
Comparative Evaluation on Parameters of Seismic Codes for the Design of Masonry Structures

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Abstract

Structures are made to withstand specific seismic lateral forces that are related to both the structure and the local seismicity along with dead, imposed and other loads. For design of masonry structure, seismic lateral force needs to be evaluated. The seismic design provisions in three building codes, Nepal (NBC105:2020), India (IS1893:2016) and New Zealand (NZS1170.5:2004) in context of design of masonry structure along with their similarities and differences are presented. Code provisions for the design of masonry structures have been elaborated. The codes and their histories are introduced. Then, the distinctions between the basic period, spectral shape factor, elastic site spectra, seismic zone factor, and importance factor for estimating the seismic load are explored in detail. Following the calculation of the seismic force, base shear coefficients and distribution methods over the building's height are compared. Compressive stress and shear stress are computed on the basis of design load combinations mentioned in respective code and comparison has been carried out. Although the three codes have some subtle differences, they have several characteristics that allow for comparison. The fundamental periods computed from the three codes resides within a contracted range of 0.19 to 0.27s, signifying marginal sensitivity of short-period masonry buildings to formulations of empirical period. Spectral shape factors also exhibit minor variation for short-period structures, whereas differences in ductility and response reduction parameters deliberately influence base shear coefficients and causing masonry stress demand. This comparison shows that the base shear coefficient from NZS is 161% higher than IS and 51% higher than NBC. Stresses obtained from NBC and IS based models shows value in similar range while from NZS based model significantly, larger stresses were obtained. This research improves masonry design safety and competence by comparing NBC, IS, and New Zealand

seismic codes, enabling engineers to carry out optimal design, retrofitting, and construction practices, lowering earthquake risks.

Keywords: *Code, Comparison, Indian Standard, Masonry, Nepal National Building Code, New Zealand Standard*

1. Introduction

Masonry buildings constitute the main residential construction typology in Nepal and resides highly prone to earthquake-induced destruction. The 2015 Gorkha earthquake opened up serious deficiencies in existing buildings, causing severe human and economic losses (Bilham, 2015; Mosleh et al., 2016). Post-earthquake assessments spotlighted deficiencies in construction quality, detailing practice, and code compliance, underlining the chief role of seismic design standards in safeguarding life safety and satisfactory performance (Gautam & Chaulagain, 2016; Waris et al., 2017). In Nepal, seismic design is governed by NBC 105:2020, which substituted NBC 105:1994 to include revised hazard representation and limit-state concepts. However, masonry-specific codes such as NBC 202:2015 (DUDBC, 2015) were formulated under the previous seismic framework, raising affairs regarding parameter compatibility, force estimation uniformity, and alignment with improved ultimate and serviceability limit-state design demand.

Comparative research consistently shows that seismic demand is very sensitive to hazard modelling, spectral shape, ductility assignment, and response reduction factors. McIntosh and Pezeshk (1997) pointed out divergence between strength-based and working stress approaches in U.S. codes, presenting that design philosophy straight influences prescribed force levels. Parallel discrepancies in base shear were conveyed by Khose et al. (2012) and Zhinan and Zhonghai (2012) among ASCE 7, Eurocode 8, IS 1893, and Chinese codes, mainly caused by variations in soil amplification models and least base shear limits. Dogangun and Livaoglu (2006) further revealed significant differences in design spectra across Eurocode 8, UBC, IBC, and Turkish provisions. These studies jointly indicate that code-to-code variability exhibits differences in reliability calibration and hazard representation instead of procedural inconsistencies only.

In the Nepalese situation, Giri et al. (2018) reported that prior NBC provisions generated comparatively lower base shear estimates than Japanese and European standards, elevating

the concerns regarding hazard and response factor standardisation. Although probabilistic seismic hazard analyses for areas such as Pokhara Valley have assisted the usual consistency of national hazard factors (Baruwal et al., 2020), the transition to NBC 105:2020 obliges renewed analytical validation. Current comparisons between NBC 105:2020 and IS 1893 (Part 1):2016 identified remarkable differences in base shear, time period, and displacement demand for reinforced concrete buildings (Khatri et al., 2025; Shah et al., 2025). Regional Himalayan comparisons also revealed variability coming from hazard zonation and response modification parameters (Kunwar et al., 2024). However, these investigations primarily focus on reinforced concrete systems in place of load-bearing masonry structures, which comprise the majority of Nepalese buildings stock.

Masonry-centric research exposes additional inconsistencies in seismic parameter treatment. Analytical and experimental studies on unreinforced, confined, and reinforced masonry systems establish noteworthy variation in drift capacity, confinement effectiveness, and nonlinear behaviour modelling (Adhikari et al., 2023; Borah et al., 2023; Chi et al., 2024; Niu, 2025). Experimental categorisation of Nepalese brick masonry specifies material and construction-specific behaviour that may not be wholly represented by generalized code norms (Parajuli et al., 2020). Furthermore, local earthquake-resistant construction practices cover up essential seismic principles, yet remain inadequately incorporated into formal analytical calibration (Dixit et al., 2004). While NZS 1170.5 (New Zealand Standard, 2004) and NZS 4229:2013 (New Zealand Standard, 2013) provide structured hazard and prescriptive masonry guidance, their direct implementation to Nepal is limited due to differences in construction practice, material control, and execution capacity.

The interaction between contemporary seismic hazard parameters and prescriptive masonry guidelines in Nepal remains inadequately examined. NBC 202:2015 (DUDBC, 2015) recommends geometric and detailing limitations intended to guarantee minimum seismic resistance for load-bearing masonry. Although such guidelines enrich constructability and compliance, they are mostly empirical and not clearly validated against systematic performance assessments under NBC 105:2020 demand formulations. Bothara et al. (2018) observed a post-earthquake shift toward cement-based masonry construction in distant rural areas, extra highlighting the need to ensure rationality between evolving construction practice and seismic demand parameters. Despite proof that seismic codes evolve in response to

research and post-earthquake lessons to be learnt (McIntosh & Pezeshk, 1997), methodical evaluation of masonry design implications under the updated national code relative to IS and New Zealand standards leftovers limited.

A critical synthesis of the literature finds three principal gaps. First, although comparative assessments exist for reinforced concrete buildings (Khatri et al., 2025; Shah et al., 2025; Kunwar et al., 2024), there is inadequate analytical comparison dedicated explicitly on low-rise masonry structures under NBC 105:2020. Second, variations in hazard factors, spectral shape representation, and response modification parameters across NBC, IS 1893, and New Zealand standards have not been systematically quantified in terms of their impact on masonry base shear and displacement demand. Third, the compatibility between present national seismic parameters and prescriptive masonry guidelines (DUDBC, 2015) has not been analytically confirmed for typical two-storey residential building configurations, despite the signal of masonry vulnerability from past earthquakes (Bilham, 2015; Gautam & Chaulagain, 2016).

An organised comparison of seismic parameters precisely for load-bearing masonry buildings under the updated NBC105:2020 code provision remains limited. Previous studies primarily focus on reinforced concrete structures and do not measure how variations in hazard representation, spectral shape, and response reduction parameters effect seismic demand in masonry structures. Since masonry buildings lead in number of residential building construction in Nepal and they have limited ductility, differences in these parameters may meaningfully affect estimation of base shear, wall stresses, and as a whole structural safety. Therefore, assimilating the significance of these code parameters is indispensable for refining seismic design consistency and reliability.

Therefore, this study accomplishes a comparative evaluation of principal seismic parameters in NBC 105:2020, IS 1893 (Part 1):2016, and appropriate New Zealand standards, containing NZS 1170.5 and NZS 4229, for the design of masonry structures. The objectives are to compute differences in hazard factors, spectral shape, response reduction parameters, and base shear estimation; to evaluate their impacts through elastic analysis of typical low-rise masonry buildings defined in NBC 202:2015 (DUDBC, 2015); and to ascertain the areas where harmonization could boost design consistency and reliability. By critically scrutinising parametric variations and their structural consequences, the study delivers evidence to aid

coherent calibration of masonry design provisions in Nepal, contributing to better seismic safety, economic competence, and context-sensitive code development.

2. Materials and Methods

The methodological flow chart for the research is as under.

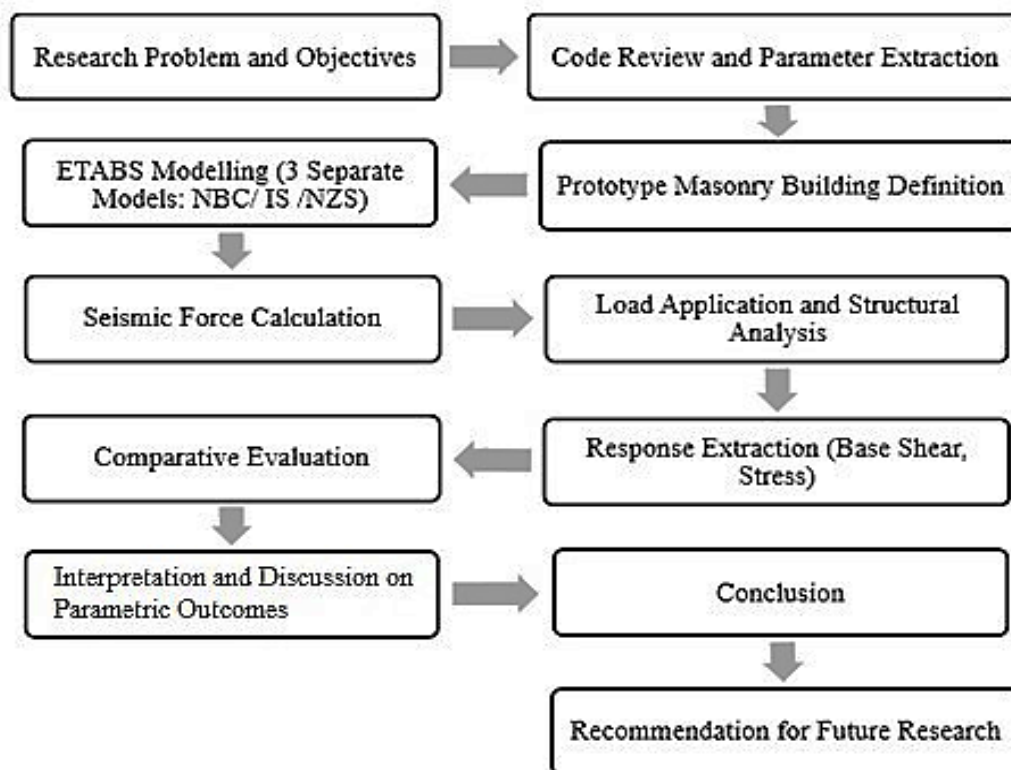


Figure 1: Flowchart of methods

This research evaluates seismic demand in two-storey load-bearing masonry buildings signifying common residential construction in Nepal. The study area is Pokhara, corresponding to a seismic zoning factor of 0.3 (PGA) under NBC105:2020. Medium dense soil ($N=15$ within 50 m depth) was supposed, classified as Soil Type B (NBC), Soil Type II (IS 1893:2016), and Class C (NZS 1170.5:2004). Soil-structure interaction was neglected, and base supports were modelled as fixed for simplification in analysis.

A masonry building Model 1 was first manually analysed applying the equivalent static (seismic coefficient) method to compare base shear coefficients across NBC105:2020, IS 1893 (Part I):2016, and NZS 1170.5:2004. Three numerical models were then developed in ETABS employing finite element method. Slabs and masonry walls were modelled with

shell elements, and beams with frame elements. The structural system comprised of two storeys with rigid diaphragm action. Model formations were complied with dimensional limits of NBC 202:2015 (DUDBC, 2015). Building descriptions are concisely presented in Table 1, and model dimensions are shown in Table 2. Representative layouts and 3D configurations are shown in Figure 2 to 5.

Table 1: Masonry Building Description

S. N	Masonry Building Description	M1
1	Plan Area	26.97m ²
2	X-Y Direction Grid Spacing	3.5m
3	Storey Height	2.5m
4	Number of Storey	2
5	Slab Thickness	125mm
Material Specification		
1	Grade of Concrete M ₂₀	$f_{ck}=20\text{N/mm}^2$
2	Grade of Mortar	M1 (Cement sand ratio 1:5)
3	Steel Fe500	$f_y=500\text{N/mm}^2$
4	Brick Compressive strength	10N/mm ²
5	Basic compressive stresses for masonry after 28 days (IS1905-1987)	0.96N/mm ²
6	Compressive strength of masonry f_m (IS1893:2016)	$=3.37\text{N/mm}^2$
7	Young's modulus of brick masonry E_m	$550 \times 3.73 = 2051.5\text{N/mm}^2$
8	Poisson's ratio for brick masonry	0.3
Design Loads		
1	Masonry wall	19kN/m ³
2	RCC Slab	25kN/m ³
3	Floor live load (IS: 875 (Part 2)-1987 Table 1)	2kN/m ²
4	Roof Live Load	1.5kN/m ²
5	RCC Beam	25kN/m ³

Table 2: Model dimensions

Model type	Single bay size	Height of storey (m)
Model 1	3.50 m x 3.50 m	2.855
Model 2	4.73 m x 3.23 m	3.200
Model 3	3.50 m x 3.50 m	3.200

Figures 2 to 5, as shown below, show the representative structural configuration employed for analytical and numerical evaluation. The models signify typical low-rise residential masonry building construction prevalent in Nepal, and were selected to confirm compliance with geometric limitations specified in NBC 202:2015.

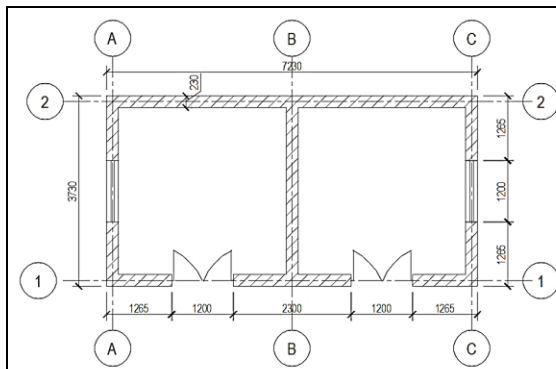


Figure 2: Ground floor plan of Model 1 for manual calculation

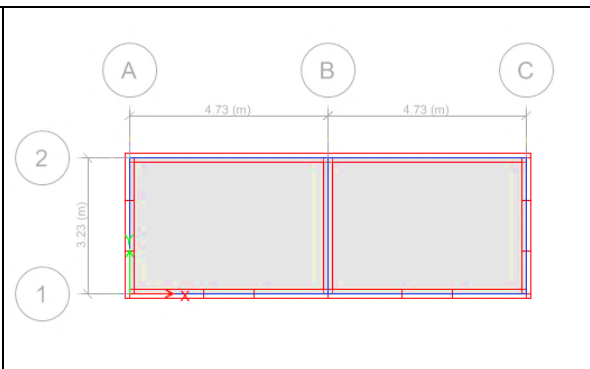


Figure 3: Ground floor plan of Model 2

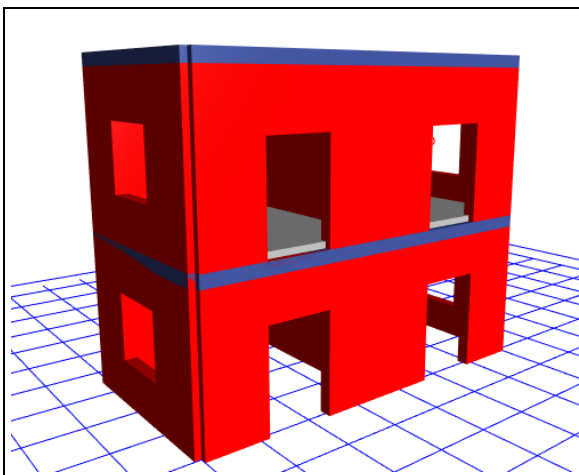


Figure 4: 3D Masonry building model (Model 1)

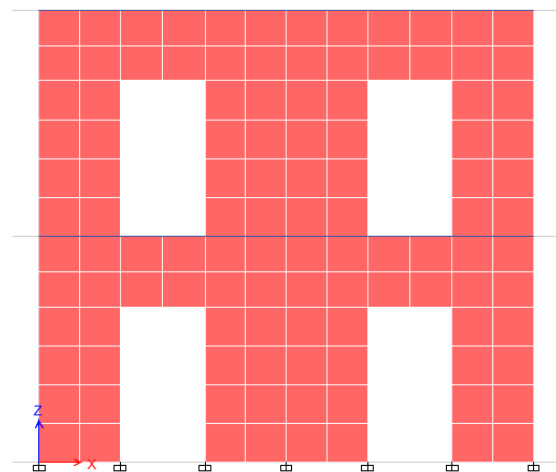


Figure 5: Front Elevation View of Model 3

Material properties included M₂₀ concrete ($f_{ck} = 20$ MPa), Fe500 steel ($f_y = 500$ MPa), brick compressive strength of 10 MPa, and masonry prism strength of 3.37 MPa. Young's modulus of masonry was taken as 2051.5 MPa with Poisson's ratio 0.3. Permissible stresses were adopted from IS 1905:1987. Dead loads were calculated by means of unit weights of 19 kN/m³ for masonry and 25 kN/m³ for RCC, with imposed loads as per IS 875 (Part 2)-1987 and live load factor as per NBC 105:2020 as shown in Table 3 and 4. Seismic weight was evaluated following corresponding codes.

Table 3: Imposed load to be considered for calculation of seismic weight as per IS code

S. N	Imposed Uniformly Distributed Loads kN/m ²	Percentage of Imposed Load to be considered
1	Up to and including 3.0	25
2	Above 3.0	50

Table 4: Live load factor as per NBC 105:2020

S. N.	Live Load Typology	Factor considered
1	Storage	0.60
2	For Other Purpose	0.30
3	Roof	Nil

The empirical formula applied to estimate the fundamental period according to individual seismic code are concisely shown below.

- NBC 105:2020 : $T_1 = 1.25 k_t H^{\frac{3}{4}} \dots$ [Eq.1] (Cl 5.1.2, 3 NBC 105:2020)

Where, T_1 = Approximate fundamental period of vibration, k_t = Structural system coefficient, H = Height of the building from foundation or from top of a rigid basement.

- IS 1893:2016: $T_a = \frac{0.09h}{\sqrt{d}} \dots$ [Eq. 2]

Where, T_a = Approximate fundamental natural period of vibration of the building, h = Height of the building in meters, d = Base dimension of the building in meters at the plinth level, measured along the direction of the lateral earthquake force being considered

- NZS 1170.5:2004: $T_1 = 1.25k_t h_n^{0.75} \dots$ [Eq. 3] (Cl 4.1.2.2 NSZ 1170.5:2020)

Where, T_1 = Fundamental natural period of the building (in seconds), k_t = Structural system coefficient, H = Height of the structure (in meters)

The design horizontal seismic coefficients were obtained as follows:

- NBC 105:2020 (ULS): $C_d(T_1) = \frac{C(T_1)}{R_\mu \times \Omega_u} \dots$ [Eq. 4]

Where, $C_d(T_1)$ = Horizontal base shear coefficient, $C(T_1)$ = Elastic response spectrum ordinate, R_μ = Ductility factor, Ω_u = Over-strength factor (for ULS)

- IS 1893:2016: $A_h = \frac{\left(\frac{Z}{2}\right)\left(\frac{S_a}{g}\right)}{\left(\frac{R}{I}\right)} \dots$ [Eq. 5]

Where, A_h = Design horizontal seismic coefficient, Z = Zone factor, I = Importance factor, R = Response reduction factor, $\frac{S_a}{g}$ = Spectral acceleration coefficient

- NZS 1170.5:2004 (ULS): $C_d(T_1) = \frac{C(T_1)S_p}{K_\mu} \dots$ [Eq. 6]

Where, $C_d(T_1)$ = Design horizontal seismic action coefficient at the fundamental period, $C(T_1)$ = Elastic site hazard spectrum ordinate at the fundamental period, T_1 = Fundamental natural period of vibration of the structure in the direction under consideration, S_p = Structural performance factor, K_μ = Ductility factor modification coefficient

Vertical distribution of storey forces obeyed code-specific formulations. Base shear and storey force patterns were acquired from ETABS and compared with manual results for validation. The consistency of modelling assumptions was established by the agreement between analytical and numerical base shear values.

- NBC 105:2020, NBC 105:1994

$$F_i = \frac{W_i h_i^k}{\sum_i^n W_i h_i^k} \times V \dots \text{ [Eq. 7]}$$

$$F_i = \frac{W_i h_i}{\sum W_i h_i} \times V \dots \text{ [Eq. 8]}$$

Where, F_i = Design lateral seismic force at level i , W_i = Seismic weight at level i (dead load + appropriate portion of imposed load), h_i = Height of level i measured from the base, k = Exponent related to the fundamental period of the building, $\sum W_i h_i^k$ = Summation over all storeys, V = Total design base shear of the building

- IS 1893:2016: $F_i = \frac{W_i h_i^2}{\sum_i^n W_i h_i^2} \times V \dots$ [Eq. 9]

Where, F_i = Design lateral seismic force at level i , W_i = Seismic weight at level i (dead load + appropriate portion of imposed load). h_i = Height of level i measured from the base, $\sum h_i^2$ = Square of the height term, indicating a parabolic distribution of seismic forces, $\sum W_i h_i^2$ = Summation $W_i h_i^2$ over all storeys, V = Total design base shear of the building.

Main assumptions include linear elastic response, equivalent static analysis applicability ($T < 0.5$ s), rigid diaphragm action, and absence of torsional irregularity. This outline enables consistent comparison of seismic demand estimates and design implications for masonry structures under different international and national seismic codes.

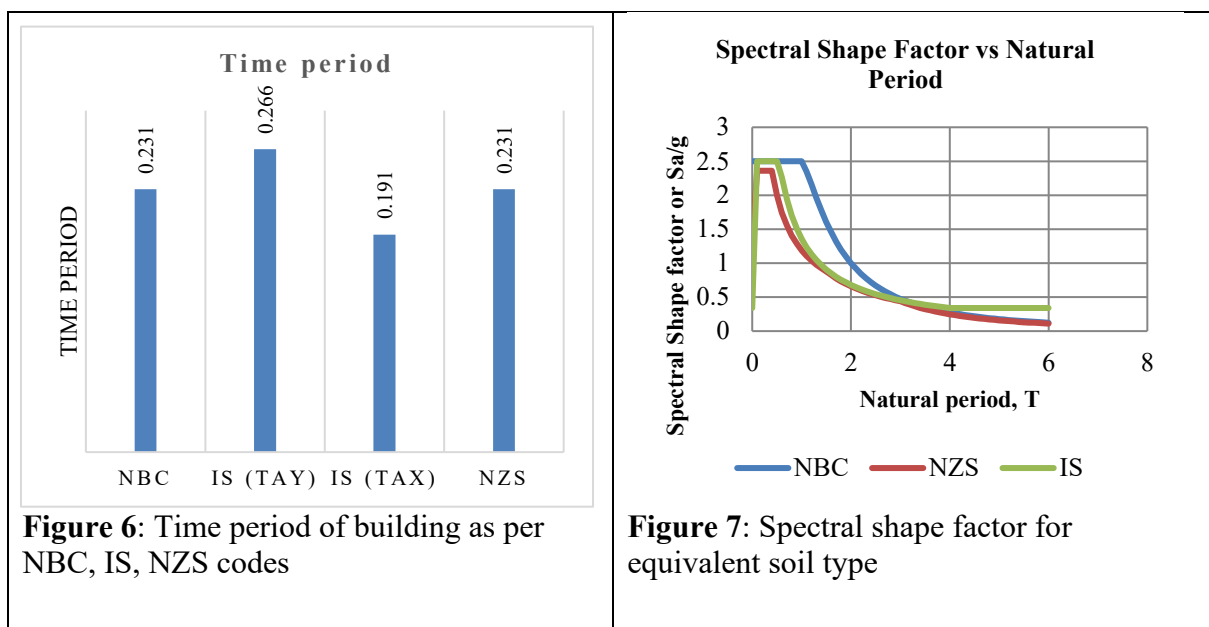
3. Results and Discussion

The comparative evaluation demonstrates how variations in seismic hazard representation, response modification factors, and force distribution rules among NBC105:2020, IS 1893:2016, and NZS 1170.5:2004 impact seismic demand in low-rise masonry buildings.

3.1 Code provisions and fundamental period

Although soil classification systems differ in nomenclature there exist four classes in NBC, three in IS, and five in NZS for the selected site condition ($N = 15$) consistently agrees to medium soil across all codes. NZS offers a more tough hierarchy for classification, emphasising shear wave velocity, whereas NBC and IS rest on mainly on standard penetration indices. This difference is methodological rather than numerical for the current case.

The empirical time period relations are mostly consistent, obeying $T_1 = 1.25 k_t H^{\frac{3}{4}}$ in NBC and NZS, while IS presents base-dimension dependency for masonry through $T_a = 0.09h/\sqrt{d}$. As shown in Figure 6, the computed periods for the two-storey model lies within a narrow band of 0.191 to 0.266 second, signifying negligible sensitivity to code choice for low-rise regular masonry buildings. This verifies that, for short-period structures ($T < 0.5$ s), differences in seismic demand are not ruled by period estimation but by force minimisation and hazard factors.



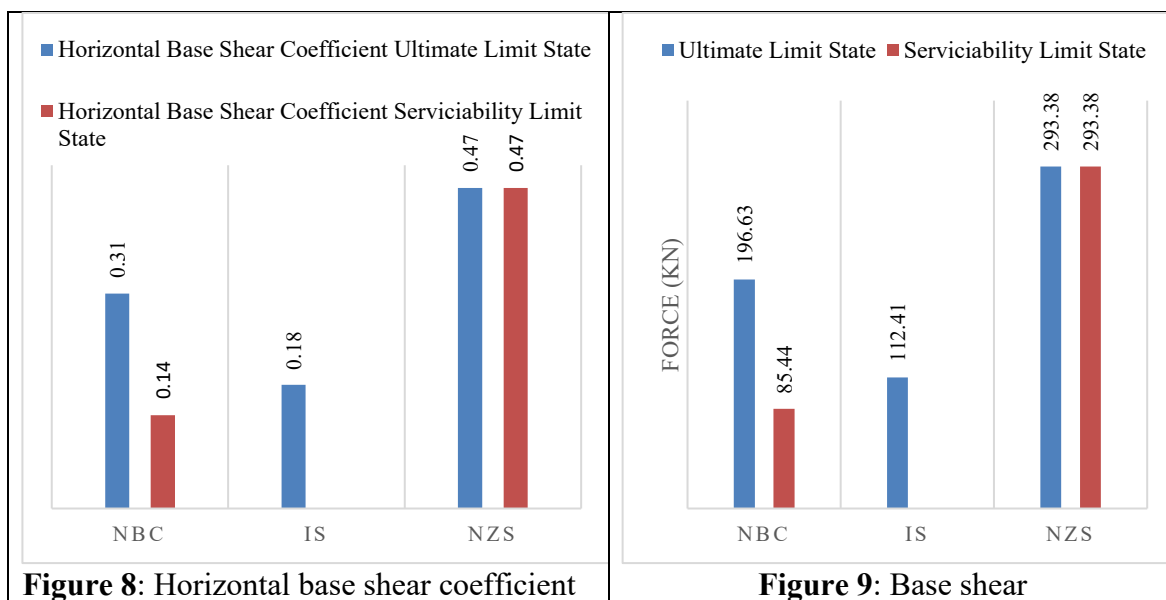
3.2 Spectral shape factor

The comparative graph of spectral shape factors presented in Figure 7 clarifies that the three codes deliver similar amplification for short-period structures. However, differences become more noticeable at longer vibration periods. For short-period structures ($T \leq 4$ s), spectral shape factors among the codes vary by only 5.93%, signifying close agreement in predicted seismic demand. However, at $T = 1$ s, the NBC curve remarkably up-rises than the others, with values 102% higher than NZS and 83% higher than IS almost twice that of NZS and 1.8 times that of IS. This graphical divergence reveals NBC's more traditional long-period amplification, suggesting considerably greater design forces for flexible or mid-rise structures. However, the study deliberates low-rise masonry buildings having less than 8 m height, the real-world difference remains limited to 5.93%, leading to comparable design implications.

3.3 Horizontal base shear coefficient

The most noticeable discrepancy was observed in horizontal base shear coefficients as shown in Figure 8. The horizontal base shear coefficient is ruled by spectral shape factor, zone (or hazard) factor, over-strength factor, and ductility factor. In IS 1893:2016, over-strength and ductility come together as the response reduction factor, whereas NZS 1170.5 initiates the elastic site hazard spectrum incorporating spectral shape, hazard, return period, and near-fault factors. The ductility factor in NZS is pointedly lower than in NBC

105:2020 and IS, causing significantly higher base shear. Consequently, NZS produces base shear coefficients 161% higher than IS and 51% higher than NBC. This illustrates NZS adopts a more traditional force-based design approach. Besides, both NBC and NZS present serviceability limit state base shear requirements, where remarkable variation is noticed, reflecting different performance prospects at reduced seismic intensity levels.



3.4 Base shear and seismic weight

Seismic weight calculations as in Table 6 show marginal variation because imposed load participation factors only slightly differ. So, the base shear variation directly indicates coefficient differences. As shown in Table 5 and Figure 9, NZS yields the largest base shear, followed by NBC and IS. The NZS base shear is about 75% higher than NBC and around 161% higher than IS results. From an engineering perspective, this denotes substantially greater member forces, reinforcement demand, and construction cost under NZS requirements.

Table 5: Horizontal base shear (kN)

Codes	Ultimate Limit State	Serviceability Limit State
NBC	196.63	85.44
IS	112.41	-
NZS	293.38	293.38

The visible variation in base shear coefficients has vital design implications. Masonry structures normally possess inadequate ductility and energy dissipation capacity.

Therefore, high value seismic coefficients translate straight into increased wall stresses instead of being absorbed by way of inelastic deformation. Accordingly, the larger base shear projected by NZS code provisions leads to higher shear demand in masonry walls, which may necessitate thicker walls, enriched mortar quality, or extra reinforcement to maintain adequate safety margins.

Table 6: Parameters for computation of base shear for Model 1

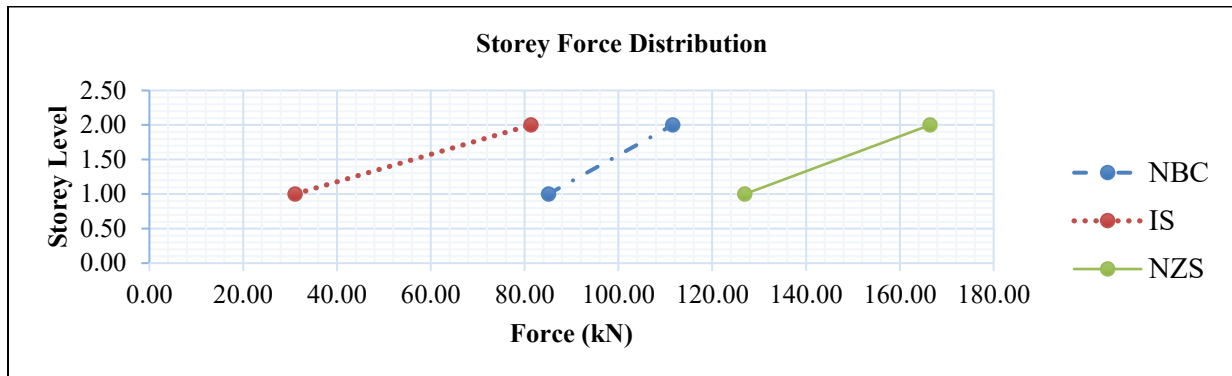
S. N.	Parameters	NBC	IS	NZS
1	Soil Classification (N Value of 15 within depth of 50m)	Soil Type -B	Soil Type-II	Class C
2	Zone factor (PGA)	0.3	0.36	0.3
3	Response Reduction Factor including overstrength factor	$R\mu \times \Omega u = 2.4$	R=2.5	$\frac{K_\mu}{S_p} = 1.475$
4	Importance Factor	1	1	NA
5	Near Fault Factor	NA	NA	1
6	Return Period Factor	NA	NA	0.975
7	Time Period	$T_1 = 1.25k_t H^{0.75} = 0.231$	$T_a = \frac{0.09h}{\sqrt{d}}$ (T_{ax})= 0.191sec (T_{ay})= 0.266sec	$T_1 = 1.25k_t h_n^{0.75} = 0.231$
8	Spectral Shape Factor	2.5	2.5	2.36
9	Base Shear Coefficient	$C_d(T_1) = \frac{C(T_1)}{R\mu \times \Omega u} = 0.313$	$A_h = \frac{(\frac{Z}{2})(\frac{S_a}{g})}{(\frac{R}{T})} = 0.18$	$C_d(T_1) = \frac{C(T_1)S_p}{K_\mu} = 0.467$
10	Seismic Weight	= DL+0.3LL=579.69 kN	= DL+0.25LL =575.07kN	=DL+0.3LL=579.69kN
11	Base Shear (Ultimate Limit State in kN)	196.63	112.41	293.38

3.5 Storey force distribution

Storey force distribution patterns in Table 7 and Figure 10 expose additional code-dependent variation. IS applies a quadratic height distribution, NBC employs a period-dependent exponent, and NZS uses 8% of base shear at roof level with the remaining 92% linearly distributed. NZS results in greater forces at both storeys, mainly at the top level, escalating overturning demand. This has direct consequences for wall border stresses and anchorage detailing.

Table 7: Storey force distribution (kN)

Storey level	NBC	IS	NZS
1st Floor	76.74	27.82	114.50
2nd Floor	104.70	75.69	156.22

**Figure 10:** Storey force distribution

3.6 Stress response from finite element analysis

Finite element analysis in ETABS computed compressive (S22) and shear (S12) stresses for three geometric models as shown in Tables 8. For all models, compressive stresses under NBC and IS remain within alike ranges and approach permissible limits defined by IS 1905:1987. NZS-based loading consistently produces higher compressive and shear stresses because of larger base shear demand.

Table 8: Average stress at strip (MPa)

Model	Stress type	NBC	IS	NZS
Model 1	Compressive stress (S22)	0.62	0.58	0.76
	Shear Stress (S12)	0.13	0.10	0.21
Model 2	Compressive stress (S22)	0.58	0.54	0.78
	Shear Stress (S12)	0.18	0.14	0.25
Model 3	Compressive stress (S22)	0.62	0.61	0.83
	Shear Stress (S12)	0.15	0.13	0.23

Shear stress values surpass permissible limits in several cases, particularly under NZS loading. This points out that shear capacity governs design for low-rise masonry instead of axial compression. Increasing wall thickness or improving masonry compressive strength would be essential to satisfy code limits. The stress contours presented in Figure

11 to 16 confirm concentration of shear stresses near wall diaphragm interfaces and at critical strips.

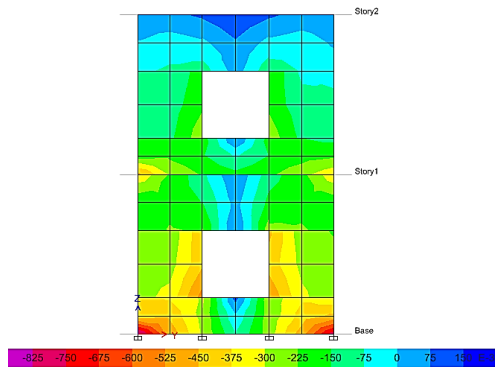


Figure 11: Compressive stress (S22) along grid A-A as per IS code (Model 1)

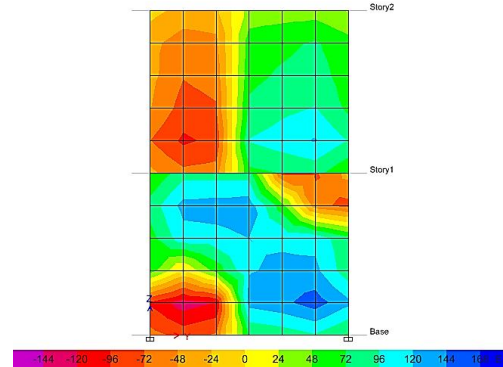


Figure 12: Shear stress (S12) at grid B-B as per IS code (Model 1)

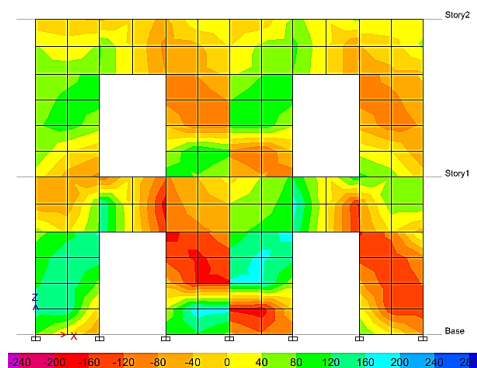


Figure 13: Shear stress (S12) along grid 1-1 as per NZS code (Model 1)

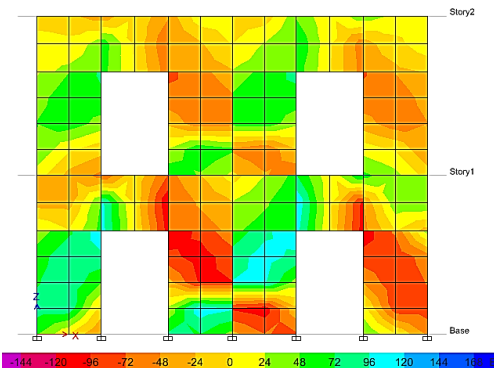


Figure 14: Shear stress (S12) along grid A-A as per NBC (Model 1)

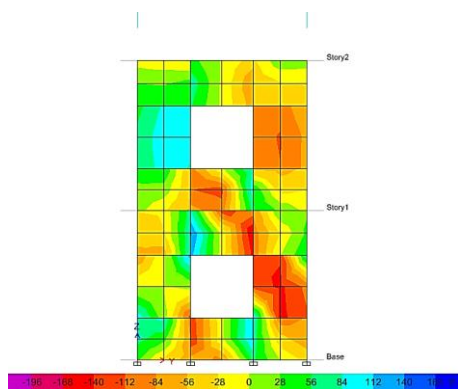


Figure 15: Shear stress (S12) along grid C-C as per IS code (Model 2)

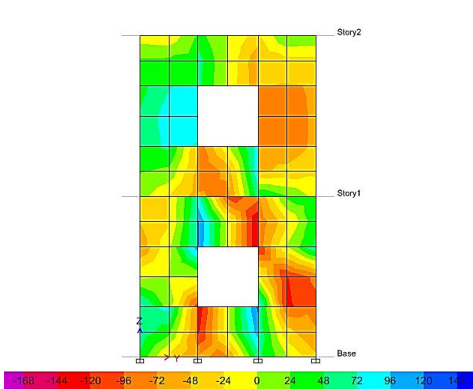


Figure 16: Shear stress (S12) along grid C-C as per IS code (Model 3)

The outcomes align with earlier comparative studies as an example (Giri et al.) that identified higher base shear estimates under more conservative or lower-ductility code bases. However, dissimilar to reinforced concrete systems, masonry structures display

limited ductility. So, higher force demand directly turns into higher stress ratios without substantial redistribution capacity.

3.7 Engineering significance

For representative low-rise masonry buildings of Nepal, estimated natural time period and spectral shape variances have limited effect on seismic design outcomes. In its place, seismic demand is highly controlled by response reduction philosophy and performance factors rooted in each code. NZS provisions primarily focus to considerably higher design forces and stress levels, requiring improved safety margins but increased material demand. IS produces the lowest force demand, reliably resulting in more economical but less conservative designs. NBC dwells in a midway position, exhibiting calibration to national hazard circumstances.

These findings validate that selection of code significantly affects structural demand predictions even for matching geometry and material properties. For masonry practice in Nepal, cautious evaluation of ductility assumptions and shear capacity is important, as shear stresses commonly govern design sufficiency.

3.8 Implications for masonry design in seismic regions

For real-world engineering application, the results advise that the selection of seismic design code pointedly influences predicted seismic demand for low-rise masonry buildings. NBC code provisions offer intermediate seismic force levels consistent with national hazard conditions, whereas IS code arrangements may lead to low value design forces and more economically optimised construction. NZS code provisions distinctly result in higher design forces and greater stress levels, which may enhance safety margins but escalate material demand. These outcomes may support engineers and code developers in evaluating the appropriateness of seismic design parameters for masonry construction in regions with alike seismic hazard features.

4. Conclusions

The research exhibits that, for typical low-rise masonry buildings of Nepal, the estimated time period across NBC, IS, and NZS codes endorses negligible variation, confirming that empirical relations yield comparable dynamic features. Spectral shape factors for short-period structures

($T \leq 4$ s) differ by only 5.93%, highlighting minimal influence of soil classification on short-period seismic demand. But, base shear coefficients vary significantly, with NZS predicting 161% higher values than IS and 51% higher than NBC, designating the differences in ductility and performance factor provisions. Storey shear distribution also varies by code, with NBC applying a period-dependent exponent, IS using a quadratic distribution, and NZS following a linear distribution with 8% applied at the roof, impacting member force allocation. Finite element analysis exposes that compressive stresses under NBC and IS remain within analogous ranges, whereas NZS generates significantly higher compressive and shear stresses, often impending or beyond permissible limits. These conclusions focus that selection of code substantially affects seismic force demand, stress levels, and design necessities, mainly for masonry walls critical in shear. The results exhibit that while empirical period estimation and spectral shape factors indicate comparatively small variation for short-period masonry structures, the selection of response reduction and performance factors considerably influences seismic force estimation. On the other hand, differences in base shear coefficients directly impact wall stress levels and structural safety limits. These relationships spotlight the significance of careful calibration of ductility and response modification parameters in seismic design codes for masonry structures. Engineering consequences suggest that careful and accountable consideration of ductility, base shear, and storey force distribution is indispensable for safe and economical design of low-rise masonry structures in seismic areas.

5. Recommendations for future research

Future research should address limitations perceived in the present study by line up with analytical models with the newest release of NBC 105:2025 (Second Revision) (DUDBC, 2025). Explicitly, revisions to masonry guidelines in NBC 202 (DUDBC, 2015) are needed to ensure wall thickness, rebar placement, and building dimensions satisfactorily limit shear stress within permissible ranges. Comparative studies could discover corrections in IS code load combinations and zoning factors to harmonize elastic site spectra with NBC provisions. Modelling should incorporate multiple seismic zone scenarios (0.25g to 0.4g) to cover up regional variability in Nepal. Furthermore, the dependence on elastic analysis should be expanded using nonlinear dynamic or pushover analysis to evaluate masonry performance under genuine seismic demand, delivering more accurate predictions of structural safety and serviceability.

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