Comparative Study Between NBC 105:2020 and IS 1893:2016 (Part 1) in torsionally irregular structure

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Abstract

Nepal lies in seismically vulnerable zone. Nepal has been hit by major earthquakes since long time, among them earthquake of 1990, 2015 AD, Jajarkot earthquake are prominent and destructive earthquakes in Nepal. In these above listed earthquakes Nepal has suffered huge loss of property and life. To minimize the losses Nepal has developed and implemented its own code NBC 105:1993 till 2019. Since Nepal lie in Indian sub-continent and NBC 105:1993 did not get updated, hence Nepal has been using IS 1893:2002 and IS 1893:2016 widely. After the NBC 105 was updated in 2020 there were major changes in the code. The major changes seen in the code are 4 types of soil type was introduced, seismic zoning was done different than IS code. The serviceability criteria are also introduced in the code. So, this article studies about comparative study between the codes in different soil types in torsionally irregular structure. The value of base shear is less by 40.57 %, 18.52% and 43.32% from IS code with respect to NBC Code in hard soil, medium soil and soft soil respectively. The value of storey drift in X direction is less than 38.95%, 14.63% and 40.60 % from IS code with respect to NBC Code in hard soil, medium soil and soft soil respectively. The value of storey drift in Y direction is less than 40.92%, 16.64% and 42.01 % from IS code with respect to NBC Code in hard soil, medium soil and soft soil respectively. Hence due to adaptation of latest seismic index result in higher lateral forces in the torsionally irregular structures in NBC 105:2020.

Keywords: *Lateral loads, Torsional Irregularity, Response spectrum*

Introduction

A lateral load has been most prominent loads in the structure while designing. Since earthquake forces results in failure of structures and result in loss of life and property designing of earthquake resistant structures is necessary. To design such structures use of codes is very important. Since Nepal lies in earthquake prone zone, between two giant tectonic plate, Indo Australian plate and Asian Plate Nepal have faced various major and minor earthquakes. To estimate the lateral forces use of codes in accurate way is must. So, India being our nearest neighbor we have been using IS and NBC code for estimation of lateral force. The building having irregularity in mass, geometry, load distribution etc. result in torsion. Torsionally irregularity is present when maximum horizontal displacement to minimum displacement in extreme edges due to lateral force is greater than 1.5 in the direction of lateral force.

Numerically it can be written as D_{max}/D_{min} >1.5 in such case we can tell as torsionally irregular, where D_{max} is maximum displacement in plan at extreme edge and D_{min} is minimum displacement in plan at extreme edge.

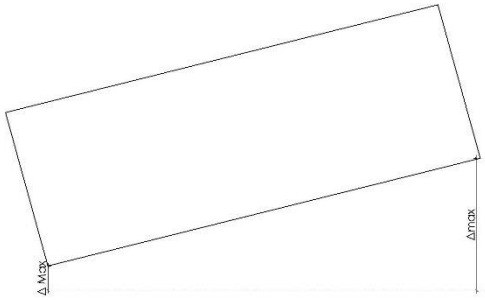

Fig 1: Torsionally Irregularity

Response spectrum method is a linear dynamic analysis method used to determine peak response of structure during a seismic event. The plot of displacement, velocity and acceleration is studied during a seismic event. From these curves are plotted and used for analysis of structures. Since it represents the peak value, it is conservative method of analysis. NBC 105:2020 has proposed four types of soil type whereas IS 1893:2016 part 1 has proposed three types of soil type. Response spectrum method has been used for studying.

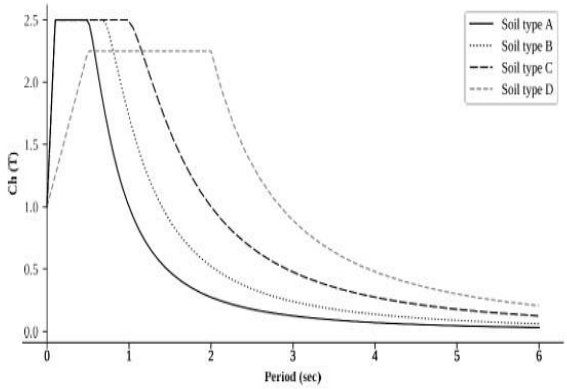

Fig 2: Response Spectrum Curve as per IS

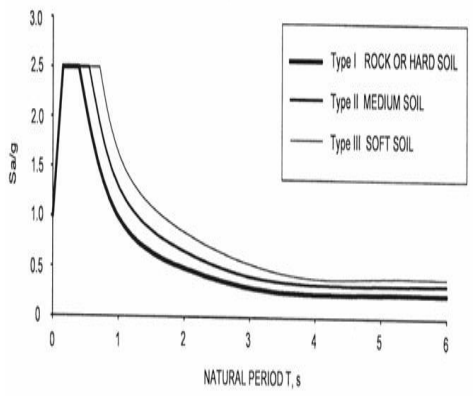

Fig 3: Response Spectrum Curve as per NBC

Seismic codes are general guidelines for designing the structures such that we can minimize the loss. The IS code and NBC 105:2020 has different seismic parameters that result in variation of earthquake force. There is wide variation of base shear, storey drift etc. when compared.

Overview between the two Codes

Nepal Building code NBC 105: 2020 Seismic Design of building in Nepal is a revision of the earlier version of NBC 105:1994. The code is based on probabilistic approach. The code has basically two objectives, damage limitation objective and life safety objectives based in earthquake ground motion with a return period of 20 years and 475 years. The code is applicable for low rise to tall structures made of concrete and steel structures. The analysis for ultimate and serviceability limit has been adopted in this code.

IS 1893:2016 (Part 1) is a revision of the earlier version IS 1893:2002 published by Bureau of Indian Standard based on deterministic approach. Part 1 deals about the earthquake resistant design of buildings applicable for all the types of buildings.

Table 1:- Difference between IS and NBC Code

S.N.	Parameters	IS 1893:2016	NBC 105:2020
1	Time Period (T_a)	$T= 0.075\ h^{0.75}$ (Bare MRF building without Infill Walls) $T= 0.09*h/\sqrt{d}$ (for All type of Building) Where h is height of Building in m d is base dimension in m	$T= K_{t*}H^{3/4}$ Where K=0.075 for MRF concrete frame. Where, H= Height of the building from foundation/rigid basement.
2	Percent in imposed Load	LL ≤ 3.0- use 25% LL ≥3.0- use 50%	Storage Purpose -60% other Purpose- 30% Roof - Nil
3	Importance Factor (I)	Other Building= 1.0 Residential, Commercial= 1.2 School, Hospital=1.5	Ordinary Building= 1.0 School, Cinema, colleges, malls=1.25 Hospital=1.5
4.	Storey Drift	0.004 times Storey height	For ULS-0.025* Storey height For SLS- 0.006* Storey Height
5.	Base Shear coefficient	A_h A_h= Design horizontal Acceleration coefficient	ULS, $C_d(T1) = C(T_1)/(R_\mu*\Omega_\mu)$ SLS, $C_d(T1) = C_s(T_1)/\Omega_s$ R_μ=Ductility Factor Ωs, Ωu= over strength Factor C(T1) =Elastic Site Spectra for ULS C_s(T1) =Elastic Site Spectra for SLS
6.	Design lateral Force	$V_B= A_h*W$	$V= C_d(T1)*W$
7	Load Combination	1.5 (DL+LL) 1.2(DL+LL±EQX±0.3EQY) 1.5(DL±EQX±0.3EQY) 0.9(DL)±1.5(EQX±0.3EQY) 1.2(DL+LL±EQY±0.3EQX) 1.5(DL±EQY±0.3EQX)	1.2DL+1.5LL DL+lLL±(EQX±0.3EQY) DL+lLL±(EQY±0.3EQX) Where, l = 0.6 for storage facilities = 0.3 for other usages

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		0.9(DL)±1.5(EQY±0.3EQX)	
8	Seismic Zone Factors	Seismic zone is divided in to 4zone.	different seismic zone interpolated for different regions.

Literature Review

Shrestha R et. al. (2024) studied RCC model having G+8 Storied building with regular configuration using static and dynamic method in ETABS in medium soil type. The base shear by NBC 105:2020 is greater by 35% than the IS 1893:2016. Also, area of reinforcement, storey drift and displacement obtained using NBC 105:2020 is greater than that of IS 1893:2016. Also, researcher found that NBC 105:2020 is more conservative and leads to uneconomical structure rather than that of IS code.

Adhikari Basanta et al., (2023) analysed 2 and 3 storey building using equivalent static method using IS and NBC code. The reinforcement needed in building using NBC is greater 22.59% and 16.26 % than IS code in columns in 2 storey and 3 storey building. For beam NBC requires less 7.24% and 0.65% less compared to IS code for 2 storey and 3 storey respectively. Also, the total reinforcement needed by NBC code is 3.60% and 6.38% higher compared to IS code in 2 storey and 3 storey respectively.

Shrestha Jagat K et al., (2021) studied for assessment of impact of the linear and nonlinear static and linear dynamic analysis in two and four storey building using IS and NBC code. After the analysis base shear of the building is greater by 60% in NBC 105:2020 compared to NBC 105:1994.

Banjara Rajesh et al., (2021) analysed low rise **RC** building of three storey and staircase cover. The base shear value is greater by 104%, 116% and 157% by ultimate limit state (ULS) NBC 105:2020 to serviceability limit state (SLS) NBC 105:2020, IS 1893:2016 and NBC 105:1994. Also, storey drift is higher by 4%, 4% and 150% by ultimate limit state (ULS) NBC 105:2020 to serviceability limit state (SLS) NBC 105:2020, IS 1893:2016 and NBC 105:1994.

Pandit Prateek Raj et al., (2019) studied about the base shear, displacement and reinforcement demand in G+21 Storey building using NBC 105:1994 and IS 1893:2016 code. According to Seismic coefficient method base shear by IS code in soil type I is 32.2% greater, 43.32 % greater in soil type II and 11.64% less in soil type III than that of NBC respectively. According to Seismic coefficient method inter storey drift ratio by IS code in soil type I is 29.95 % greater, 40.91 % greater in soil type II and 13.19% less in soil type III than that of NBC respectively. According to Seismic coefficient method total reinforcement by IS code in soil type I is 34.57 % greater, 46.48 % greater in soil type II and 19.16% more in soil type III than that of NBC respectively.

Materials and Methods

The building taken for study is basement+ four storey with staircase cover is taken into consideration for study. The building has built up area of 3875.50 Sq. Ft. In our analysis we have considered bare frame model. All the outer wall adopted is 230mm. The building is torsionally irregular due to geometry.

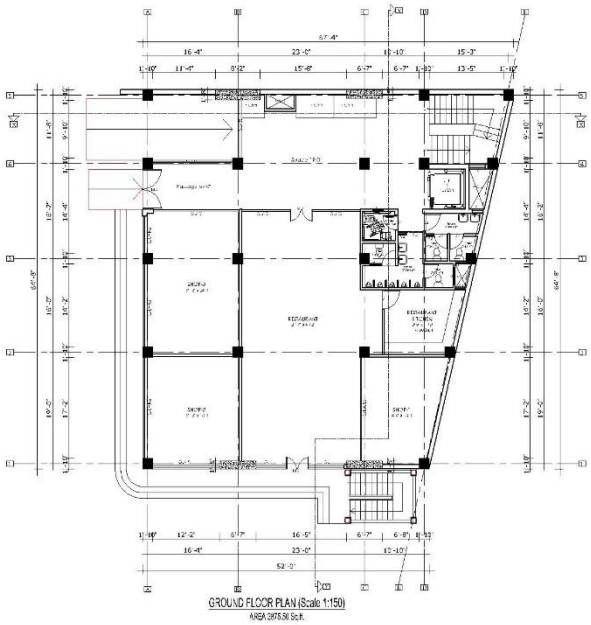

Fig 4: Typical Floor Plan

Table 2: Input Parameters

S.N.	Materials	Property Value
1	Characteristics strength of concrete (Fck)	M25
2	Yield strength of rebar (Fy)	500 MPa
3	Unit weight of RCC	25 KN/m^3
4	Unit weight of Brick Masonary	20 KN/m^3

Table 3: Section Properties

S.N.	Section	Size
1	Floor Beam	375mm*600mm
2	Secondary Beam	230mm*350mm
3	Column Size	550mm*550 mm
4	Shear wall 1	2000mm*425mm
5	Shear wall 2	2500*500mm
6	Partition wall	115mm thick
7	Outer wall	230mm thick

Results

A. Base Shear

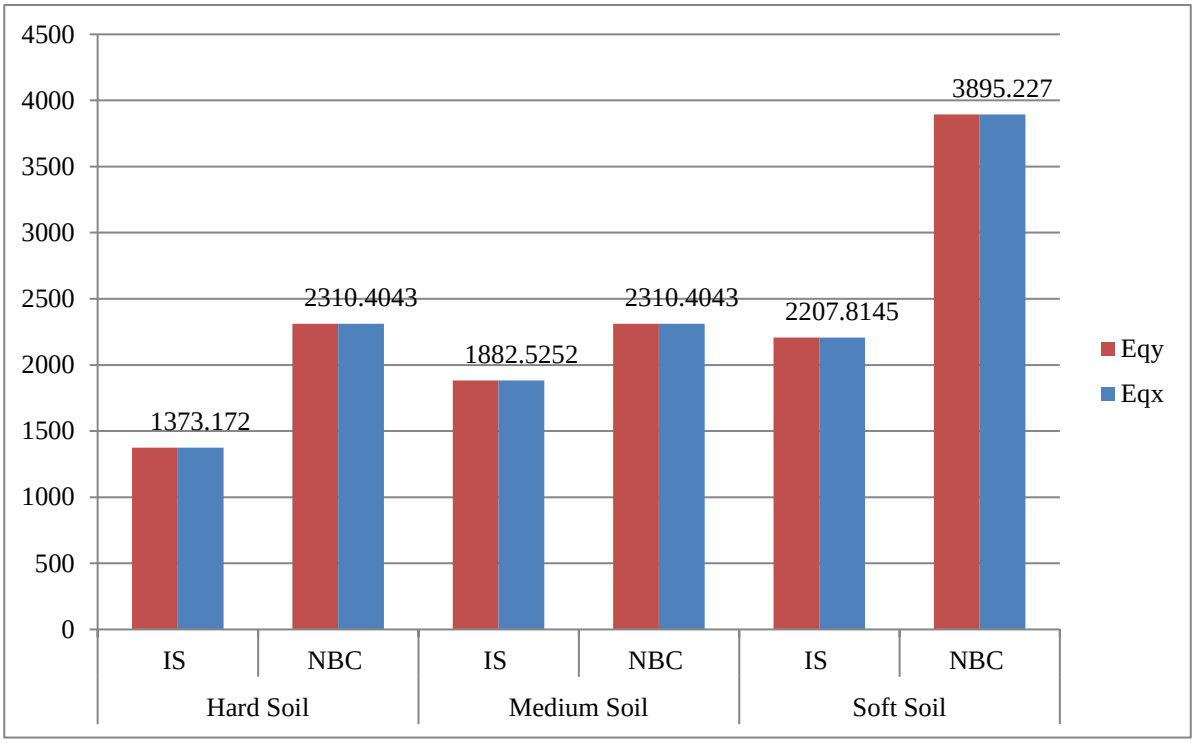

Fig 5: Base shear values in different soil types

While analyzing the base shear by using both codes we can see that base shear from IS code is lesser than from NBC in all three soil types. It is observed that base shear from IS code is lesser by 40.57% as compared to NBC code in hard soil type, 18.52% lesser as compared to NBC code in medium soil type, lesser by 43.32% as compared to NBC code in soft soil type. Also, there is great deviation between base shear values in soft soil.

Based on the design base shear, NBC code has higher values due to design horizontal acceleration coefficient since NBC uses higher coefficient values. The reason behind the above result is the zone factor as per IS code is 0.36 but NBC has 0.4. Response Reduction factor as per IS code is 5 however for NBC code it is 4 times over strength factor, resulting in higher design horizontal acceleration coefficient.

B. Storey Drift

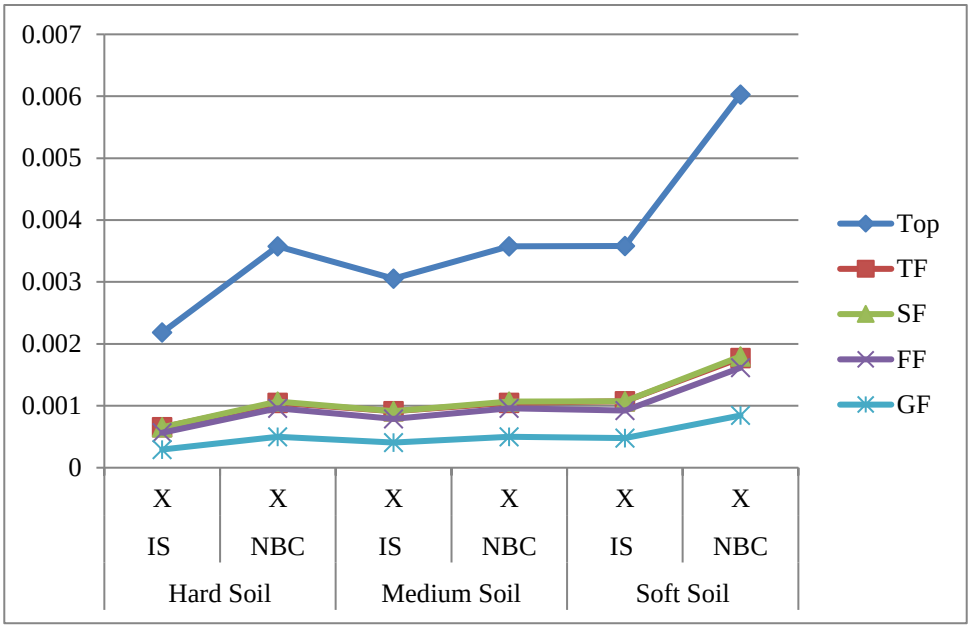

Fig 6: Storey Drift in X Direction in different soil type

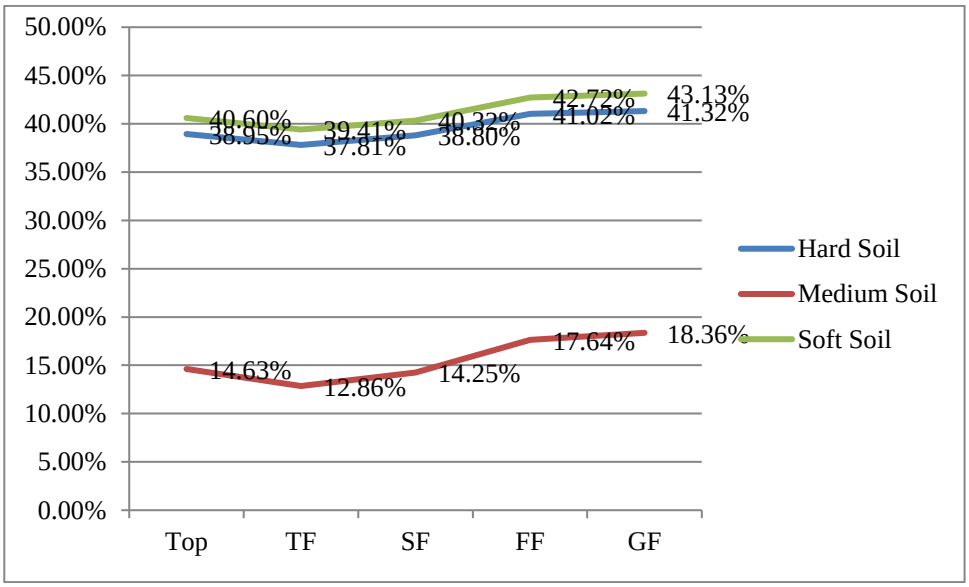

Fig 7: Comparison of storey drift between IS to NBC code to X Direction in different soil types

From above diagram it is observed that drift ratio in X direction is greater in NBC code as compared to IS code. Maximum drift ratio/displacement is seen in Top floor due to mass irregularity. The storey drift ratio is less than 38.95% ,14.63% and 40.60% respectively in hard, medium, soft soil from IS code with respect to NBC Code in X direction. The least deviation in storey drift is seen in medium soil and maximum deviation of storey drift is seen in soft soil.

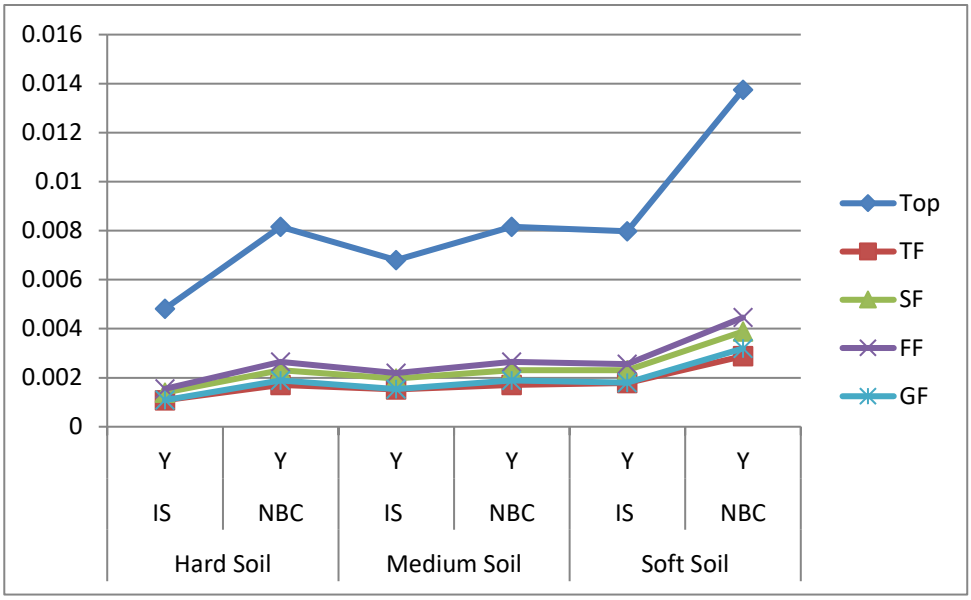

Fig 8: Storey Drift in Y Direction in different soil types

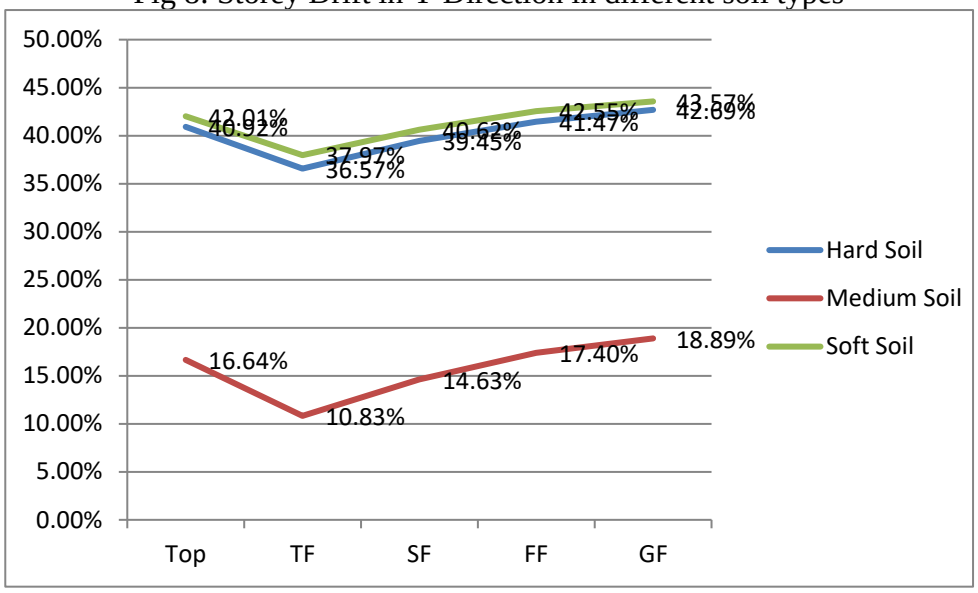

Fig 9: Comparison of storey drift between IS to NBC code to Y Direction in different soil types

From above diagram it is observed that drift ratio in Y direction is greater in NBC code as compared to IS code. Maximum drift ratio/displacement is seen in Top floor due to mass irregularity. The storey drift ratio is less than 40.92% ,16.64% and 42.04% respectively in hard, medium, soft soil from IS code with respect to NBC Code in Y direction. The least deviation in storey drift is seen in medium soil and maximum deviation of storey drift is seen in soft soil.

From above result it is observed that Storey drift from NBC code is higher than that IS code. The higher lateral force results in higher displacement and similar for storey drift.

Conclusion

Based on the analysis of torsionally irregular building using IS and NBC code base shear is less by 40.57% as compared to NBC code in hard soil type, 18.52% lesser as compared to NBC code in medium soil type, lesser by 43.32% as compared to NBC code in soft soil type. The storey drift ratio is less than 40.60% in

IS code to NBC code in X direction in soft soil, 38.95% in hard soil and 14.63% in medium soil. The storey drift ratio is less than 42.01% in IS code to NBC code in Y direction in soft soil, 40.92% in hard soil and 16.64% in medium soil.

NBC code has higher values due to design horizontal acceleration coefficient since NBC uses higher coefficient values. The reason behind the above result is the zone factor as per IS code is 0.36 but NBC has 0.4. Response Reduction factor as per IS code is 5 however for NBC code it is 4 times over strength factor, resulting in higher design horizontal acceleration coefficient. Similarly for Storey drift from NBC code is higher than that IS code. The higher lateral force results in higher displacement and similar for storey drift.

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