.	4
	1	31.	3
		23.	2
		15.	1
		7.	
Total	–	1068 kN	1224 kN

V. RESULTS AND DISCUSSION

5.1 General

This chapter presents a comparative discussion of the seismic analysis results obtained using IS 1893:2016 and IS 1893:2025. The comparison is based on manual calculations performed using the equivalent static method for a tall reinforced concrete moment-resisting frame building. The influence of revised seismic parameters and response spectrum formulation introduced in IS 1893:2025 is evaluated.

5.2 Comparison of Design Parameters

The fundamental natural period of the selected G+15 building was found to be 1.37 seconds, placing the structure in the long-period range where the impact of revised spectral ordinates becomes significant. While the overall analysis procedure remains similar in both codes, IS 1893:2025 introduces modifications in seismic hazard representation and response spectrum shape, particularly for medium soil conditions.

5.3 Comparison of Base Shear

A comparison of the calculated design base shear values reveals a noticeable increase in seismic demand when IS 1893:2025 provisions are used.

Code Edition	Design Base Shear (kN)
IS 1893:2016	1068
IS 1893:2025	1224

The base shear obtained using IS 1893:2025 is approximately 14.6% higher than that obtained using IS 1893:2016. This increase can be attributed to the revised zone factor and modified long-period response spectrum adopted in the updated code.

5.4 Storey-wise Lateral Force Distribution

The storey-wise distribution of seismic forces shows that lateral force demand increases with building height for both code editions. IS 1893:2025 results in consistently higher lateral forces at all storey levels, with the most significant increase observed at the upper storeys. This highlights the increased sensitivity of tall buildings to long-period ground motion effects accounted for in the revised code.

5.5 Engineering Implications

The increase in base shear and storey-level forces under IS 1893:2025 implies higher design forces for structural members such as beams, columns, and foundations. While this may lead to increased material consumption, it enhances the overall seismic safety and reliability of tall structures. The revised provisions encourage more realistic assessment of seismic demand, particularly for high-rise buildings located in high seismic zones.

5.6 Summary of Results

The analytical comparison clearly indicates that IS 1893:2025 results in higher seismic demand for tall reinforced concrete buildings compared to IS 1893:2016. The observed increase emphasizes the importance of adopting the revised code provisions in seismic design practice to ensure improved structural performance during earthquakes.

VI. CONCLUSION

The present study analytically compared the seismic design provisions of IS 1893:2016 and IS 1893:2025 using a manual calculation-based approach for a tall reinforced concrete moment-resisting frame building. The equivalent static method was employed to evaluate seismic forces, ensuring transparency and ease of interpretation without reliance on numerical software.

The results indicate that IS 1893:2025 introduces a more refined representation of seismic hazard and long-period ground motion effects, leading to an increase in design base shear and storey-level lateral forces. For the selected G+15 building, the design base shear increased by approximately 15% under the revised code provisions. This increase is particularly significant for taller structures, where long-period response governs seismic behavior.

The study concludes that IS 1893:2025 provides a more conservative and realistic framework for earthquake-resistant design, especially for high-rise buildings in seismic regions. Adoption of the revised code is expected to enhance structural safety and resilience, contributing to improved seismic performance of buildings in India.

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