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Comparative Study on Structural Design and Cost Analysis of Low-Rise Public Building Designed as per IS 1893:2016 and Withdrawn IS 1893:2025 Seismic Provisions

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Abstract: The Bureau of Indian Standards (BIS) has issued IS 1893:2025 with major revisions to revise the seismic hazard assessment, zoning and design provisions for earthquake resistant structures. But the code was withdrawn soon after its publication and IS 1893:2016 still remains the prevailing seismic design code in India. Although withdrawn, the assessment of the engineering implications of the proposed provisions provides valuable insight to the potential impact of future revisions to Indian seismic design practice.

The present work is an attempt to compare the structural and economical aspects of G+2 with Mumty railway station building designed as per IS 1893:2016 and withdrawn IS 1893:2025 provisions. The building at Devprayag, Uttarakhand, India was modelled and analysed in ETABS with the same geometry, material properties, loading conditions and design assumptions excepting the seismic parameters prescribed by the two codes. The comparison was done based on design base shear, storey displacement, storey drift, reinforcement requirement & construction cost.

The results show that the seismic provisions of IS 1893:2025 would increase the design base shear by about 2.25 times, maximum storey displacement at Mumty level by 2.147 times and maximum storey drift by 2.187 times compared to IS 1893:2016. The average reinforcement requirement was increased by 24.9% for beams and 49.5% for columns, leading to an increase in the total structural cost of about 27%. The study shows that the provisions, which were withdrawn, lead to a considerably more conservative design with higher seismic resistance and simultaneously cause a significant increase in the amount of material used and the construction cost. The results provide valuable technical information for structural engineers, researchers and code development authorities on the practical implications of proposed amendments to seismic design standards for low rise public buildings.

Keywords: IS 1893:2016; IS 1893:2025; Seismic Design; Reinforced Concrete Building; Structural Analysis; Construction Cost Assessment; Earthquake-Resistant Design, Railway Station Building.

I. INTRODUCTION

The effect of an earthquake on a structure depends not only on how strong the ground shakes but also on the structure's design, construction quality, and building methods used. As cities grow and infrastructure develops, making buildings safe from earthquakes has become a vital part of structural engineering.

India is very susceptible to earthquakes due to its varied geological and tectonic conditions. A large part of the country lies in areas with moderate to severe seismic activity, which makes earthquake-resistant design essential for construction. Regions like the Himalayas, northeastern states, and some areas in northern and western India have experienced major earthquakes in the past. This shows that the requirement of strong design standards and building practices.

To ensure that structures can withstand earthquakes, the Bureau of Indian Standards (BIS) has created and regularly updated seismic design codes. IS 1893, titled "Criteria for Earthquake Resistant Design of Structures," is the main code that oversees seismic analysis and design in India. It offers guidelines for estimating seismic forces, assessing how structures respond, and perform well during earthquakes.

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At very start India was split into seven earthquake zones, i.e. Zone 0 to Zone VI. To more accurately depict the seismic characteristics of various places, the boundaries of numerous zones were altered in 1966 when the map was updated with newly available earthquake data. India saw several large earthquakes between 1966 and 1984. The seismic zones reduced to five zones, ranging from Zone I to Zone V, with Zone 0 being eliminated, based on the lessons learned from these incidents.

Another significant update to the map was made in 2002. There are now only four seismic zones: Zones I, III, and V. By taking a more cautious approach, this amendment made sure that even areas with comparatively lesser seismic risk included a minimal degree of earthquake-resistant architecture. The 2002 zoning framework's validity and applicability were confirmed by the 2016 revision, which kept the same seismic zone map.

A new Zone VI has been added to IS 1893:2025 to indicate regions with exceptionally high seismic susceptibility. The table given below represents the update of the seismic zones as per revision of IS 1893:2025.

TABLE I EVALUATION OF SEISMIC ZONE FACTOR

<table>
<tr><th>1966</th><th>1984</th><th>2002</th><th>2016</th><th>2025</th></tr>
<tr><td>0</td><td rowspan="2">I</td><td rowspan="3">II</td><td rowspan="3">II</td><td rowspan="3">II</td></tr>
<tr><td>I</td></tr>
<tr><td>II</td><td>II</td></tr>
<tr><td>III</td><td>III</td><td>III</td><td>III</td><td>III</td></tr>
<tr><td>IV</td><td>IV</td><td>IV</td><td>IV</td><td>IV</td></tr>
<tr><td>V</td><td rowspan="2">V</td><td rowspan="2">V</td><td rowspan="2">V</td><td>V</td></tr>
<tr><td>VI</td><td>VI</td></tr>
</table>

Until 2016, seismic zoning was mostly determined by past seismic events, measured intensities, and historical earthquake records. However, a major change in technique is introduced in the 2025 version. Probabilistic Seismic Hazard Analysis, or PSHA, a more sophisticated and scientific method that assesses the probability of various degrees of ground shaking occurring over a certain time period, was used to create the new seismic zone map. As a result, the new zoning system strengthens the foundation for earthquake-resistant architecture throughout India and offers a more accurate evaluation of seismic danger.

II. LITERATURE REVIEW

Ahirwar, J., & Saxena, A. K. [1]. Seismic analysis and cost comparison of multistorey building on sloping ground. International Journal for Research Trends and Innovation (IJRTI), Volume 7, Issue 7, ISSN 2456 3315. In this study, the performance of a 10-storey concrete building during an earthquake is analysed in two cases: 1. the building is located on a flat ground. 2. the building is located on a 20-degree slope. Different types of soils and expenses are considered. The identical G+10 RC frame is considered in ETABS for Zone V according to IS 1893 standards. The analysis is done twice, on flat land and on a slope, for soft, medium and hard soils. The researchers examined at how much the building bent, twisted, and sheared at the base. They also assessed sway and inter story movement. They also figured just how much concrete and steel material they would require. Especially on soft soil, when erected on a slope, the structure shows higher bending moments and torsion. So you have to add more reinforcement to deal with this. For a 20-degree slope, the base shear increases. Also, storey displacement grows with the slope, mainly up top. Meanwhile, the fundamental time period drops as the slope rises. Costs climb too. Buildings on soft soil start off pricey, and the price jumps around 20% from level to a steep 20-degree slope. (Ahirwar and Saxena, 2022)

Ajay Kumar [2] "A comparative study of static analysis (as per IS: 1893-2002) & dynamic analysis (as per IS: 1893-2016) of a building for zone V" International Journal of Civil Engineering and Technology (IJCIET) In this study, buildings of varying heights (4, 8 and 11 stories) were modelled and analysed using Staad Pro software. The seismic analysis was performed using two Indian codes namely IS: 1893 -2002 and IS: 1893-2016. Static seismic analysis was performed with the old code for buildings up to 39.6m high and dynamic seismic analysis with the new code. Factors such as axial force, bending moment, displacement and material quantities were considered. A cost study was also done for steel and concrete. The results indicated that the amount by dynamic method is 1.06 to 1.1 times more expensive

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than the buildings developed by static method. The economic ramifications of the seismic design methodologies prescribed by the respective Indian regulations have become more apparent. (Kumar and Chand, 2019)

Davari, O. S., & Patil, A. D. [11] Seismic assessment of public building by IS 1893-1984 in comparison with IS 1893-2016. International Journal of Creative Research Thoughts (IJCRT), Volume 10, Issue 5, May 2022, ISSN 2320-2882. This paper looks at how a real G+4 RCC public building—a bank—behaves during an earthquake based on two sets of rules: the old IS 1893-1984 code and the new IS 1893-2016 code. The researchers built an exact 3D model of the structure in ETABS, including all the actual dimensions of columns, beams, and walls, as well as the loads from things like floors, stairs, and stored items. What they found is pretty interesting. When using the 2016 code instead of the 1984 one, the total lateral forces and base shear increase by roughly a third in the X direction and a fifth in the Y direction. This indicates the 2016 code requires a much stronger design. Also, after beefing up the structure to meet these heightened standards, the team noticed the max displacements and story drifts were smaller compared to the 2016-based design, suggesting the building responds more rigidly and safely to quakes. However, because the original building likely doesn't fit the stricter requirements of the 2016 code, the study suggests tacking on a shear wall at the lift shaft to boost its lateral resistance. The 2016 code increases earthquake force estimates, highlights those existing structures. (Davari and Patil, 2022)

Dheple, M. R., & Shaikh, M. Z. [12]. Comparative study of old earthquake IS codes IS 1893:2002, IS 1893:2016 and draft IS 1893:2023 using multi-storey RCC building analysis. International Advanced Research Journal in Science, Engineering and Technology This paper examines how three versions of the Indian earthquake code—IS 1893:2002, IS 1893:2016, and the draft IS 1893:2023—affect the design of a multi-story reinforced concrete building. A standard G+14 reinforced concrete building is created in ETABS, and seismic analysis is performed using the response spectrum method based on each code. The same building model is used for all three code versions, and important seismic results are collected and compared. The study shows that newer codes require higher seismic forces and allow more controlled lateral movement.

Base shear increases significantly from the 2002 code to the 2016 code, and it rises even more with the 2023 draft, indicating that seismic requirements are becoming more demanding. Maximum displacement and drift values also increase, a shift toward performance-based design, where buildings are expected to safely move during an earthquake rather than remain almost rigid. The authors mention that the draft IS 1893:2023 includes more advanced and realistic guidelines and recommend that engineers use dynamic and nonlinear analysis to better understand how buildings respond during earthquakes. (Prof. M. Z. Shaikh, 2025)

Dutta, A. B., & Shukla, D. [13]. Seismic Zone VI in IS 1893 (Part 1): 2025 — A critical review and design implications. International Journal of Latest Technology in Engineering, Management & Applied Science (IJLTEMAS), Volume XIV, Issue XII, December 2025. This paper explains what it means when IS 1893 (Part 1): 2025 adds a new Seismic Zone VI for India. Previously, engineers only had to design buildings up to Zone V, assuming that was the worst-case scenario. Now, with Zone VI having Z = 0.75 compared to Zone V's Z ≈ 0.36, the code tells designers that certain areas face way more intense shaking. The authors prove that changing just the seismic zone from V to VI for a standard 6-storey RC frame building results in more than double the base shear. This means every component—columns, beams, foundations, and drifts—needs to meet stricter standards.

Additionally, the paper states that simply increasing member sizes isn't sufficient for these extreme zones. Instead, designers must plan the entire system to be regular, ductile, and continuous in load path. They have to conduct full 3D dynamic analysis, manage torsion and soft stories, carefully follow detailing rules for beams, columns, and shear walls as laid out in IS 13920, and account for soil-structure interaction and foundation behaviour plain terms, moving to Zone VI shifts the goal in Indian practice from ensuring life safety during strong shaking to avoiding collapse. (Bijon Dutta and Durgesh Shukla, 2025)

Gupta, R. K., & Budhlani, D. L. [14]. Review of IS 1893:2016 with IS 1893:2002 with plan irregularity. International Journal of Scientific Engineering and Research (IJSER), Volume 6, Issue 2, February 2018, ISSN 2347-3878. The researchers in this study examined a 10-storey concrete building in two different formats – one with a standard rectangular layout and the other with a plan irregularity. The team did the analysis two times for each version of the buildings. They did it first using the guidelines from IS 1893:2002 and then they did it again using the new rules from IS 1893:2016. All the buildings were the size, and they all used the same materials and loads. The team used something called response spectrum analysis with a program called STAAD. PRO to do this project. When the team switched from using the 2002 code to the new 2016 code they saw a big increment in the total lateral force for both types of models. Total base shear, for IS 1893:2002 and IS 1893:2016 went up by 30 percent for both the X direction and the

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Y direction. directions. Plus, the maximum lateral displacements across all directions (X, Y, and Z) increased too – somewhere between 40 to 60%. This indicates that the updated code essentially requires designs to be tougher and forecasts bigger movements. Also, buildings with plan irregularities showed generally less favourable performance compared to those with a regular frame. To sum it up, the IS 1893:2016 standards make earthquake forces and displacements more substantial for both regular and irregular layouts.(Volume 6 Issue 2, February 2018 www.ijser.in Licensed Under Creative Commons Attribution CC BY, 2018)

Haresh Kumar Solanki, Mili Sankhla [15]. Seismic resilience assessment of G+14 Buildings: A comparative analysis of IS 1893 PART-1 (2023) Draft and IS 1893 Part-1 (2016) The guidelines of IS 1893 Part-1:2016 and the projected IS 1893 Part-1:2023 are used in this study to compare the response of a G+14 building. The main goal of this study is to see how the building behaves when there is an earthquake and to look at the spectrum acceleration response.IS 1893 Part-1:2016 and IS 1893 Part-1:2023 have some differences in seismic design parameters and these changes can affect how safe and strong the building is. To understand how earthquake design is developing we looked at things like the time period of the building the modal participation factor and the damping ratio. The new rules are supposed to make buildings better, at withstanding earthquakes and to make them more stable and resilient. The report shows how the revised IS 1893 Part-1:2023 guidelines can improve the performance of a G+14 building. Additionally, the comparative analysis offers useful data about the practical implications and efficiency of the suggested code revisions for current earthquake-resistant design.(Haresh Kumar Solanki, Mili Sankhla 2024)

Jagdishbhai, P. K. [16]. Comparative study of seismic design provisions: Impact of IS 1893:2025 Part 1 and Part 5 on multi-storey RC buildings. International Journal of Creative and Open Research in Engineering and Management, 02(05), Article 402. This article looks at how Reinforced Concrete (RC) buildings fare in earthquakes under the current Indian earthquake code, IS 1893:2016, compared to a stricter 2025 version that was eventually withdrawn. The 2025 code changed everything; instead of its straightforward, zone-based approach, it incorporated a more complex probabilistic hazard method. It added a new Zone VI and enhanced its design spectrum for taller buildings. Moreover, it brought clearer guidelines and checks for building irregularities and non-structural parts. To examine the actual impact, the writer modelled three RC structures—a six-story, fourteen-story, and nineteen-story building—in ETABS and analysed them according to the 2025 code and the 2016 one. They found some pretty drastic differences. For instance, under the 2025 rules, earthquake forces and deformations significantly increased. Base shear jumped between 1.4 to 1.8 times, roof displacement doubled or exceeded, and inter-storey drifts rose between 1.3 to 2 times. That means buildings would need sturdier lateral systems and heavier reinforcement, particularly the mid and high-rise ones. (Prajapati Keyur Jagdishbhai and Dr. Poonam I. Modi, 2026).

Keer, S. N., Pilankar, K. M., Pilankar, S. V., & Gujarathi, S. S. [17]. A comparative study of IS code 1893-2002 and IS code 1893-2016 for the design of earthquake-resistant structure. IRE Journals, Volume 4, Issue 12, ISSN 2456-8880. The authors of this paper look at two buildings made of concrete. One building has four floors. The other has seven floors. They want to see how these buildings would do during an earthquake. They use two versions of the Indian earthquake code to do this. The two versions are the IS 1893-2002 and the new IS 1893-2016.

The Indian earthquake code has rules that change. The shape and materials of the buildings are the same. The authors use a program called ETABS to find out the sideways force at the bottom of the building, which is called base shear. They also find out how much each floor moves compared to the one below which is called storey drift. When they use the Indian earthquake code they find that both buildings experience more force from the earthquake and show bigger movements. For the building with four floors, the movement and the base shear increase by sixty percent. For the building with seven floors the movement almost. The base shear goes up a lot. This happens because the new Indian earthquake code uses an importance factor for buildings where people live. It also treats the building as if it is already cracked, which makes it less strong and leads to movement and higher forces. In terms the new Indian earthquake code thinks the building is a bit weaker, so it needs to be designed to be stronger. This can increase costs. It makes the building safer when there is an earthquake. The new Indian earthquake code makes sure the building is safer, for people. (Keer et al., 2021)

M. Bello, A.A Adedeji, R.O. Rahmon, and M.A. Kamal [18]. "Dynamic Analysis of Multi-Storey Building under Seismic Excitation by Response Spectrum Method using ETABS" Journal of Research Information in Civil Engineering This study carryout to see how building the ones made of RCC handle earthquakes. The people doing the study used a computer program called ETABS to make a model of a building. They wanted to see what happens to the building when there is an earthquake. They made the model. Then they looked at it according to some rules. What they found out was that the building moves the most and gets deformed the most on the floor when the earthquake hits from one side. This is important to know because it helps us understand how buildings react when the ground shakes. The study shows us things that can help us design buildings that can withstand earthquakes better. (Bello et al., 2017)

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Patel, I. [19]. A critical review and comparative study of IS 1893:2016 and IS 1893:2023 (Part 1 and 2) with applications in seismic design. International Journal of Innovative Research in Technology (IJIRT), 11(1), 2103–2107, ISSN 2349-6002. This paper looks at the differences between the 2016 and draft 2023 versions of the Indian earthquake code IS 1893, focusing on buildings and liquid tanks. It covers changes in zone factors, , lateral force formulas, and soil interaction with structure. To help these changes, there's a small example included that lets designers see how the numbers actually shift rather than just describing the changes in words. The sample problem involves designing a 4-storey building in IV earthquake zone and on medium soil twice – first with the 2016 rules, then with the 2023 draft guidelines. Using the updated spectral values in 2023, the design coefficient Ah increases slightly. Consequently, the design base shear rises from around 540 kN to 594 kN, which is a roughly 10% bump. So, the takeaway is that the new draft aims for greater safety by making designs more conservative and precise. However, it also means the calculations get more intricate and require lots of data, which means engineers have to use better tools and gather more seismic and soil info to handle these changes properly.(2024)

Ravikant Singh, Vinay Kumar Singh [20]. "Analysis of Seismic Loads acting on multi-storey Building as per IS: 1893-2002 and IS: 1893-2016-A comparative Study" Journal of Civil Engineering and Environmental Technology The way that design structures to resist earthquakes has significantly improved in the past several years. The 2016 revision of the Indian seismic code, IS 1893, a major change after almost 14 years, demonstrates this advancement. The study examines the seismic loads for a four-story reinforced concrete multi-story building in detail and contrasts the recommendations from the most recent IS 1893-2016 with those from the earlier IS 1893-2002. The study focuses on a particular structure that was created in accordance with the previous code. The main objective is to assess the structure's earthquake resistance and evaluate its safety while considering the new IS code into account. (Singh and Singh, 2021)
Rita Debnath, Lipika Halder [21]. "A Comparative Study of the Seismic Provisions of Indian Seismic Code IS 1893 2002 and Draft Indian Code IS 1893:2016" Advances in Structural Engineering, Volume 2 This study analyses the 2002 and current Indian Seismic Code (IS 1893: 2016) earthquake design guidelines. It looks on differences in earthquake-related building design guidelines. Significant differences in calculations, including building shaking duration, structural validity, and other parameters, are found in the study. The revised standard simplifies some earthquake design guidelines and adds more details on building flaws and the impact of brick walls. The results, which show the similarities and differences between the two code versions, are displayed in simple tables and graphs.(Debnath and Halder, 2019)

Saxena, N. K. [22]. Critical comparison of IS 1893-2002 and IS 1893-2016. International Journal of Engineering Development and Research (IJEDR), Volume 14, Issue 1, ISSN 2321-9939. The article talks about how the old Indian earthquake code, IS 1893-2002, differs from the IS 1893-2016, looking at things from a designer's perspective. The code has improved response spectra, especially helpful for tall buildings. Engineers now need to model Reinforced Cement Concrete (RCC) frames as if they were cracked, not solid. Rules for infill walls and irregular buildings are clearer too. Plus, there's a stronger push towards dynamic analysis rather than just using static methods. Overall, this brings Indian practices more in line with modern international standards. To highlight the difference, the author looks at a basic five-story residential building in Zone IV, figuring out the seismic weight and base shear under both sets of rules. Using the 2002 guidelines, the base shear comes to around 710 kN. With the 2016 code and a more realistic model, this jumps by about 40% to around 994 kN. So, the main takeaway is that the new code generally ups the seismic requirements, demands better modeling, and makes analysis more thorough. Structures end up safer but will cost more in materials and design work. (Saxena, 1893)

III. RESEARCH GAP

A review of existing literature indicates that considerable research has been conducted on the seismic analysis and design of reinforced concrete buildings using previous versions of seismic codes, particularly IS 1893:2002 and IS 1893:2016. However, limited research is available on the comparative assessment of buildings designed according to IS 1893:2016 and the recently introduced IS 1893:2025.

Also, most of the research focus on high-rise or irregular buildings and not much work has been done on low-rise residential buildings. Also, little research has been done to assess the impact of updated seismic regulations on construction cost and material usage. Hence, a detailed assessment of the structural performance and economic impact due to the implementation of IS 1893:2025 is required.

The key research gaps are:

- Limited studies on low rise RCC buildings.
- Most research focuses on medium- and high-rise structures.

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- Lack of detailed comparison between IS 1893:2016 and Proposed IS 1893:2025 for low-rise buildings.
- Insufficient studies on the impact of revised seismic provisions on member design and reinforcement requirements.
- Very limited research on construction cost implications of the proposed code changes.
- Absence of a comprehensive study combining structural design and cost analysis for G+2 with Mumty RCC buildings.

To enable to offer a complete understanding of the development of seismic design standards in India, this review study tries to collect, compare, and critically examine the important seismic design provisions of IS 1893:2016 and the proposed IS 1893:2025

IV. RESEARCH OBJECTIVES

The goals of the present study are:

- To model and analyse a low-rise railway station reinforced concrete building using structural analysis software.
- Model the structure by adopting the analysis as per IS 1893:2016.
- Model the structure by adopting the seismic analysis as per IS 1893:2025.
- Compare lateral forces, storey displacement, storey drift, & cost of structure.
- Compare the demand of reinforcement and concrete quantities resulting from the revised seismic provisions.
- To perform comparative construction cost analysis for both design approaches.

V. METHODOLOGY

The focus of this study is to analyse the construction costs and structural behaviour of a public reinforced concrete building designed in accordance with IS 1893:2016 and the projected IS 1893:2025 seismic regulations. A G+2 with Mumty reinforced concrete building was selected for the present study. The selected structure represents a typical low-rise building commonly used for commercial purposes. The geometry, material properties, and loading conditions were kept same for real comparison between the two seismic code provisions.

The building consists of reinforced concrete beams, columns, and slabs designed according to relevant Indian Standard codes. The selected configuration evaluating the influence of revised earthquake provisions structural behaviour & construction cost. The design parameters required for the analysis were collected from relevant Indian Standard codes and published technical documents. The seismic parameters such as seismic zone factor, soil type, importance factor, and response reduction factor were selected according to code provisions.

The following phases define the methodology used for the study:

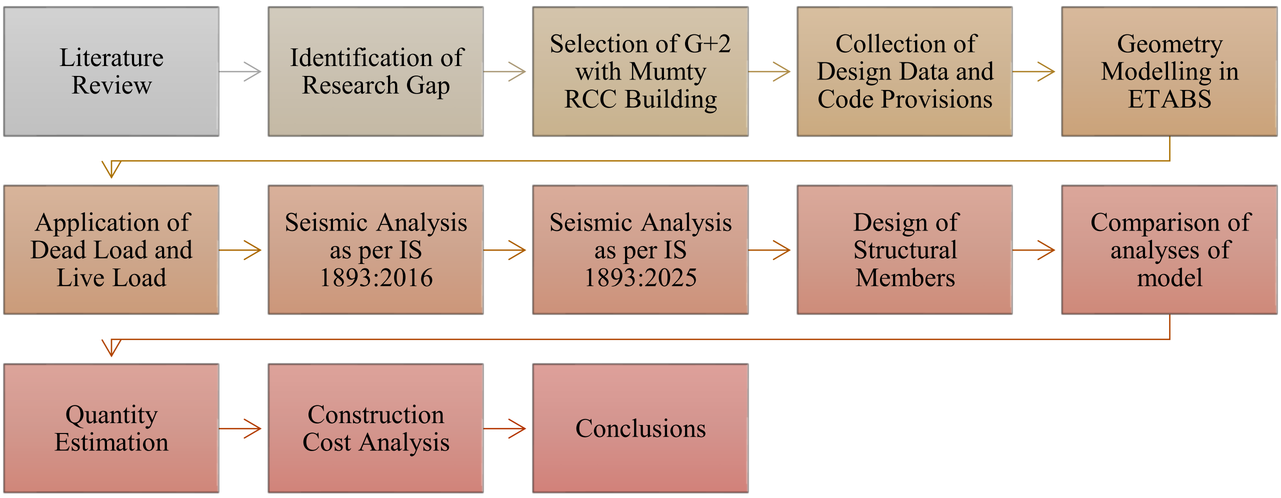

Fig. 1 Research Methodology Flow Chart

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VI. ANALYSIS

The seismic analysis is performed on a G+2 with Mumty reinforced concrete station building as a prototype structure. The building comprises passenger facilities on the ground floor, staff accommodation on the first and second floors an accessible roof terrace and Mumty. A brief description of the architectural configuration used for structural modelling is described in below paragraph.

The ground floor is planned to accommodate passenger amenities and station operations. It consists of a Waiting Room (4.0 m × 6.0 m) for passenger convenience, a Station Superintendent (SS) Room (3.335 m × 6.0 m) for administrative functions, Male and Female Toilets (1.8 m × 1.923 m each), an additional Toilet (1.8 m × 1.923 m), an Infant Nursing Cubicle (3.77 m × 1.57 m) beneath the staircase landing, a 2.5 m wide Verandah for passenger circulation, and a staircase providing access to the upper floors. The first floor is designated for staff welfare facilities and includes a Female Staff Rest Room (4.0 m × 6.0 m), a Male Staff Rest Room (3.335 m × 6.0 m), Male and Female Toilets (1.8 m × 1.923 m each), an additional Female Toilet (1.8 m × 1.923 m), a 2.5 m wide Verandah, and a staircase for vertical circulation. The second floor has the same layout as the first floor, comprising a Female Staff Rest Room (4.0 m × 6.0 m), a Male Staff Rest Room (3.335 m × 6.0 m), Male and Female Toilets (1.8 m × 1.923 m each), an additional Female Toilet (1.8 m × 1.923 m), a 2.5 m wide Verandah, and a staircase. The roof floor comprises an open terrace accessible through the staircase. A Mumty is provided over the staircase to facilitate safe roof access and protect the stair enclosure.

The design parameters used for the Analysis of the Buildings are given below:

TABLE II : PARAMETERS USED FOR THE ANALYSIS

No. of Structure Storeys	G+2 with Mumty
Height of the structure	17.25 m
Length of Building	13.639 m
Width of Building	8.66 m
Area of Building	118.11 m^2
Plan Shape	Rectangular
Slab Thickness	Base slab at plinth level = 175 mm rest all the slab is 150 mm
Floor-to-Floor Height	Base to GF = 2.25 m, GF to FF = 4.2 m, FF to SF =3.9 m, SF to RF = 3.9 m, Mumty = 3 m
Concrete Grade	M30
Structural Reinforcement Grade	FE500D

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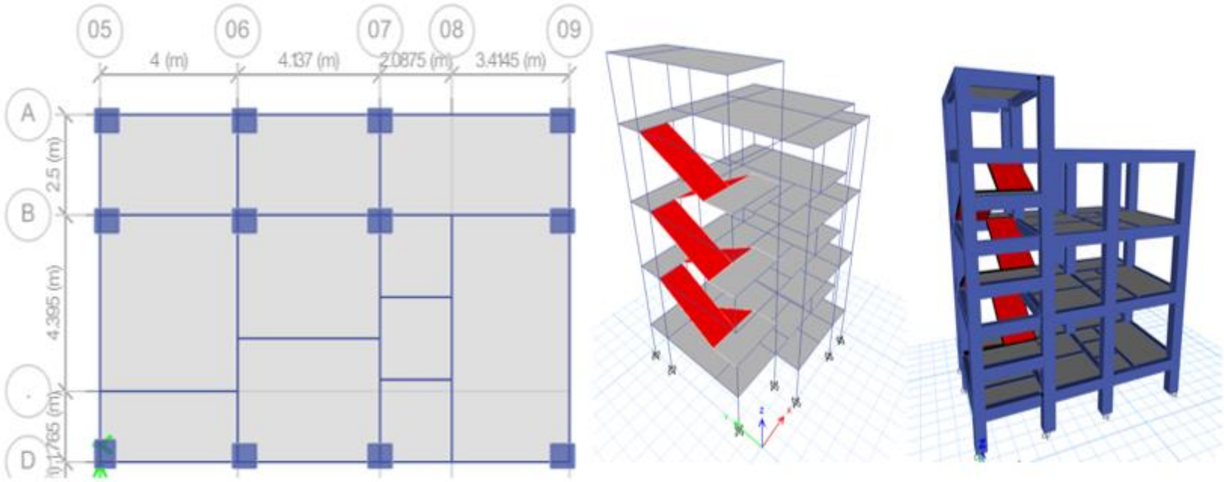

Fig. 2 ETABS Model of Buildings

List of Loads Applied in ETABS Models

- Wall load on all beams at Plinth Level = 0.23*20*3.6 = 16.56 kN/m (Assuming 230mm thick walls with 20 kN/m3 density of partition walls and wall height of 3.6m).
- Parapet load at all External Roof Beams = 0.23*20*1 = 4.6 kN/m (Assuming 230mm thick walls with 20 kN/m3 density of parapet walls and height of 1m).
- Floor Finish Load of 1.5 kN/m2 (75 mm finishes)
- Load of 2.7kN/m2 on Toilet Plinth Slab (For soil fill in Toilet Floors).
- Water Proofing Load at all Roof Slabs = 0.25*20 = 5kN/m2 (equivalent to 250mm thick brick layer of 20kN/m3 density).
- Minimum live load of the is 5 kPa will be applicable to all operating floors.
- Roof live Load – 5 kPa (Provision for installation of Solar Panels)
- Staff rest room – 5 kPa
- SS room – 5 kPa
- Toilet – 3 kPa
- Waiting hall, Porch – 5 kPa
- Wind Loads: Wind Load automatically applied in ETABS based on the parameters mentioned below:
  - Basic wind speed – 39 m/s (for Devprayag)
  - Category 2 is chosen for the wind load.
  - The Risk Coefficient has been taken as 1.06 as the building is a railway station.
- Earthquake Loads: The building was analysed under earthquake loading conditions using the selected analysis procedure. Separate analyses were performed according to the provisions of IS 1893:2016 and IS 1893:2025.

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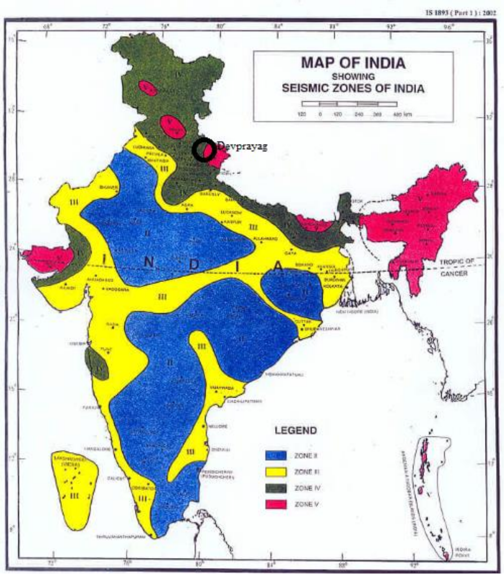

Fig. 3 Map of India showing the Seismic Zones as per IS 1893:2016

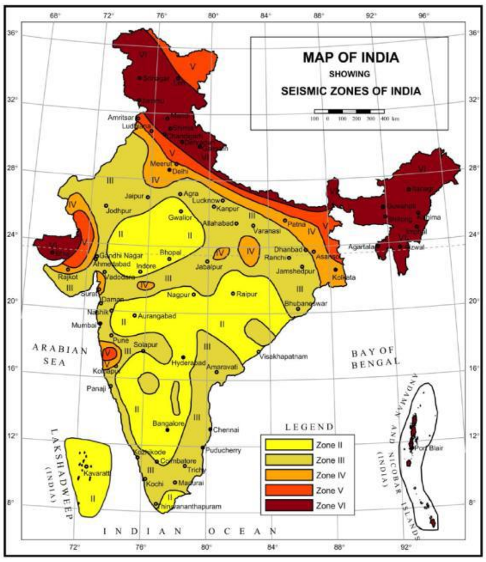

Fig. 4 Map of India showing the Seismic Zones as per IS 1893:2025

Earthquake Load automatically applied in ETABS based on the parameters mentioned below:

a) Earthquake Load as per IS 1893:2016
b)
zone – V (0.36)

TABLE III ZONE FACTOR Z FOR HORIZONTAL MOTION AS PER 1893:2016

Seismic Zone	**II**	**III**	**IV**	**V**
Z	0.10	0.16	0.24	0.36

As per IS 1893-2016, Sa/g for station building is 2.5
I = 1.5 (Station building)
R = 5 -RC building with special moment resisting frame (SMRF)

$$A_h = \frac{Z}{2} \times \frac{I}{R} \times \frac{S_a}{g}$$

$$A_v = \frac{Z(\frac{2}{3})}{2} \times \frac{I}{R} \times 2.5$$

For Devprayag, Ah = 0.36/2*1.5/5*2.5 = **0.135**

Av =0.36*(2/3)/2*1.5/5*2.5 = **0.09**

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c) Earthquake Load as per IS 1893:2025

TABLE IV DESIGN PARAMETERS CONSIDER AS PER 1893:2025

Sr. No	Parameter	Value / Description
1.	Earthquake Zone	Zone VI
2.	Category of structure	Important
3.	Return Period *T*R (in Years)	975 for LSM
4.	Zone Factor (Z)	0.60
5.	Importance Factor (I)	1.0
6.	R	5 (SMRF)
7.	Site Class	Site Class C – Very Dense Soil / Soft Rock (Vs30 = 360–760 m/s)
8.	Damping	5%

Time Period Calculation

Type of Building	=	a	
Where a= Building with RCC MRFs with or without RC Structural walls and with or without URM infills			
Height of Building, H	=	17.25	m
Dimension of Building at Base along Y	=	8.66	m
Dimension of Building at Base along X	=	13.639	m
Building Area at Base	=	118.11	sq. m
Structural Plan Density of all Concrete Columns at Base, ρ_{CC}	=	4.267	%
Structural Plan Density of Infill Walls at Base, ρ_{mw} -X	=	0.000	%
Structural Plan Density of Infill Walls at Base, ρ_{mw} -Y	=	0.000	%
approximate fundamental translational natural period T_a H	=	0.466	s

$$T_a = \frac{0.075H^{0.75}}{\sqrt{[1 + 0.2\rho_{CC} + \Sigma \{\rho_{CSWi} (0.2 + (L_{CSW_i} / H)^2 N_{CSW_i})\} + 0.02\rho_{MW}]}}$$

The denominator becomes:

$$\sqrt{(1+0.2(4.267) +0+0.02(0))} = \sqrt{1.8534} = 1.3614$$

The numerator is:

$$0.075(17.25)^{0.75} = 0.075(8.4808) = 0.6361$$

Therefore:

$$T_a = \frac{0.6361}{1.3614} = 0.466 \text{ sec}$$

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Design Seismic Coefficient (Ah):

- $A_{HD} = Z * I * A_{NH}(T_H) / R$
- $A_{VD} = Z * I * A_{NV}(T_v)$

Where,

A_{HD}= Design Horizontal acceleration coefficient, A_{VD} = design vertical acceleration coefficient, R = elastic force reduction factor, Z = Zone factor, I = Importance factor, A_{NH} = horizontal spectral acceleration, A_{NV} = vertical spectral acceleration

Calculation of Horizontal Design Acceleration Coefficient (AHD)

Given:

$T_H = 0.466\ s$, $Z = 0.6, I = 1.0, R = 5.0$, Site Class = C

From the spectrum for Site Class C: $0.1 < T_H \leq 0.6\ s$

Therefore,

$$A_{NH}(T_H) = 2.5$$

Substituting into the equation:

$$A_{HD} = \frac{Z \times I \times A_{NH}(T_H)}{R}$$

$$A_{HD} = \frac{0.60 \times 1.0 \times 2.5}{5}$$

$$\boxed{A_{HD} = 0.30}$$

Calculation of Vertical Design Acceleration Coefficient (AVD)

Given:

$T_V = 0.46\ s$(taken form model), $Z = 0.60$, $I = 1.0$, Site Class = C

From the vertical spectrum for Site Class C: $0.1 < T_V \leq 0.6\ s$

Therefore,

$$A_{NV}(T_V) = 2.5$$

Substituting into the equation:

$$A_{VD} = Z \times I \times A_{NV}(T_V)$$

$$A_{VD} = 0.60 \times 1.0 \times 2.5$$

$$\boxed{A_{VD} = 1.50}$$

Base Shear Calculation VBD/Lateral force:

- $V_{BD}H = A_{HD} * W$
- $V_{BD}.V = A_{VD} * W$

AHD (T) = Horizontal Acceleration Coefficient

AVD (T) = Vertical Acceleration Coefficient

W= Seismic weight of the structures

Therefore,

- $\boldsymbol{V_{BD\,H} = 0.3 * W}$
- **$V_{BD\,V}$ = 1.5 * W**

The modelling inputs for both models were kept identical in terms of geometry, material properties, Dead, Live and Wind Load, and design parameters of ETABS. The only difference between the two models was the seismic parameters used in accordance with the respective codal provisions.

The structure was analysed and designed in ETABS after incorporating the revised seismic parameters. It was observed that all the twelve reinforced concrete columns met the design requirements without any change in their cross-sectional dimensions. Thus, the column size remained 600 mm × 700 mm for both models. However, a number of beams did not

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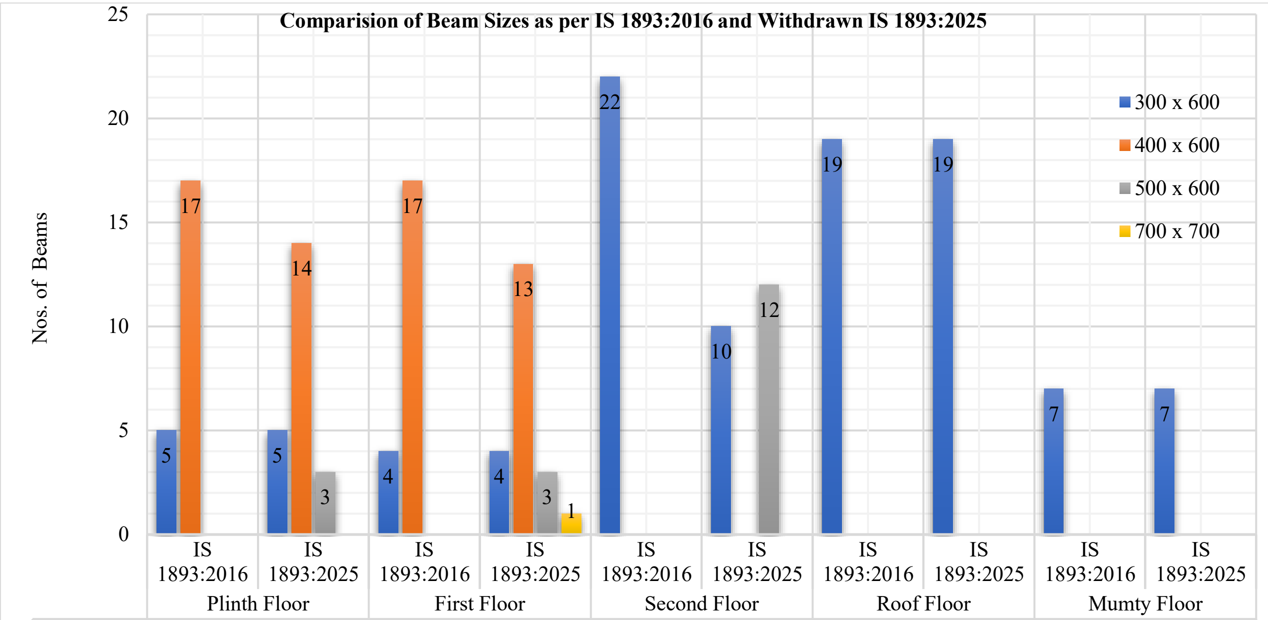
meet the design requirements under the revised seismic provisions. Therefore, the beam cross-sectional dimensions were increased until all design checks were fulfilled. The final beam sizes for the ETABS model are presented in the table below.

TABLE V COMPARISON OF BEAM SIZES DESIGNED AS PER IS 1893:2016 AND THE WITHDRAWN IS 1893:2025

Structural Level	**IS 1893:2016 Beam Size (B × D)**	**Withdrawn IS 1893:2025 Beam Size (B × D)**	**Observation**
Plinth Floor	17 beams of 400 × 600 mm 5 beams of 300 × 600 mm	3 beams of 500 × 600 mm 14 beams of 400 × 600 mm 5 beams of 300 × 600 mm	Three 400 × 600 mm beams were increased to 500 × 600 mm to meet higher seismic demand.
First Floor	17 beams of 400 × 600 mm 4 beams of 300 × 600 mm	1 beam of 700 × 700 mm 3 beams of 500 × 600 mm 13 beams of 400 × 600 mm 4 beams of 300 × 600 mm	Four beams were enlarged, including one critical beam increased to 700 × 700 mm.
Second Floor	22 beams of 300 × 600 mm	12 beams of 500 × 600 mm 10 beams of 300 × 600 mm	More than half of the beams required section enhancement to resist increased seismic forces.
Roof Floor	19 beams of 300 × 600 mm	19 beams of 300 × 600 mm	No change in beam sections.
Mumty Floor	7 beams of 300 × 600 mm	7 beams of 300 × 600 mm	No change in beam sections.



	IS 1893:2016 (Plinth Floor)	IS 1893:2025 (Plinth Floor)	IS 1893:2016 (First Floor)	IS 1893:2025 (First Floor)	IS 1893:2016 (Second Floor)	IS 1893:2025 (Second Floor)	IS 1893:2016 (Roof Floor)	IS 1893:2025 (Roof Floor)	IS 1893:2016 (Mumty Floor)	IS 1893:2025 (Mumty Floor)
300 x 600	5	5	4	4	22	10	19	19	7	7
400 x 600	17	14	17	13						
500 x 600		3		3		12				
700 x 700				1						

Fig. 5 The Comparison of Beam Sizes Designed Using IS 1893:2016 and IS 1893:2025

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VII. RESULTS

The results obtained from both analyses were compared with respect to:

A. Base shear

TABLE VI COMPARISON OF BASE SHEAR

Description	IS 1893:2016	IS 1893:2025	Increase Factor (2025/2016)
Base Shear Vb (kN)	1612.36	3625.29	2.248
Seismic Weight (kN)	11943.4	12084.3	1.012
Horizontal Coefficient Ah	0.135	0.3	2.222
Zone Factor	0.36	0.6	1.667

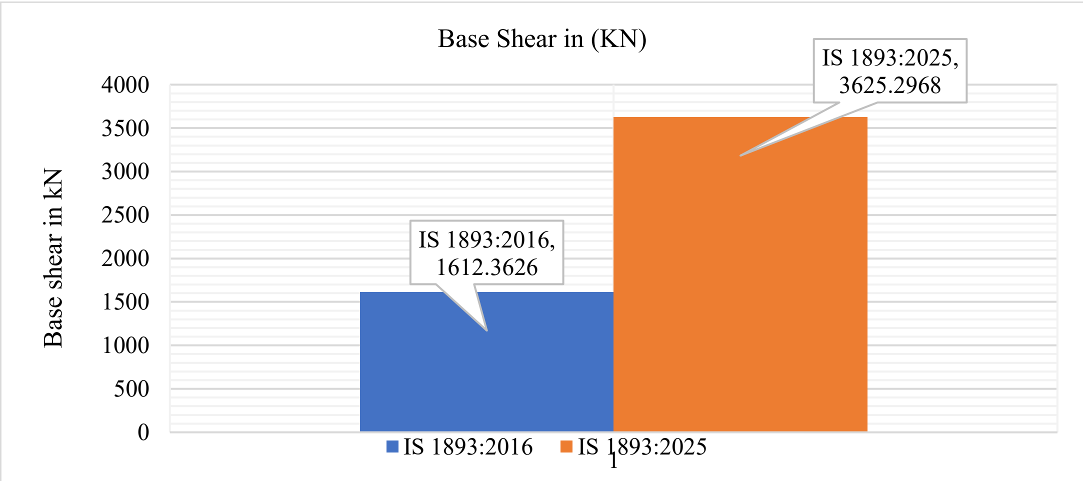

Fig. 6 The Comparative Assessment of Base Shear

The study concluded that the base shear is increased 2.25 times than that of IS 1893:2016. which is clearly indicated that the base shear is more than double by using the seismic design parameters in proposed IS 1893:2025.

B. Story Displacement

Table VII Comparison of Story Displacement

Description	Output Case	Direction	IS 1893:2016	IS 1893:2025	Increase Factor (2025/2016)
Mumty	EQX	X	12.607	27.066	2.147
Roof	EQX	X	11.285	24.186	2.143
FF+1	EQX	X	8.596	18.528	2.155
FF	EQX	X	5.004	10.92	2.182
Plinth	EQX	X	0.897	1.958	2.183

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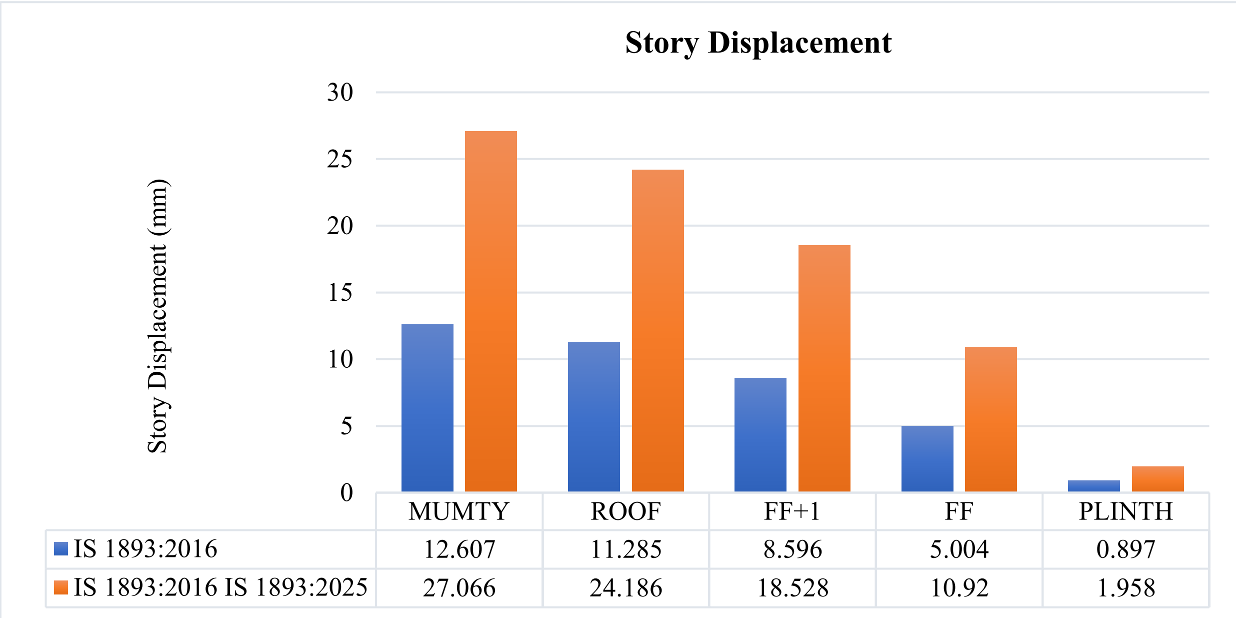
The study concluded that the Maximum story displacement in IS 1893:2025 is increased from 12.607 mm to 27.066mm which clearly indicates that Maximum story displacement increased by 2.147 times than that of IS 1893:2016.

B. Story Drift

TABLE VII COMPARISON OF STORY DRIFT



Sr. No	Description	Output Case	Direction	IS 1893:2016	IS 1893:2025	Increase Factor (2025/2016)
1	Mumty Beam	EQX	X	0.000505	0.00109	2.154
2	Roof Beam	EQX	X	0.000689	0.00145	2.106
3	Second Floor Beam	EQX	X	0.000921	0.00195	2.118
4	First Floor Beam	EQX	X	0.000978	0.002	2.187
5	Plinth Beam	EQX	X	0.000399	0.00087	2.180

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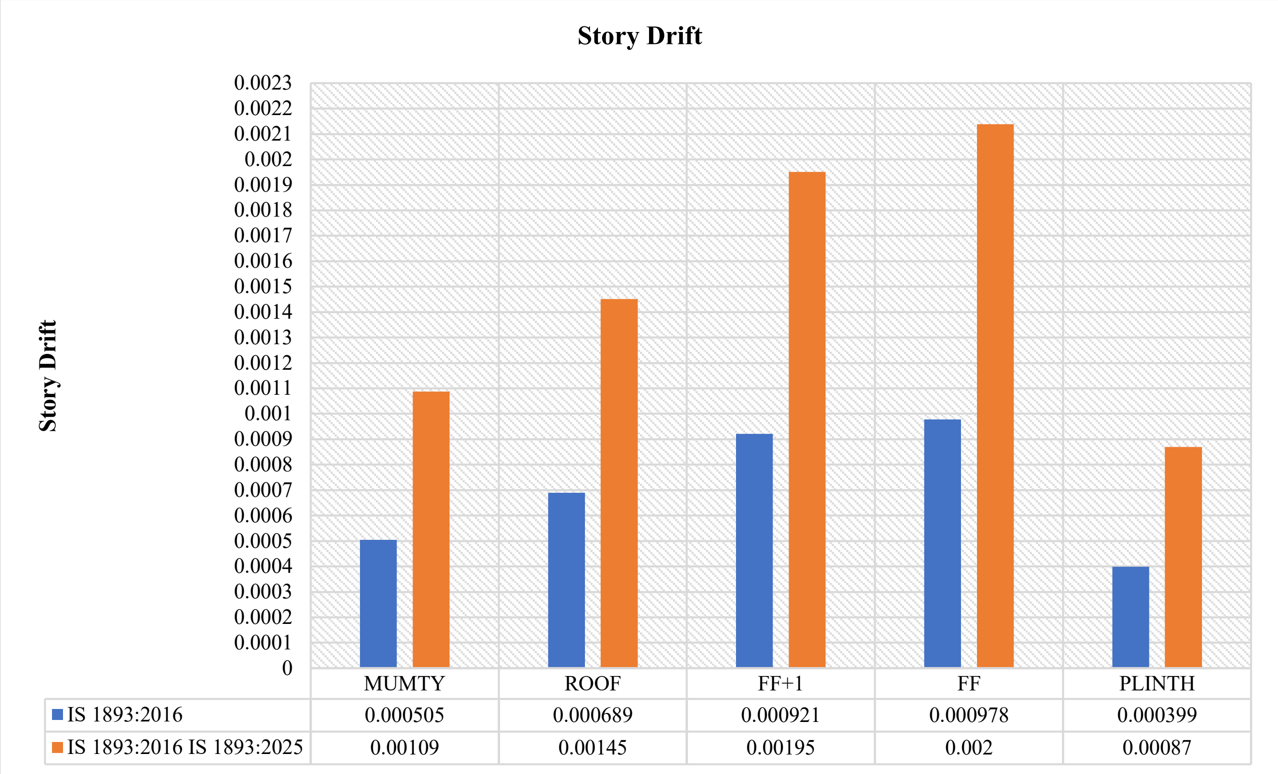

Fig. 8 The Comparative Assessment of Story Drift

The study concluded that the Maximum story drift in IS 1893:2025 is increased from 0.000978 to 0.002 which clearly indicates that Maximum story drift increased by 2.187 times than that of IS 1893:2016.

C. Beam-Reinforcement in Kg/m

TABLE VIII COMPARISON OF BEAM-REINFORCEMENT IN KG/M

Description	IS 1893 :2016	IS 1893 :2025	Relative Increase in Kg/m (2025/2016)
	Steel provided Kg/m	Steel provided Kg/m	
Mumty Beam	41.60	44.23	1.063
Roof Beam	58.19	67.46	1.159
Second Floor Beam	67.03	90.37	1.348
First Floor Beam	79.03	97.70	1.236
Plinth Beam	70.37	95.26	1.354
Average	**63.24**	**79.00**	**1.249**

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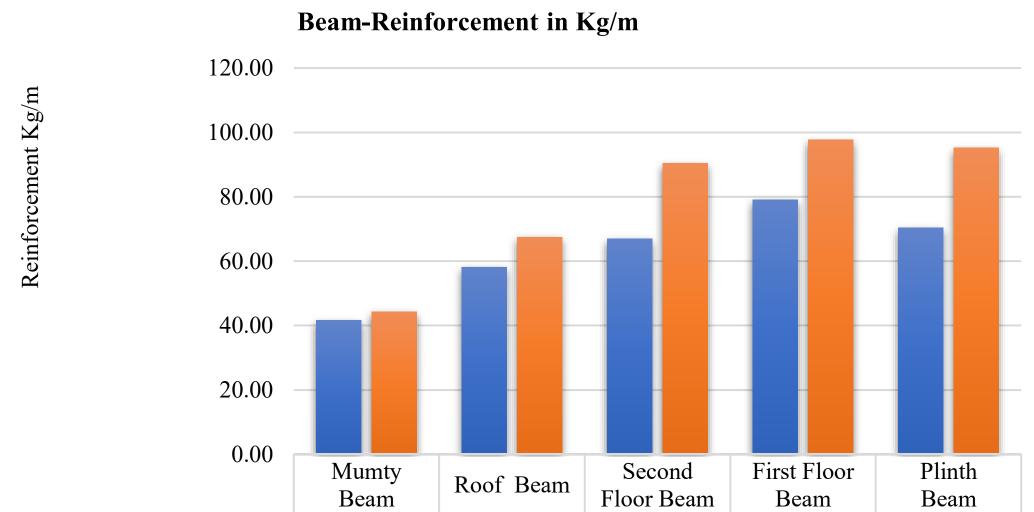

	Mumty Beam	Roof Beam	Second Floor Beam	First Floor Beam	Plinth Beam
IS 1893 :2016 Steel provided Kg/m	41.60	58.19	67.03	79.03	70.37
IS 1893 :2025 Steel provided Kg/m	44.23	67.46	90.37	97.70	95.26

Fig. 9 The Comparative Assessment of Beam-Reif. in Kg/m

The study concluded that the average beam reinforcement in IS 1893:2025 is increased from 63.24 kg/m to 79 kg/m which clearly indicates that reinforcement demand in beams increased by 1.249 times than that of IS 1893:2016.

D. Column -Reinforcement in Kg/m

TABLE IX COMPARISON OF COLUMN -REINFORCEMENT IN KG/M

Description	IS 1893 :2016	IS 1893 :2025	Relative Increase in Kg/m (2025/2016)
	Steel provided Kg/m	Steel provided Kg/m	
Roof to Mumty	64.05	98.83	1.54
Second Floor to Roof	58.07	93.40	1.61
First Floor to Second Floor	64.50	93.40	1.45
Plinth to first Floor	64.45	93.37	1.45
Base to Plinth	65.06	93.69	1.44
Average	**63.23**	**94.5**	**1.50**

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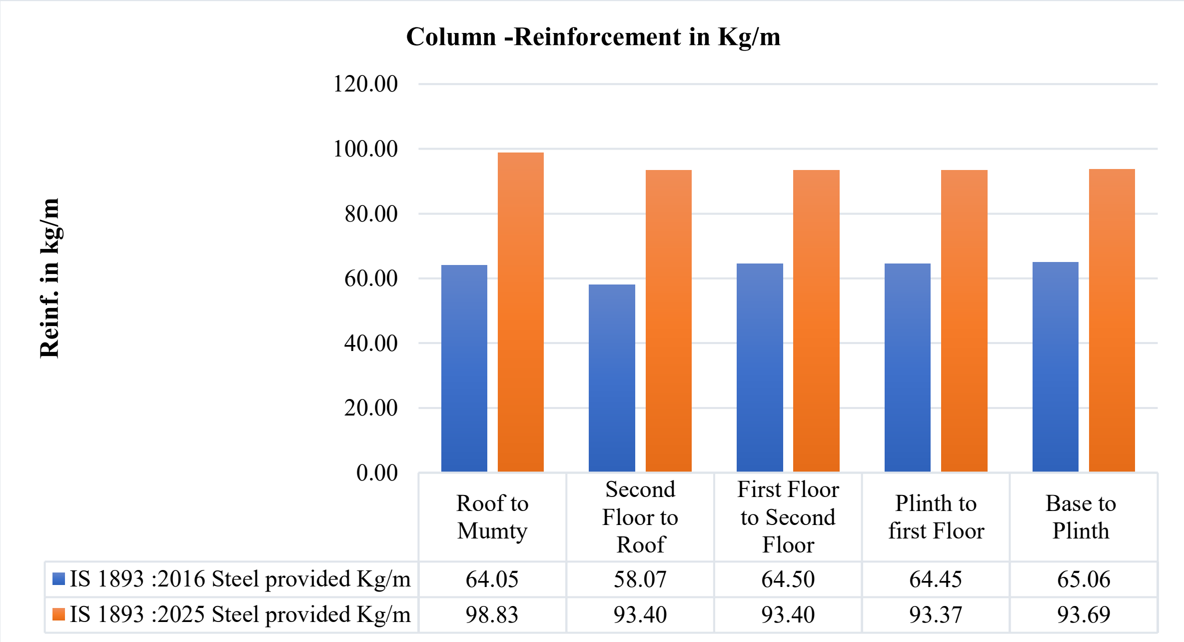

Fig. 10 The Comparative Assessment of Column-Reif. in Kg/m

The study concluded that the average column reinforcement in IS 1893:2025 is increased from 63.23 kg/m to 94.54 kg/m which clearly indicates that reinforcement demand in column increased by 1.5 times than that of IS 1893:2016.

E. Percentage of Beam Reinforcement

TABLE X COMPARISON OF PERCENTAGE OF BEAM-REINFORCEMENT

Description	IS 1893 :2016	IS 1893 :2025	Relative Increase in % (2025/2016)
	% of Steel Provided	% of Steel Provided	
Mumty Beam	2.09	2.28	1.088
Roof Beam	3.07	3.65	1.191
Second Floor Beam	2.58	3.18	1.234
First Floor Beam	3.14	3.42	1.086
Plinth Beam	2.76	3.53	1.278
Average	**2.73**	**3.21**	**1.177**

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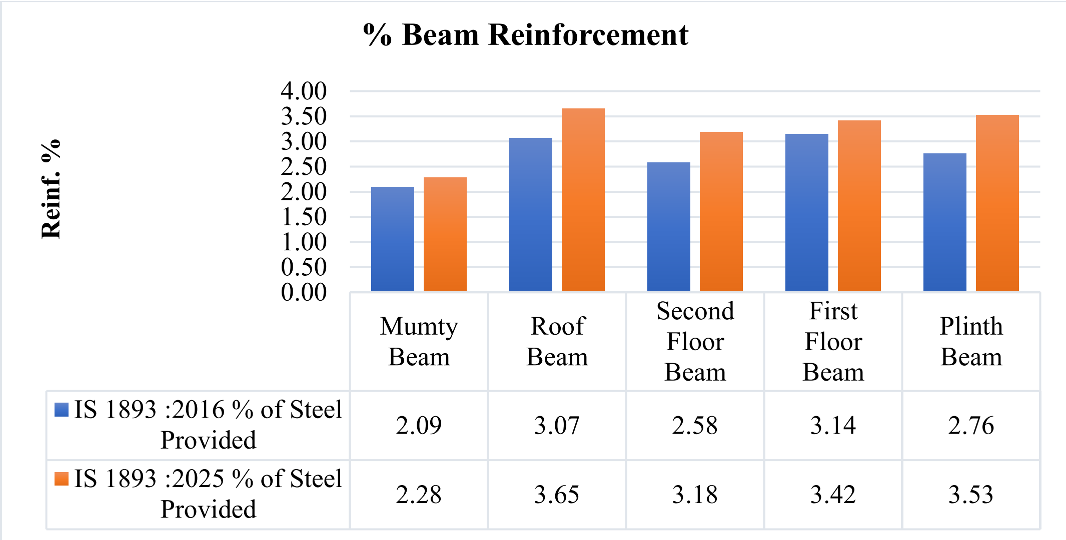

Fig. 11 The Comparative Assessment of % of Beam-Reif.

The study concluded that the average % beam reinforcement in IS 1893:2025 is increased from 2.73 % to 3.21% which clearly indicates that reinforcement demand in beams increased in % by 1.177 times than that of IS 1893:2016.

F. Percentage of Column -Reinforcement

TABLE XI COMPARISON OF PERCENTAGE OF COLUMN -REINFORCEMENT

Description	IS 1893 :2016	IS 1893 :2025	Relative Increase in% (2025/2016)
	% of Steel Provided	% of Steel Provided	
Roof to Mumty	1.17	2.51	1.346
Second Floor to Roof	1.14	2.47	1.327
First Floor to Second Floor	1.34	2.47	1.132
Plinth to first Floor	1.34	2.47	1.132
Base to Plinth	1.34	2.47	1.132
Average	**1.27**	**2.48**	**1.214**

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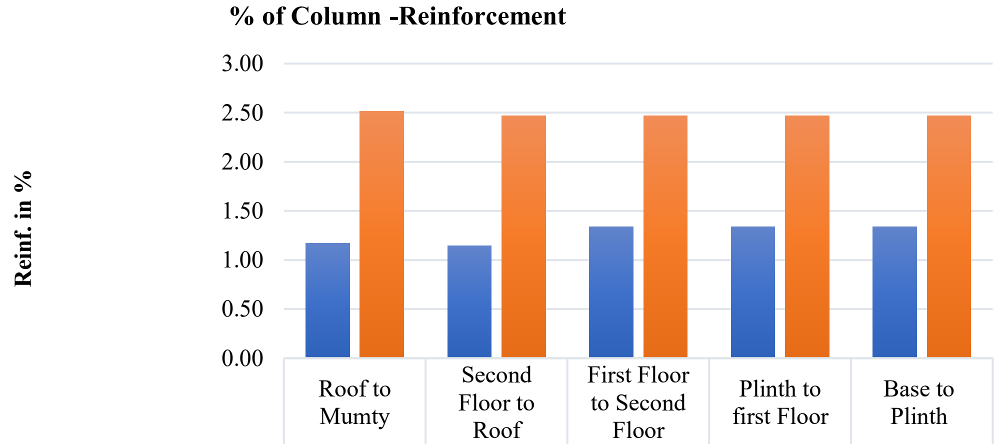

	Roof to Mumty	Second Floor to Roof	First Floor to Second Floor	Plinth to first Floor	Base to Plinth
IS 1893 :2016 % of Steel Provided	1.17	1.14	1.34	1.34	1.34
IS 1893 :2025 % of Steel Provided	2.51	2.47	2.47	2.47	2.47

Fig. 12 The Comparative Assessment of Column-Reif. %

The study concluded that the average % of Column reinforcement in IS 1893:2025 is increased from 1.27 % to 2.48% which clearly indicates that reinforcement demand in beams increased in % by 1.214 times than that of IS 1893:2016.

G. Cost Analysis

Cost was estimated using the quantities of concrete and reinforcement steel obtained from both the models. The Unit rates of reinforcement is taken from RVNL SBOQ and the Unit rate of Concrete M30 is taken from DSR.
The comparative cost analysis of both the models as per IS 1893:2025 and IS 1893:2016. are given below:

TABLE XII COST COMPARISON

Description	**Unit**	**Rate in Rs.**	**IS 1893 :2016**		**IS 1893 :2025**		**% increase**
			Quantity	**Amount**	**Quantity**	**Amount**	
Beam Concrete	Cum	10222	84.45	863202.94	87.23	891658.11	3%
Column Concrete	Cum	10222	79.38	811398.55	79.38	811398.55	0%
Beam Reinforcement	MT	96264	25.60	2463932.26	34.00	3272607.99	33%
Column Reinforcement	MT	96264	11.89	1144980.95	17.76	1709362.52	49%
Total Amount				**5283514.7**		**6685027.167**	**27%**

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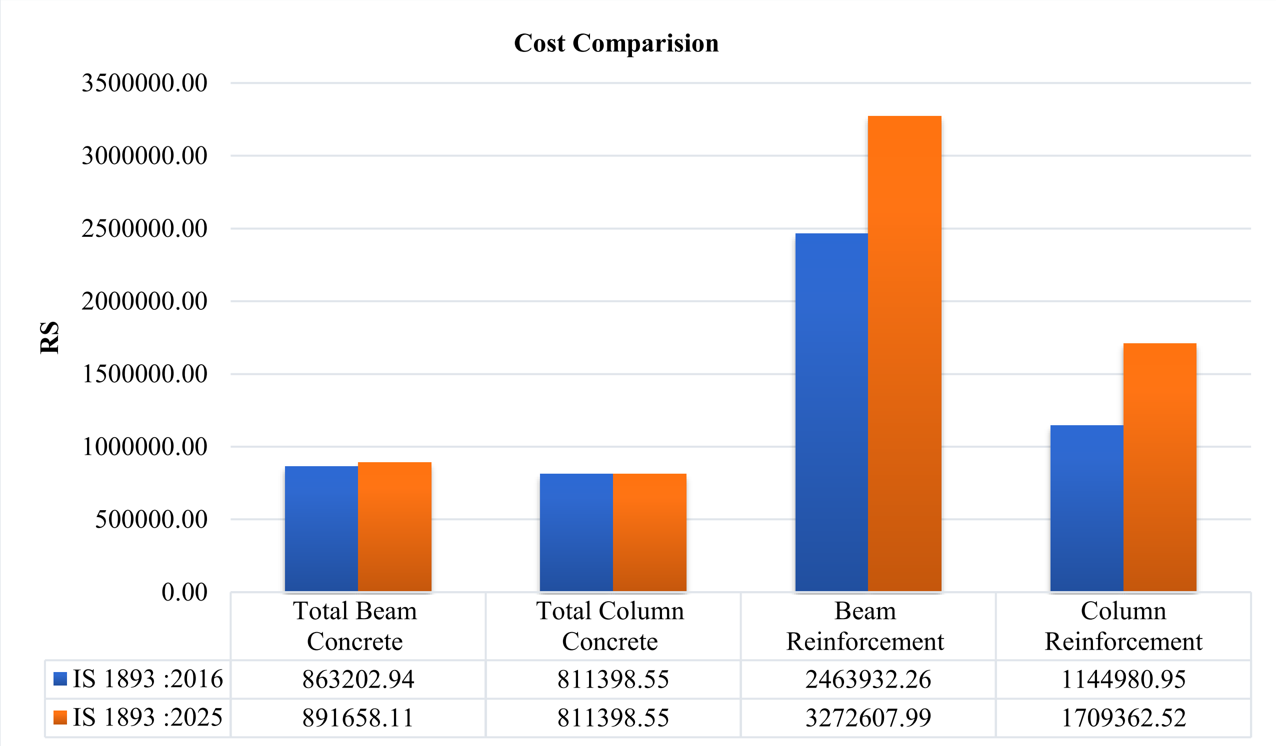

Fig. 13 The Comparative Assessment of Cost between two study Codes

From the result it is concluded that by using the seismic design provision as per IS 1893:2025 the total cost is increased by 27% than that of IS 1893:2016.

VIII. CONCLUSION

In the present study, seismic design of a G+2 with Mumty Reinforced Concrete Railway Station Building has been compared using IS 1893:2016 and proposed IS 1893:2025. The modelling of building is done in ETABS and then the results from both the models is compared in terms of base shear, story displacement, and story drift. After verifying all the structural checks, the beam and column were designed followed by quantity estimation and cost analysis.

The Summary conclusion table present all the quantitative findings are given below:

TABLE XIII SUMMARY OF QUANTITATIVE FINDINGS (IS 1893:2016 VS IS 1893:2025)

Sr. No.	Parameter	IS 1893:2016	IS 1893:2025	Increase Factor (2025/2016)	(%) Increase
1	Design Base Shear (kN)	1612.36	3625.30	2.248	124.84
2	Maximum Storey Displacement (mm)	12.607	27.066	2.147	114.67
3	Maximum Storey Drift	0.000978	0.002	2.187	104.50
4	Average Beam Reinforcement (kg/m)	63.24	79.00	1.249	24.90
5	Average Beam Reinforcement (%)	2.73	3.21	1.177	17.70
6	Average Column Reinforcement (kg/m)	63.23	94.54	1.5	49.50
7	Average Column Reinforcement (%)	1.27	2.48	1.214	95.30
8	Total Structural Cost (₹)	52,83,515.7	66,85,027.16	1.265	27

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- The comparison shows that the proposed 2025 code leads to much larger seismic forces than the 2016 code.
- The design base shear was increased from 1612.36 kN to 3625.30 kN, approximately 2.25 times higher. This means the building is designed to withstand much larger earthquake forces as per IS 1893:2025.
- The maximum storey displacement also increases from 12.607 mm to 27.066 mm, and the storey drift has increased by about 2.19 times. This indicates that the structure has a higher lateral response because of increased seismic demand.
- Due to higher earthquake forces, more reinforcement is required in both beams and the columns. The beam reinforcement was increased by about approx. 25% and the column reinforcement by about approx. 50%. This increases the strength of the structural members but also increases the Steel consumption.
- The higher reinforcement requirement can lead to reinforcement congestion, especially at beam column joints making it difficult to place reinforcement and concreting during construction.
- Because of the increase in reinforcement and overall structural demand, the total structural cost increased by about 27% when the building was designed as per the proposed IS 1893:2025.
- From a safety point of view, the proposed IS 1893:2025 provides a more conservative design, because it considers higher seismic forces. Hence it can be used to improve the earthquake resilience of the building.
- From practical and economic point of view IS 1893:2016 is more suitable as it requires less reinforcement, easy to construct and results in a lower construction cost. It also remains the current BIS-approved seismic design code.
- The proposed IS 1893:2025, although it provides a higher level of seismic safety, it also increases material consumption, complexity in construction, and overall cost of the project. The code was in use for a short duration, but it met with practical difficulties during its implementation and was ultimately withdrawn by the Bureau of Indian Standards (BIS). The significant increase in the requirement of reinforcement and construction cost observed in this study indicates that economic and practical considerations were among the factors that led to the withdrawn of this code by Bureau of Indian standards (BIS).

Based on the findings of this study, it was concluded that IS 1893:2025 is better when the main objective is to achieve higher seismic safety, while IS 1893:2016 is more suitable for practical application as it provides a good balance between safety, economy and constructability.

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