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Comparison of Seismic Analysis And Design Outputs Using IS 1893(Part 1): 2016 And NBC 105:2020 Codes Using Finite Element Software

[1*]Prasham Shah, [1]Sudarshan Karki, [1]Rojit Magar, [1]Shree Krishna Pathak, [1]Nimnuri Sherpa, [1]Nitesh Kumar Keshari, [1]Binaya Prasad Dhakal

[1]*Department of Civil Engineering, Advanced College of Engineering and Management, Kathmandu, Nepal*

[*]*Corresponding Author:* [*]*prasham.077bce059@acem.edu.np*

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Abstract

Nepal is located in one of the most seismically active regions in the world and has experienced numerous destructive earthquakes throughout its history. The 1988 earthquake, with a magnitude of 6.8, highlighted the urgent need for earthquake-resistant design standards, leading to the introduction of the Nepal National Building Code (NBC 105:1994) [3]. Despite the availability of a national seismic code, many engineers in Nepal continue to rely on the Indian Standard (IS 1893) due to familiarity and lack of local implementation experience. The diverse architectural styles and varying shapes and sizes of buildings in Nepal further increase their vulnerability to seismic forces, making proper code adoption critical for ensuring structural safety. This study focuses on the comparison of seismic performance of a five-story residential building located in Seismic Zone V, characterized by Type III soil conditions according to IS 1893:2016 and in Kathmandu, characterized by Type C soil conditions according to NBC 105:2020. The main objective of this research is to compare the updated Nepal National Building Code NBC 105:2020 with the Indian Standard IS 1893 (Part 1):2016 in terms of structural response and design requirements. The Response Spectrum Method is employed using ETABS software to evaluate key parameters, including base shear, storey displacement, storey drift, and reinforcement requirements. By systematically analyzing the building under both codes, the study provides a detailed understanding of how the choice of code affects structural behavior during seismic events. The results reveal that buildings designed according to NBC 105:2020 experience higher base shear and greater storey displacements and drifts compared to those designed with IS 1893:2016. Additionally, the NBC code generally requires higher quantities of reinforcement, reflecting its more conservative approach to earthquake-resistant design. These findings emphasize the importance of adopting context-specific seismic design standards that consider local geological and seismic conditions. The study provides valuable insights for engineers, policymakers, and stakeholders, highlighting the need for careful code selection to ensure both safety and economic efficiency in building construction in Nepal.

Keywords*—Base Shear, Storey Displacement, Storey Drift, Total Reinforcement Demand*

1. INTRODUCTION

Nepal, located in a tectonically active zone, has endured numerous destructive earthquakes throughout its history. The high concentration of earthquake epicenters in

Nepal and the surrounding Himalayan region is primarily due to the subduction of the Indian plate beneath the Eurasian plate. This tectonic movement occurs at an approximate rate of 40 cm per year [1], resulting in the accumulation of stress along plate boundaries, which leads to high seismic activity. Significant historical earthquakes in the region include those in the years 1255, 1810, 1866, 1934, 1980, 1988, and the most recent one in 2015 A.D. [2].

Following the 1988 earthquake, the Department of Urban Development and Building Construction (DUDBC) introduced the Nepal National Building Code (NBC) in 1994 A.D. The formal implementation of the code was supported by the Ministry of Physical Planning and Works (MPPW) through the establishment of the Building Construction System Improvement Committee [3]. Seismic analysis of structures in Nepal is now guided by NBC 105:2020. However, despite the availability of national guidelines, many structures are still analyzed and designed using the Indian Standard codes. This trend persists mainly because the Nepalese code lacks comprehensive coverage and updated reference materials. Consequently, design practices in Nepal often rely on Indian textbooks, academic curricula, and design standards.

2. LITERATURE REVIEW

Numerous comparative studies have been conducted globally to evaluate the influence of national seismic codes on the structural behavior of buildings under earthquake loading. **Pandit [5]** compared Nepal's NBC 105:1994 with India's IS 1893:2016 and found that the seismic coefficient method consistently produces higher estimates of base shear, lateral displacement, and reinforcement demand than the response spectrum method. The study also highlighted soil-dependent variations, with IS 1893:2016 predicting greater base shear and drift for soil types I and II, while NBC 105:1994 yielded higher values for soil type III. Additionally, IS 1893:2016 generally required more reinforcement, reflecting differences in design philosophy and underlying assumptions.

Expanding the comparison regionally, **Adhikari et al. [6]** analyzed the effects of seismic codes in Nepal, India, Bangladesh, and China. Their findings indicated that the Chinese code results in the highest base shear due to the absence of a response reduction factor, whereas NBC 105:1994, IS 1893:2016, and BNBC codes account for buildings' capacity to dissipate seismic energy. Structural shape minimally influenced base shear, but fundamental time periods varied significantly, with IS 1893:2016 predicting the highest and NBC 105:1994 the lowest values (0.491–0.614 seconds), highlighting the impact of code-specific assumptions on dynamic behavior. These results demonstrate that differences in national seismic codes can lead to markedly different structural responses during earthquakes.

Recent studies have focused on the evolution of Nepalese codes and their implications for structural design. **Shah and Chalotra [7]** compared RC frame buildings under NBC 105:2020 and IS 1893:2002, reporting slightly higher base shear but lower inter-story drifts under NBC 105:2020, reflecting a more conservative approach while maintaining ductility. Similarly, **Adhikari and Poudel [8]** found that NBC 105:2020 leads to higher reinforcement requirements for mid-rise structures compared to IS 1893:2016, emphasizing stricter detailing provisions. **Ansari et al. [9]** analyzed G+8

RC buildings under NBC 105:1994, NBC 105:2020, and IS 1893:2002, showing that the updated NBC 105:2020 increases base shear and reinforcement demand relative to the 1994 version. **Aryal and Dhungana [10]** also concluded that NBC codes generally produce more conservative designs than IS codes, particularly for medium-rise buildings on soft soils. Collectively, these studies indicate that NBC has progressively evolved toward more stringent seismic design provisions, and highlight the importance of considering both code-specific parameters and site conditions in seismic design, while revealing gaps in harmonizing design approaches for complex or high-rise structures.

3. METHODOLOGY

Five Storey Residential building is analyzed and designed using both IS 1893(Part 1):2016 and NBC 105:2020 using Response Spectrum Method in ETABS. The building has a regular plan and the dimension of the building is kept constant. The salient features of our building is tabulated below:

Table 1: Salient Features of the building

1. Location	a. Province: Bagmati b. District: Kathmandu
2. Type of Building	Residential Building
3. Structural System	Special Moment Resisting Frame
4. Seismic Zone	V (IS 1893 (Part 1): 2016) / Kathmandu (NBC 105:2020)
5. Soil Type	Type III (IS 1893 (Part 1): 2016/ Type C (NBC 105:2020)
6. No of Storey	5
7. Dimension of building	a. Maximum length: 49’6” b. Maximum Breadth: 46’6”
8. Type of Stair	Open well
9. Type of Foundation	Mat Foundation
10. Floor Height	10’
11. Infill Wall	Brick Masonry a. Main wall: 9” b. Partition wall: 4”
12. Design Criteria	As per NBC 105: 2020
13. Compared with	IS 1893(Part 1) : 2016
14. Preliminary size of structure:	a. Beam: 300 * 450 mm b. Column: 450 * 450 mm c. Slab thickness: 150 mm
15. No of columns:	Typical: 16 on each floor Staircase cover: 4

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The final element sizes adopted for the analysis and design by both NBC and IS models is tabulated below:

Table 2: Element Sizes Adopted for analysis and design of building

Elements	**Size (mm)**
Column	500*500
Beam	500*325
Slab	150
Secondary Beam	450*300

After analyzing and designing the building, comparison is carried out between the analysis and design results obtained from both IS 1893(Part 1):2016 and NBC 105:2020 codes. The plan and 3D view of the building is shown in figures below:

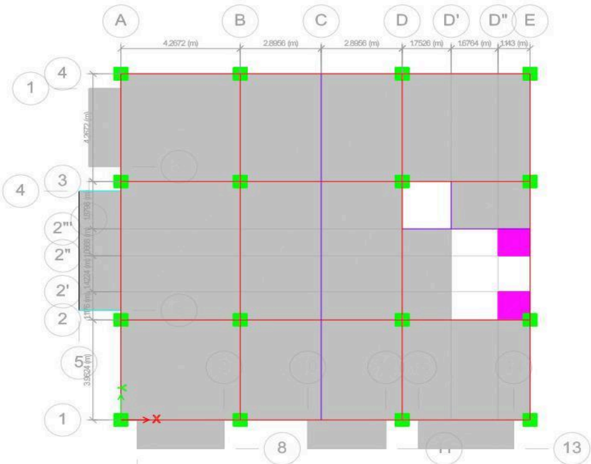

Figure 1 Plan of Building

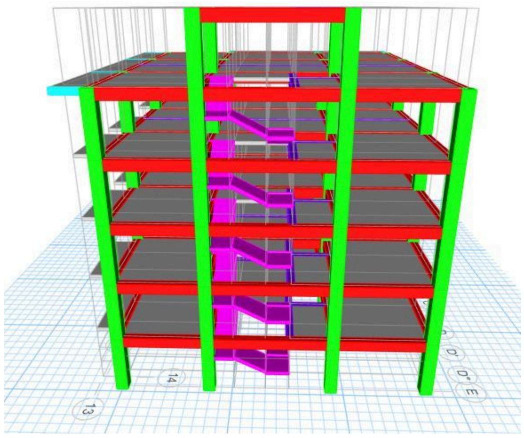

Figure 2 3D Model of Building

4. RESULTS

The comparison between IS 1893(Part 1):2016 and NBC 105:2020 model using Response Spectrum Method gave the following results:

A. Base Shear

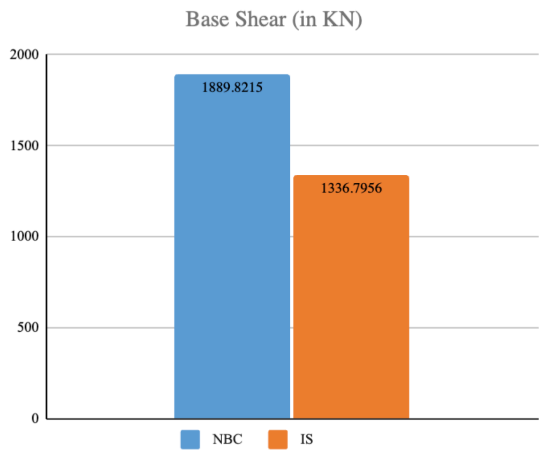

Figure 3 Base Shear Comparison

From the Figure 3 it can be seen that NBC code exhibits 29.263% more base shear in comparison to IS code.

B. Inter Storey Drifts

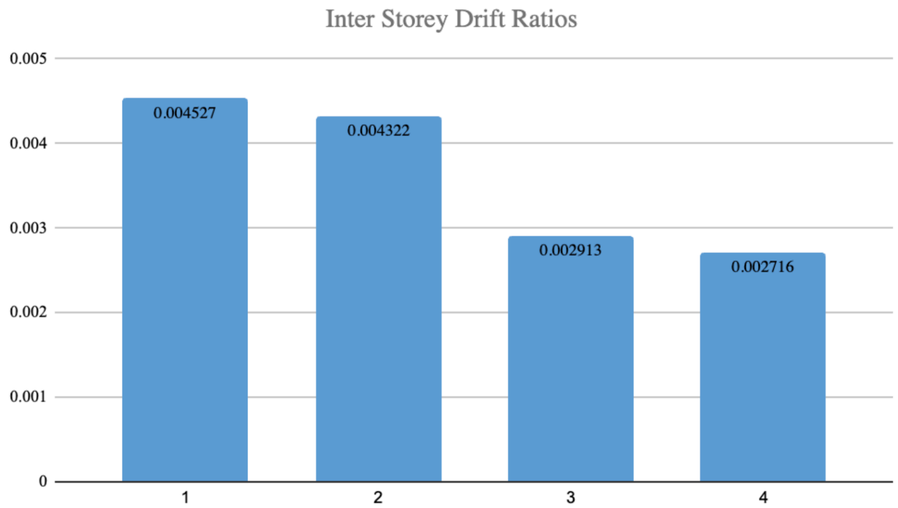

Figure 4 Inter storey drift ratio comparison

From the Figure 4 it can be seen that the value of inter storey drift for NBC code for X and Y direction respectively are 28.286 % and 29.963% more in comparison to IS code.

C. Storey Displacement

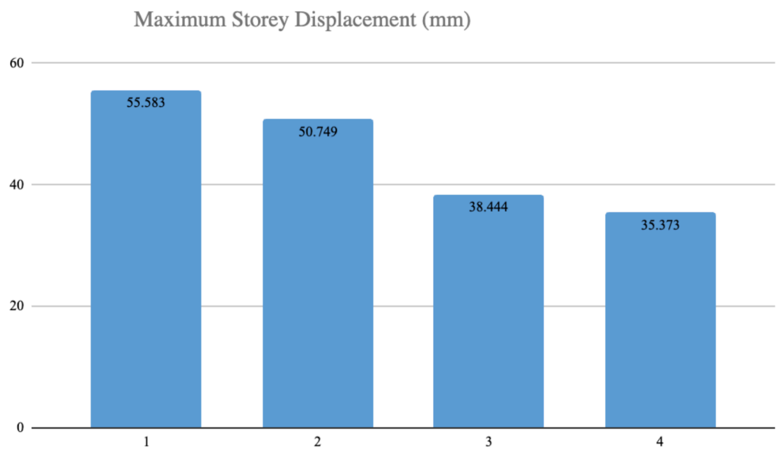

Figure 5 Storey Displacement Comparison

From the Figure 5 it can be seen that the value of maximum storey displacement for NBC code for X and Y direction respectively are 22.914 % and 22.316% more in comparison to IS code.

D. Longitudinal reinforcement demand

1. Longitudinal Reinforcement Demand for Column

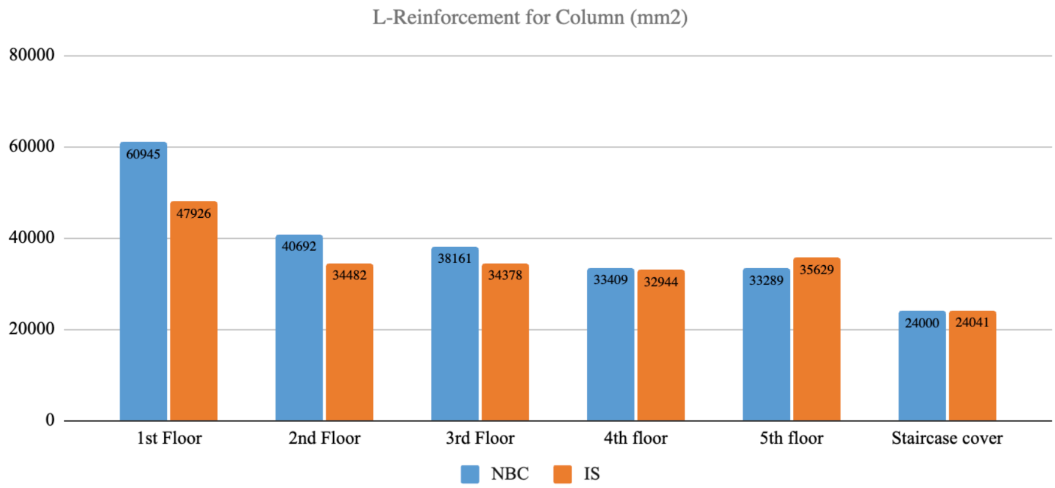

Figure 6 Longitudinal Reinforcement Demand for Column

From the Figure 6 it can be seen that total longitudinal reinforcement for column is similar from both the codes. Overall NBC requires more longitudinal reinforcement in comparison to IS code.

2. Longitudinal Reinforcement Demand for Beam

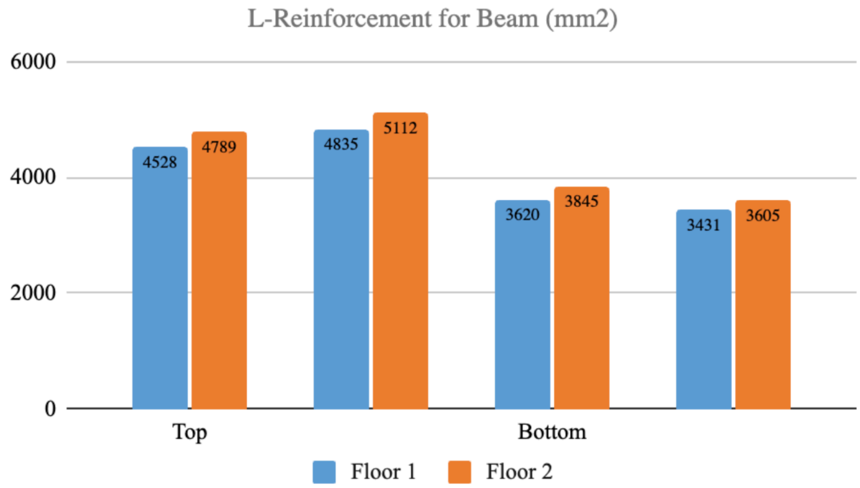

Figure 7 Longitudinal Reinforcement Demand for Beam

From the Figure 7 it can be seen that the value longitudinal reinforcement for beam is similar from both the codes. Overall NBC requires lesser top longitudinal reinforcements and more bottom longitudinal reinforcements in comparison to IS code.

E. Manual Design Outcomes

1. Beam Design

Table 3 Design Output Comparison for Beam

Parameters	NBC	IS
Width Used	325 mm	325 mm
Depth Used	500 mm	500 mm
Top Rebars	2-16ΦTh+2-20ΦExt	2-16ΦTh+3-20ΦExt
Bottom Rebars	2-16ΦTh+2-16ΦExt	2-20ΦTh
Stirrups (Mid)	2L-10Φ @ 4"c/c	2L-10Φ @ 4"c/c
Stirrups (Ends)	4L-8Φ @ 4"c/c	2L-12Φ @ 4"c/c

From the Table 3 it can be seen that NBC code requires less top longitudinal reinforcements whereas more bottom longitudinal reinforcements in comparison to IS code for a column.

2. Column Design

Table 4 Design Output Comparison for Column

Parameters	NBC	IS
Size Used (in mm)	500 x 500	500 x 500
Longitudinal Reinforcements	4-25 Φ +12-16 Φ	4-20 Φ +12-16 Φ
Lateral Ties	8 Φ -200c/c	8 Φ -200c/c

From the Table 4 it can be seen that NBC code requires more longitudinal reinforcements in comparison to IS code for a column.

3. Mat Foundation Design

Table 5 Design Output Comparison for Mat Foundation

Parameters	NBC	IS
Overall Depth	525 mm	550 mm
Top Reinforcements	16 mm dia. bars @175 mm c/c	16 mm dia. bars @150 mm c/c
Bottom Reinforcements	16 mm dia. bars @175 mm c/c	16 mm dia. bars @150 mm c/c

From the Table 5 it can be seen that NBC code requires less depth of mat compared to IS code. The top and bottom reinforcements required is also lesser for NBC in comparison to IS code for mat foundation.

5. CONCLUSION

The findings of this study indicate that buildings designed according to NBC consistently exhibit higher seismic demands than those designed using IS code. Specifically, NBC results in approximately 29.26% higher base shear, inter-story drifts that are 28–30% greater, and maximum story displacements increased by around 22% in both X and Y directions. These results suggest that NBC adopts a more conservative design approach, emphasizing greater structural stiffness and strength to better resist earthquake forces. This is consistent with previous studies; **Shah and Chalotra [7]** and **Adhikari and Poudel [8]** also reported higher base shear and drift values under NBC 105:2020 for medium-rise RC buildings. Similarly, **Pandit [5]** and **Aryal and Dhungana [10]** observed that NBC codes generally produce more conservative designs than IS codes, particularly on soft soil, reflecting differences in design philosophy and seismic detailing requirements.

Reinforcement requirements further illustrate the contrast between the codes. While total longitudinal reinforcement for columns is slightly higher under NBC, top and bottom reinforcement distributions differ, with NBC requiring less top but more bottom reinforcement compared to IS code. Beam reinforcement is broadly similar, though NBC adjusts top and bottom placement to meet specific design criteria. For mat foundations, NBC requires reduced depth and lower top and bottom reinforcement relative to IS code, suggesting that NBC incorporates both conservatism in seismic demands and efficiency in material usage. These observations align with the findings of **Ansari et al. [9]** and **Aryal and Dhungana [10]**, who highlighted that NBC balances structural safety with practical detailing considerations, particularly for medium-rise buildings.

The practical implications of these findings are significant for seismic design in earthquake-prone regions. Higher base shear, drifts, and displacements under NBC indicate improved resilience, ensuring that structures are better equipped to withstand seismic events. At the same time, the differences in reinforcement detailing emphasize the importance of carefully interpreting code requirements during design and construction to optimize both safety and material efficiency. While this study focuses on medium-rise RC buildings, future research should explore high-rise, irregular, and mixed-use structures, as well as investigate the harmonization of national seismic codes to improve overall safety and cost-effectiveness. Overall, the study demonstrates that national seismic codes, particularly the evolution of NBC, play a critical role in shaping structural performance and guiding earthquake-resistant design practices.

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REFERENCES

[1] S. Nienhuys, "Seismic building codes in the Himalayan region," *Issue*, pp. 02–04, May 2016.

[2] H. Chaulagain, D. Gautam, and H. Rodrigues, "Revisiting major historical earthquakes in Nepal: Overview of 1833, 1934, 1980, 1988, 2011, and 2015 seismic events," in *Impacts and Insights of Gorkha Earthquake*, D. Gautam and H. Rodrigues, Eds., Elsevier, 2018.

[3] P. Neupane, "Comparative analysis of seismic codes of Nepal and India for RC buildings," *International Journal of Engineering Trends and Technology (IJETT)*, vol. 28, ISSN: 2231-5381.

[4] A. Shrestha, *Comparison between common seismic codes used in Nepal and Eurocode 8: Study case analysis of RC building*, Master's thesis, Polytechnic University of Catalonia, 2018.

[5] P. Pandit, "Comparative analysis of NBC 105:1994 and IS 1893:2016 seismic codes with G+21 RC buildings," *International Research Journal of Engineering and Technology (IRJET)*, vol. 6, no. 11, pp. 1995–2000, Nov. 2019.

[6] D. Adhikari, S. Adhikari, and D. Thapa, "A comparative study on seismic analysis of National Building Code of Nepal, India, Bangladesh and China," *Open Access Library Journal*, vol. 9, e8933, Jun. 2022

[7] D. Shah and S. Chalotra, "Comparative Study of RC Frame Building with NBC 105:2020 and IS Code 1893:2002," *International Journal of Innovative Research in Engineering & Management (IJIREM)*, vol. 9, no. 4, pp. 68–73, 2022

[8] B. Adhikari and A. Poudel, "Comparative Study of Building Response on Adoption of NBC 105: 2020 and IS 1893 (Part 1): 2016," *Indian Journal of Structure Engineering (IJSE)*, vol. 3, no. 1, pp. 14–21, May 2023.

[9] F. Ansari, A. Pokharel, A. Khatri, and J. Gwachha, "Comparative Analysis of NBC 105:1994, NBC 105:2020 and IS 1893:2002 Seismic Codes With G+8 RC Building," *International Journal of Structural and Civil Engineering Research*, Sep. 2024.

[10] A. Aryal and S. Dhungana, " Comparative Analysis of NBC With IS Code for RC Structures," *International Research Journal of Engineering and Technology (IRJET)*, vol. 6, no. 24, pp. 2113–2117, Feb. 2020.