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Comparative Study of Building Response on Adoption of NBC105: 2020 and IS 1893 (Part 1): 2016

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Abstract: ***Nepal suffered a massive loss of life and property from Gorkha Earthquake in 2015AD. Many building structures were either partially or fully damaged and most affected were classic buildings and monuments which were constructed without any design consideration and didn't pose any resistance during the earthquake. After, a broad study and hazard analysis of earthquakes, the Nepal government concluded that the construction methods needed to be revised. The first building regulation in 1994AD known as NBC: 105: 1994 was drafted after the earthquake in 1988 in the eastern part of Nepal. Moreover IS 1893 (Part 1) and IS 13920 codes are still used widely for earthquake resistance design and detailing. But now the Department of Urban Development and Building Construction (DUDBC) has introduced an updated building code of practice NBC 105: 2020 for earthquake-resistant design. In this paper, an effort is done to analyse and compare the effects on buildings of 2-Storey and 3-Storey under the application of IS and NBC code. Equivalent static analysis was carried out with the help of ETABS v19.1.0 and the parameters like base shear, storey displacement and storey drift under both codes are compared. The analysis result shows that the response of building subjected to NBC: 105: 2020 exhibits higher storey responses compared to IS 1893: 2016. Also, the NBC code demands a higher percentage of reinforcement requirements compared to IS code.***

Keywords: Storey Displacement, Storey Drift, Base Shear, Reinforcement Requirement.

I. INTRODUCTION

Construction of RC frame low rise as well as high rise structures has rapidly increased in contemporary period. Safe as well as economic building design practise is a pre requisite for the growth of socio-economic status of individual and society. At present, IS 1893 (part 1): 2016 “criteria for earthquake resistant design of structures” and NBC 105:2020 “Seismic Design of Building in Nepal” are adopted for analysis and design of earthquake resistant building in Nepal. The code IS 1893: 2016 and NBC: 105: 2020 provides different flexural stiffness to the different structural components.

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Applying two different codes to the same type of building shows the different responses in terms of base shear, storey displacement, storey drift and reinforcement requirement. Variation of response occurs due to the assumptions directed by the codes for strength.

To achieve the objective of the square plan is considered with 2-Storey and 3-Storey. Both building models are analysed using ETABS v19.1.0 software with consideration of both IS and NBC code for each model. Different responses like Base Shear, Storey Displacement, Storey Drifts and reinforcement requirement of same building with application of two different codes are compared.

II. LITERATURE REVIEW

Aashish et al. [1] researched about Comparative Analysis of NBC With IS Code For RC Structures and after the studied elevated structure taller than 30-36m in soil type III, they concluded that it gets hard to sum up which code gives increasingly preservationist results and when it is considerably taller, NBC 105 yield higher seismic request and turn out to be more moderate than IS 1893. Also, they found that Indian seismic codes are more moderate than Nepali seismic code

Jagat K. et al [2] studied that the Impact of Revised Code NBC105 on Assessment and Design of Low Rise Reinforced Concrete Buildings in Nepal and after the analysis of 2 storey and 4 storey building they found that the base shear of the building under the revised NBC105:2020 is 60% higher compared to the previous code NBC 105:1994.

Rajesh B. et al [3] studied Seismic Behaviour of Buildings as per NBC 105:1994, NBC 105:2020 and IS 1893:2016 and they analyse the 3 storey building with stair cover. After the analysis, they found that the different parameters like base shear, Storey drift, Storey Displacement, time period etc are higher for NBC 105 2020.

Prateek R. et al [4] researched about Comparative Analysis Of NBC 105:1994 And IS 1893:2016 Seismic Codes With G+21 RC Building and they found that the soil type I and II, IS1893:2016 gives higher base shear, displacement and drift than NBC 105:1994, For soil type III NBC 105:1994 give higher base shear, displacement and drift than IS 1893:2016 and IS 1893:2016 gives higher reinforcement demand than NBC 105:1994.

III. BUILDING CONFIGURATION

A. Loads

All assigned loads on the structure is obtained as per **IS: 875 (Part 1) - 1987**, and **IS : 875 (Part 2) - 1987**. The different types of loads assigned is demonstrated in **Table I**.

Table I: Loads

Dead Loads	
Masonry Brick Wall with Common Burnt clay Bricks ➢ Outer Wall load ➢ Partation Wall Loadd	19.2 kN/m 10.1 kN/m 5.1 kN/m
Reinforced Cement Concrete With 2% steel	25 kN/m^3
Floor Finished	2 kN/m^2
Live Loads	
Live Load for Rooms Live load for Roof	2 kN/m^2 1.5 kN/m^2
Seismic Loads:	
As per NBC 105 2020 As per IS: 1893 (Part 1) - 2016	

B. Building Summary

It includes the physical properties of the building, sectional properties and material properties. The summary of all properties is listed in Table-II.

Table II: Building Properties

Building Properties	
Building System	RCC Framed Structure
Building Type	Residential building
Number of Storey	G+1 Storey (2-Storey) and G+2 Storey (3-Storey)
Floor Height	3.2m
Span	3.9m in X-direction and 3.9m in Y direction
Sectional Properties	
Column Size	300mm × 300mm
Beam Size	250mm × 350mm
Slab Thickness	125 mm
Concrete Grade	M20
Reinforcement Grade	Fe500
Brick Wall	
Outer Wall Thickness	230mm
Partition Wall Thickness	115mm

C. Assumptions

NBC 105:2020

The software ETABS does not include NBC 105:2020 so the parameters need to be calculated and assigned. The design parameters were manually calculated as tabulated in **Table-III**.

Table III: Design Parameters For NBC

Design Parameters	Formula	NBC 105:2020	
		2-Storey	3-Storey
Seismic Coefficient			
Time Period, T	$1.25 \text{x} k_t \text{x} H^{\frac{3}{4}}$	0.377 sec	0.5112 sec
Seismic Zone Factor, Z		0.4	0.4
Soil Type		C	C
Importance Factor, I		1	1
Base Shear Distribution Factor, k		1	1.01
Spectra Shape Factor, $C_h(T)$		2.5	2.5
Elastic Site Spectra, C(T) or $C(T_1)$			
Ultimate Limit State (ULS), $C(T_1)$	$C_h(T)$xZxI	1	1
Serviceability Limit State (SLS), $C_s(T_1)$	0.2x$C(T)$	0.2	0.2
Base Shear Coefficient, $C_d(T_1)$			
Ultimate Limit State (ULS)	$\frac{C(T_1)}{R_\mu \text{ x } \Omega_u}$	0.166	0.166
Serviceability Limit State (SLS)	$\frac{C_s(T_1)}{\Omega_s}$	0.160	0.160
Eccentricity Ratio		10%	10%

IS 1893: 2016

Parameters necessary for the analysis as per IS 1893 (Part 1): 2016 is presented in Table-IV

Table-IV: Design Parameters for IS

Design Parameters	IS 1893:2016
Importance Factor, I	1
Zone Factor, Z	0.36
Soil Type, S	II
Response Reduction Factor, R	5
Eccentricity Ratio	5%
Time Period, T	0.301 sec

D. Building Models

In this study, the 2-Storey and 3-Storey RC frame building model are considered with same square plan area, same sectional properties, floor heights and loads. The building models represented by **Figure 1** - **(a), (b)** and **(c).**

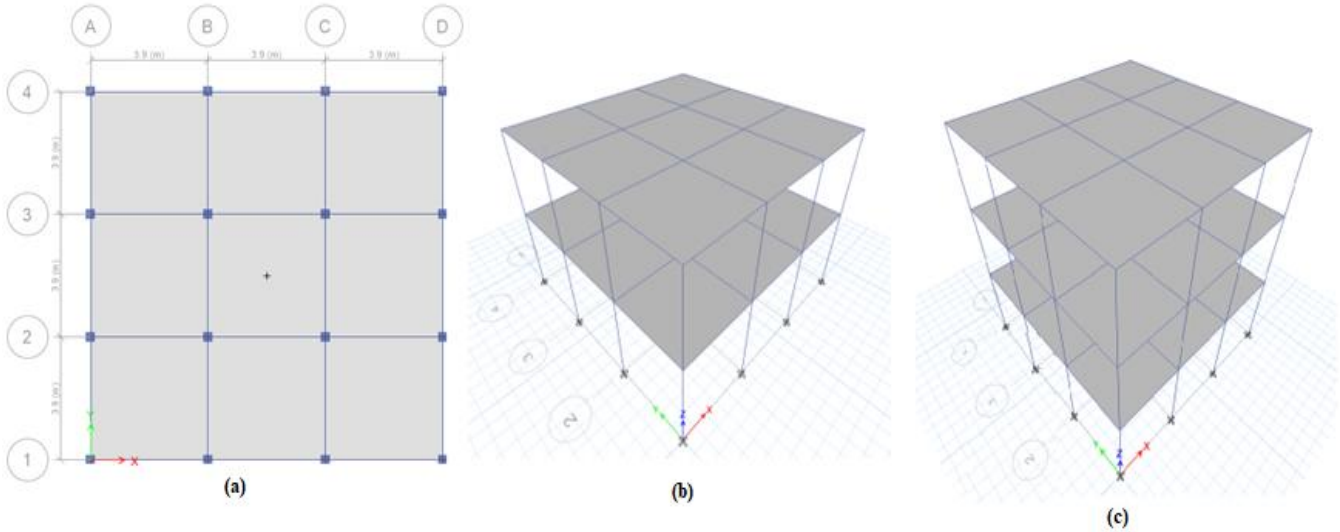

Figure -1: Building Model, (a) Plan, (b) 2-Storey and (c) 3-Storey

E. Sampling of Building Members

For sampling of column, whole columns are divided into three categories on the basis of location which is Centre Column, Outer Mid Column and Corner Column with 4, 6 and 4 Number of Columns respectively as seen from **Figure-2**. For sampling of beam, the critical Beam is selected. The beam along Grid A-A as shown in **Figure-3** is selected for comparison.

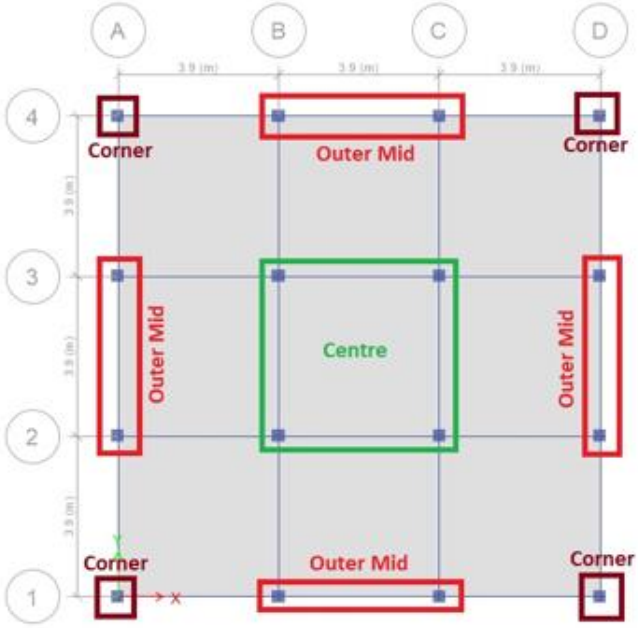

Figure -2: Sampling of Column

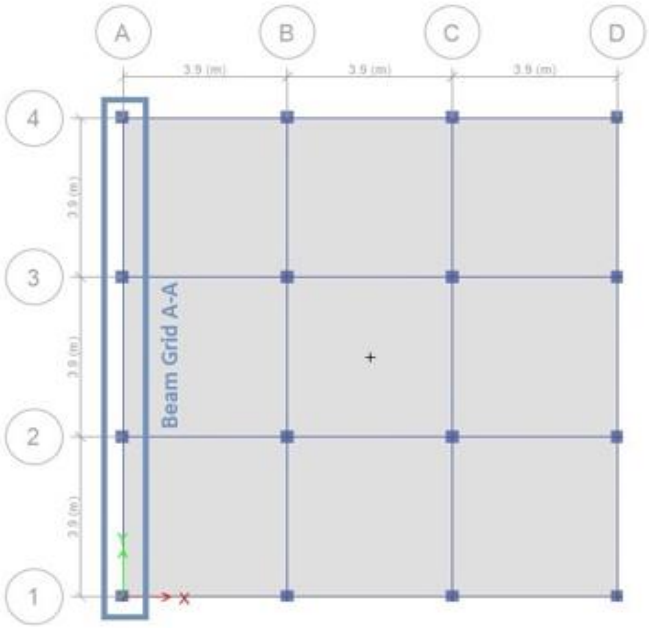

Figure-3: Beam Sample

IV. RESULTS AND DISCUSSIONS

The results are obtained for the parameters i.e. storey drift, lateral sway and base shear for 2-Storey and 3-Storey building model both analysed using IS **1893: 2016 and NBC 105: 2020**and compared. In this case, equivalent static analysis is done for the seismic analysis of the building.

A. Base Shear

It can be seen from **Figure 4** that the building model using NBC code exhibits higher base shear compared to the model using IS code. The base shear of building model using NBC code for 2-Storey is about **44.26%** and for 3-Storey is about **44.22%** higher compared to building model using IS code.

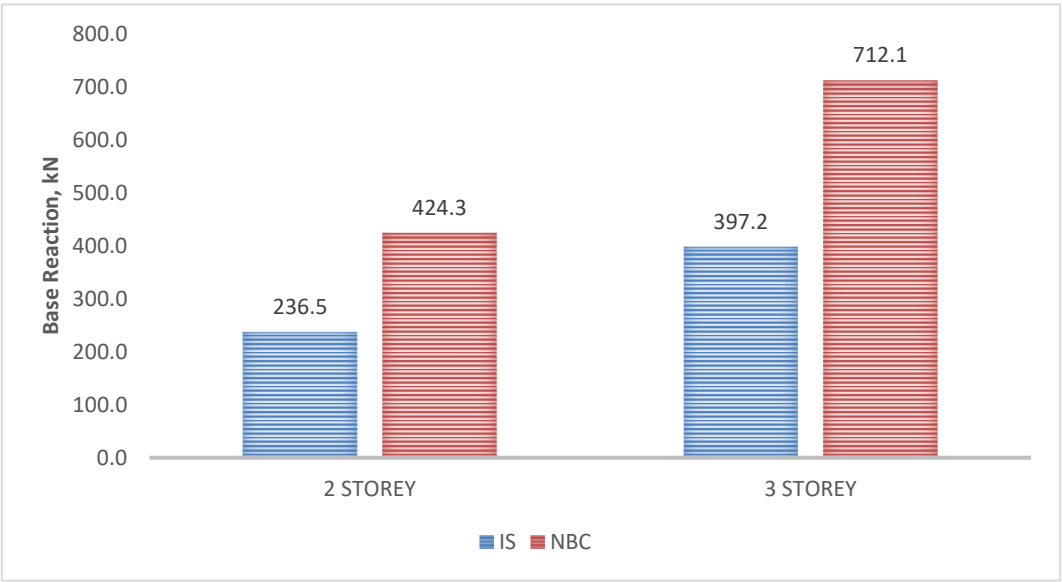

Figure 4: Base Shear of 2-Storey and 3-Storey Building

B. Lateral Displacement

According to **IS 456: 2000, Cl. 20.5**, the lateral Displacement at the top should not exceed (H/500), where H is the total height of the building. In this case, the height of the building is about 6.4m and 9.6mfor two and three storey respectively for which the lateral sway limit is 12.80 mm and 19.20mm.

After analysis of models following results were obtained and presented in Table-V. Maximum displacement is obtained from the analysis using NBC code. Maximum lateral sway obtained are **11.3 mm** and **29.4 mm** for 2-Storey and 3-Storey building models respectively which is nearly 60% more than that obtained using IS 1893.

Table-V: Lateral Displacement of 2-Storey and 3-Storey Building

Storey	Sway in 2 storey (mm)		Sway in 3 storey (mm)	
	IS	NBC	IS	NBC
Story3	-	-	18.6	29.4
Story2	7.1	11.3	14.3	23.7
Story1	3.8	6.6	6.6	11.6
Base	0	0	0	0

C. Storey Drift

It is the relative displacement between the floors above and or below the storey under consideration. According to the code **IS 1893 (Part 1): 2016**, Storey drift in any stories shall not exceed 0.004 times the storey height. For the height of 3.2m, the storey drift works out to 0.012.

According to **NBC 105:2020** the ratio of the inter storey deflection to the corresponding storey height shall not exceed 0.024 at Ultimate Limit State (ULS) and 0.006 at serviceability Limit State (SLS). In this code The Storey drift shall be determined by the multiplying the horizontal deflection found from Equivalent Static Method by the Ductility factor (Rμ). In our case, the storey drifts is under limitation.

The storey drift is obtained from static analysis as per code **IS 1893 (Part 1): 2016** and **NBC 105:2020**, The storey drift is represented in Table-VI

Table-VI: Storey Drift of 2-Storey and 3-Storey Building

Storey	IS		NBC	
	2-Storey	3-Storey	2-Storey	3-Storey
Story3	-	0.00135	-	0.001814
Story2	0.00104	0.00239	0.00148	0.003757
Story1	0.00118	0.00207	0.00205	0.003626
Base	0	0	0	0

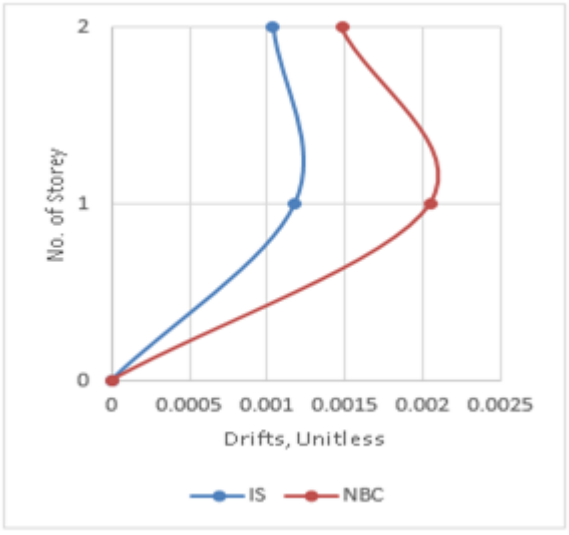

Figure-5: Interstorey drift of 2-storey

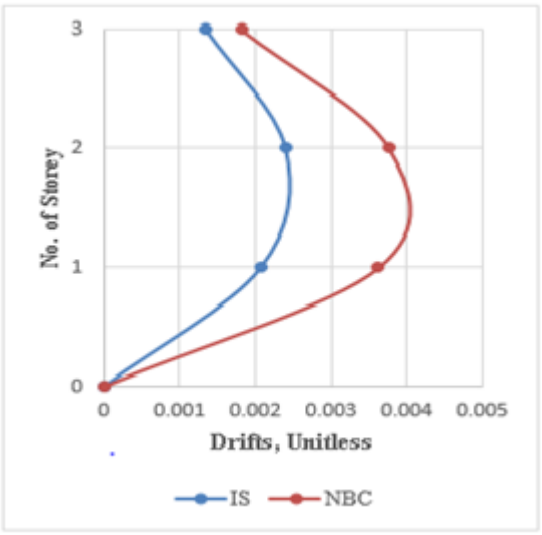

Figure-6: Interstorey drift of 3-storey

It can be shown from Figure-5, Figure-6, that the pattern of inter storey drift is almost similar for both models. In the case the model analysis with using IS and NBC code, the maximum Storey drift is observed at the level between first floor and second floor for 3-Storey and First Floor for 2-Storey building. The storey drift of the 2-storey building model with using of IS code is **42.99%** less and for 3-Storey building model with using NBC code is **36.38%** high compared to building model using IS code. Overall, NBC exhibits larger storey drift in comparison to IS code of practice.

D. Longitudinal Reinforcement

The reinforcement quantity for column in each floor is extracted from design for both IS and NBC Building Models in ETABs. The quantity of longitudinal reinforcement of Column and Beam are calculated and then compared. The longitudinal rebar requirement in column is as tabulated in **Table-VII.**

Table-VII: Column Longitudinal Reinforcement Details for IS and NBC

Storey	Floor	Sum of Corner Columns Reinforcement (mm2)		Sum Of Outer Mid Columns Reinforcement (mm2)		Sum of Centre Columns Reinforcement (mm2)		Total (mm2)	
		IS	NBC	IS	NBC	IS	NBC	IS	NBC
2-Storey	GF	4300	6456	8572	13304	3948	5908	16820	25668
	FF	3092	2880	6224	6060	2880	2880	12196	11820
3-Storey	GF	9616	13896	21172	29176	11760	14408	42548	57480
	FF	6700	6304	17460	19964	8616	9452	32776	35720
	TF	3068	2900	6614	6212	3072	2880	12754	11992

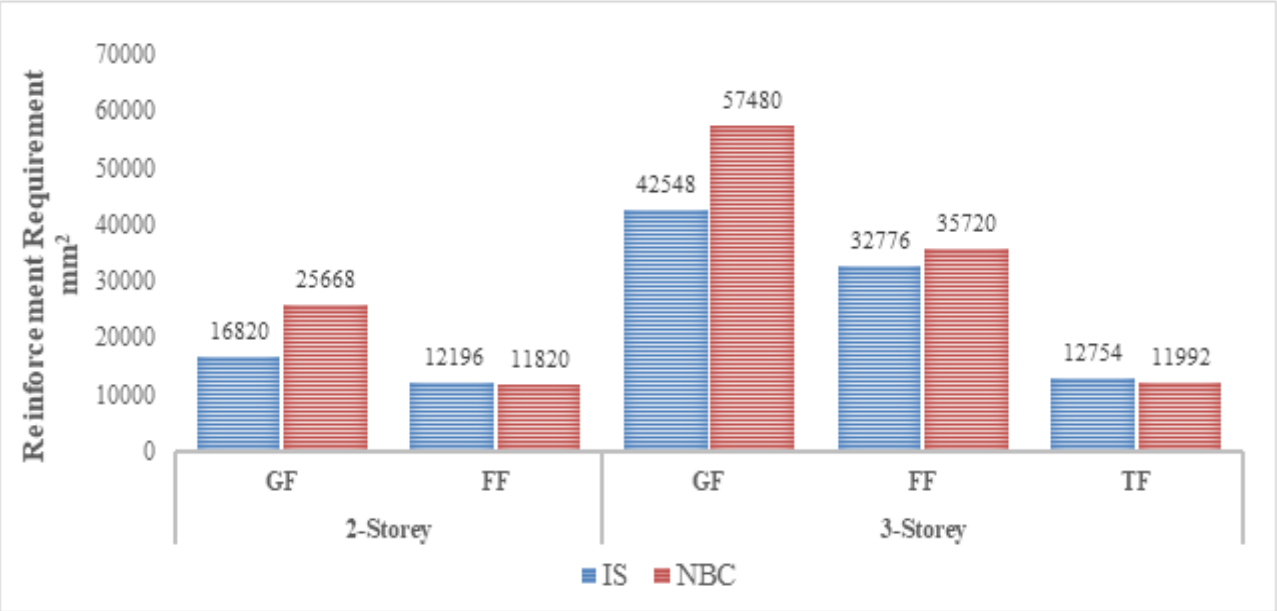

Figure 7: Total Reinforcement Quantity Comparison in Each Floor

Overall, it can be depicted from Figure 7 1 that IS code demands lesser quantity of longitudinal rebar in columns as compared to NBC. For 2-Storey Building Model, the Maximum percentage of Reinforcement requirement as per IS is about 1.27% on Ground Floor while NBC demands 1.98%. For 3-Storey Building Model, The Maximum percentage of reinforcement requirement for IS is about 3.27% on Ground Floor while NBC required 4.26%. Figure 7 shows that the building model with NBC code required high reinforcement on the almost every floor compared to building designed with IS code for both 2-Storey and 3-Storey building. Also, the total reinforcement requirement for building model with NBC code is about 22.59 % and 16.26 % high compared to building model with IS code for 2-Storey and 3-Storey building respectively.

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Table-VIII: Beam Longitudinal Reinforcement Details for IS and NBC

Storey	Floor	Code	Area of Critical Reinforcement over Length, mm2						
			0 m	1.95 m	3.9 m	5.85 m	7.8 m	9.75 m	11.7 m
2-Storey	GF	IS	488	260	564	161	564	260	488
		NBC	502	235	533	156	533	235	502
	FF	IS	216	156	235	156	235	156	216
		NBC	195	156	205	156	205	156	195
3-Storey	GF	IS	827	371	833	213	833	371	827
		NBC	928	384	892	215	892	384	928
	FF	IS	682	301	700	194	700	301	682
		NBC	663	271	662	174	662	271	663
	TF	IS	256	156	255	156	255	156	254
		NBC	221	156	217	156	217	156	221

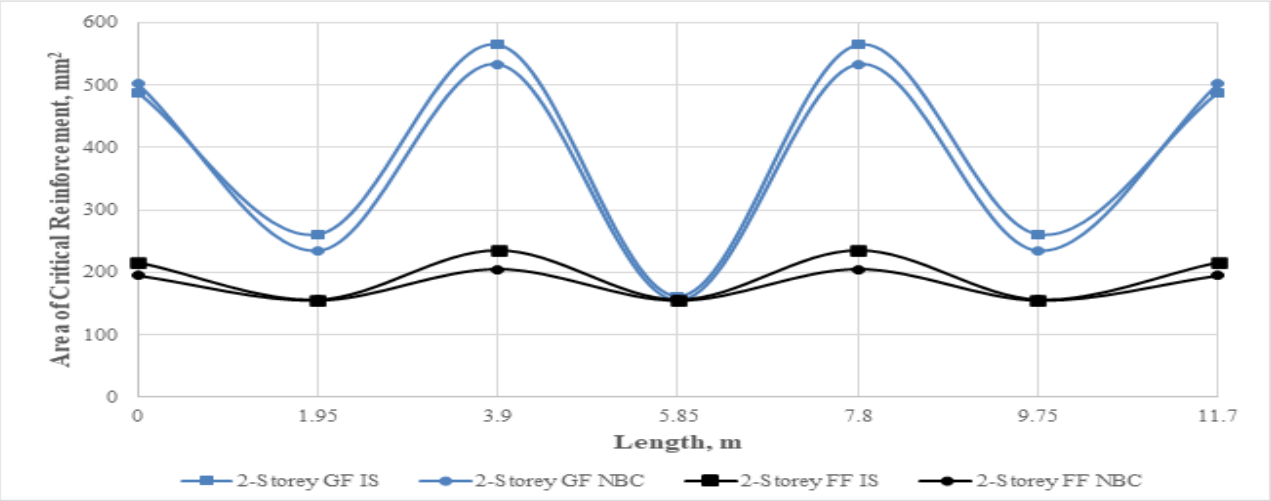

Figure -8: Beam reinforcement in 2-storey building

Beam reinforcement in a Critical grid is calculated and represented in **Table-VIII** after the design using both IS and NBC design codes. The graphical representation of the same in **Figure 8 and 9** for 2 and 3 storey respectively, reflects that reinforcement quantity demand following IS code is slightly higher than that following NBC in beams.

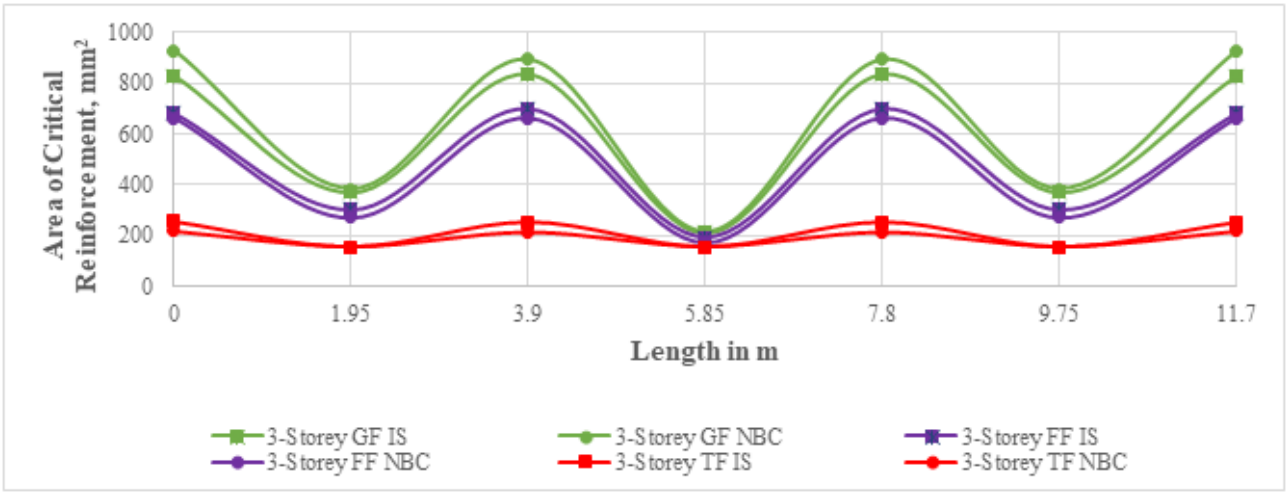

Figure -9: Beam Reinforcement Requirement for 3-Storey Building Model

The longitudinal reinforcement requirement for critical span over 1.95m intervals for both 2-Storey and 3-Storey Building respectively is represented. The graph neatly shows that the pattern of reinforcement requirement for building model with IS and NBC for 2-Storey building is almost same for all Floors while 3-Storey building, building model with NBC code required less reinforcement except Ground Floor beam compared to Building model with IS code from the comparison, the building model using **NBC 105: 2020** code required high reinforcement compared to **IS 1893: 2016** code which is **3.60 %** and **6.38 %** for 2-Storey and 3-Storey respectively for critical grid considered for beam reinforcement.

V. CONCLUSION

Based on the analysis of 2-Storey and 3-Storey building models using IS and NBC code of practice and analysing the outcomes NBC code seems to overestimate the load causing greated response of building. Building model with using NBC code gives the higher lateral displacement, higher storey drift and greater base shear than IS code. Both models provide sufficient resistance to the earthquake. The reinforcement requirement for the building model using NBC code for column is about **22.59 %** and **16.26 %** higher than that using IS code. In contrary, for beam it is about **7.24 %** and **0.65%** less compared to IS code for 2-Storey and 3-Storey respectively. Also, the building model with NBC code required higher quantity of total reinforcement which is **3.60%** and **6.38 %** higher compared to building model using IS code for 2-Storey and 3-Storey respectively.

DECALARION

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REFERENCES

1. E. A. Aryal and E. S. Dhungana, "COMPARATIVE ANALYSIS OF NBC WITH IS CODE FOR RC STRUCTURES," International Research Journal of Engineering and Technology (IRJET), vol. 06, no. 24, pp. 2114-2117, Feb 2020.
2. J. K. Shrestha, . N. Paudel, B. Koirala, B. . R. Giri and A. Lamichhane, "Impact of Revised Code NBC105 on Assessment and Design of," Journal of the Institute of Engineering, vol. 16, no. 1, pp. 1-5, April 2021. [CrossRef]
3. R. Banjara, D. Thapa, T. B. Katuwal and S. Adhikari, "Seismic Behaviour of Buildings as per NBC 105:1994, NBC," Proceedings of 10th IOE Graduate Conference, vol. 10, p. 1461 – 1471, October 2021.
4. P. R. Pandit and V. M. V, "COMPARATIVE ANALYSIS OF NBC 105:1994 AND IS 1893:2016 SEISMIC," International Research Journal of Engineering and Technology (IRJET), vol. 06, no. 11, pp. 1995-2000, Nov 2019.

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