Comparative Study And Seismic Analysis Of Educational Building With Nbc 105:2020 And Is 1893:2016(Part I)

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Abstract: There is rapid emersion of the new technologies related to safe, economical, stable construction. In such a trend, earthquake has become one of the natural challenging factors for the efficient construction works. Every country has specific building design codes which provide the standards to engineers for the design of various structural components like beam, column and slab. RC building design of every country is based on their geographical location. Considering the focus of this research work is to bring out differences and similarities between IS 1893 (part I):2016 and NBC 105:2020. The focus is the relative gains and shortcomings of both buildings design codes under certain criteria like loading analysis, design analysis, ease of use and economical point of view. Comparison work has worked out based on loading comparison like live load, dead load, and different parameters for various elements of the building such as beam, column and slab. This comparison investigates the design capacities for both building design codes. In present study RCC building models having G+8 stories with regular plan is considered for analysis. The analysis of model is done using equivalent static method and dynamic method in ETABS software. The responses of the building under the parameters like base shear, absolute displacement, drift, reinforcement in column and beam are compared for both codes. Based on the design base shear, NBC code showed a higher value compared with IS code because the design horizontal seismic force coefficient, base shear, and absolute displacement of NBC code is maximum than IS codes.

Key words: *Base shear; Story Shear; Seismic Analysis; Story Drift*

I. INTRODUCTION

Structural Analysis deals with the prediction of performance of a given structure under stipulated loads and other external effects. Structural design deals with the designing (sizing: member sizes, reinforcement details and grading of materials) various members of the structure to resist various forces to which they might be subjected during the life period of the structure. While analysis, frames are analyzed for earthquake as lateral or horizontal load. During the earthquake, structural and non-structural damages occur in which both are hazardous to occupants. When earthquake shaking occurs, a building gets thrown from side to side or up and down i.e. ground moves violently side by side and building stay at rest. Thus, the building gets thrown back and forth by the motion of the ground with some part of building lagging behind and then moving in the opposite direction. The level of damage depends upon how well the building has been designed and constructed.

In our context, the analysis of earthquake is based on seismic coefficient design method and response spectrum method as described in NBC: 105: 2020 and IS 1893: 2016 (SEISMIC DESIGN OF BUILDINGS IN NEPAL NBC: 105: 2020, 2077) (Criteria for earthquake resistant design of structure, December, 2016).The project report has been prepared in complete conformity with various provisions in Indian Standards as Code of practice for plain & reinforced concrete IS 456-2000; Code of practice for Design loads IS 875 (Part 2)-1987 (CODE OF PRACTICE FOR IS : 875 (Part 2) -1987 (Reaffirmed 2008) DESIGN LOADS (OTHER THAN EARTHQUAKE) FOR BUILDINGS AND STRUCTURES , June 1998), Design Aids for Reinforcement Concrete (SP 16) IS 456-1978are thoroughly referred for proper analysis, design and detailing of structural elements with respect to safety, strength, stability, ductility & economy in addition to adequate serviceability requirements of cracking and deflection in concrete structures. All the codes are based on the principles of limit state of design. The project report possesses modeling output, analysis results, load calculations, architectural drawings, structural drawings and sample calculations of various structural elements and their detailing as well.

II. OBJECTIVES OF THE STUDY

The main objectives of this thesis are to analyze RCC framed building using both Nepal Building Code and Indian Building Code. We can summarize the objective as follows:

• To compare base shear, drift value, displacement value and reinforcement using both codes (SEISMIC DESIGN OF BUILDINGS IN NEPAL NBC: 105: 2020, 2077) (Criteria for earthquake resistant design of structure, December, 2016).

III. LITERATURE REVIEW

Adhikari, B.et al. (Adhikari, Adhikari, & Thapa , May 26,2022) did Comparative Analysis of NBC With IS Code For RC Structures and after the study of 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.

J.K.Srestha .et al. (Srestha, Poudel, Koirala, Giri, & Lamichhane, 2020-7-24) studied impact of revised NBC 105 code and design of low rise RCC building in Nepal and concluded that Indian Standard Codes for seismic hazard analysis is deterministic approach whereas Nepal Building Code is based on probabilistic approach and impact of revised code is has been studied. The response of the buildings such as time period, base shear, drifts, and story forces from the application of the four codes was compared in this study. The comparison of the results concludes that the base shear of the building under the revised NBC105:2020 is 60% higher compared to the previous code NBC105:1994.

Rajesh B. et al. (Banjara, Thapa, Katuwal, & Adhikar, 2021)studied Seismic Behavior of Buildings as per NBC 105:1994, NBC 105:2020 and IS 1893:2016 and they analyze the 3-story building with stair cover. After the analysis, they found that the different parameters like base shear, Story drift, Story Displacement, time period etc. are higher for NBC 105 2020 (SEISMIC DESIGN OF BUILDINGS IN NEPAL NBC: 105: 2020, 2077).

Ramhari Shrestha et al.(Shrestha et al. 2024) studied Seismic Behavior of Buildings as per NBC 105:2020 and IS 1893:2016 and they analyze the 7 story building with stair cover. After the analysis, they found that the different parameters like base shear, Story drift, Story Displacement, time period etc. are higher for NBC 105 2020 (SEISMIC DESIGN OF BUILDINGS IN NEPAL NBC: 105: 2020, 2077)

IV. METHODOLOGY

For moving forward with the project, we adopted the method much suitable for analysis of the structure. We adopted limit state design for the analysis. We started with preliminary design of the structure where we calculated the size of beam, column and slabs. We further calculated the dead load in each floor. The calculation was done with the help of IS code and NBC code. After this we moved towards the structural design and analysis of the structure in ETABS software. We designed the structure both manually and through the software and compared the results with each other and checked the structure for drift, displacement and also calculated the area of steel in different structural member like beams and columns both manually and through the software for both IS and NBC code.

Building summary

Number of story	9 including basement
Floor height	3.6 m
Type of building	SMRF
Location	Lalitpur (with soil type medium)
Area	3188.729 sq.ft
Load	**Dead load=** calculated as per IS 875- part I 1987 Live load =calculated as per IS 875-part II 1987 Seismic load =calculated as per NBC: 105: 2020 and IS 1893:2016
Seismic zone factor	0.36 as per IS **0.3 as per NBC**
Importance factor	1.5
Response reduction factor	5
Natural time period	$0.075h^{0.075})/\sqrt{Aw}\ >=0.09h/\sqrt{d}$ = 0.64 and 0.58sec

Structural Design

S.No.	Structural Member	Size(mm*mm)	Reinforcement
1	Primary Beam	350*600	4-20mm diameter top bars and 2-16mm diameter bottom bars. 2-legged 8mm@150mmc/c spacing at edge and 200mm c/c spacing at middle
2	Secondary Beam	250*400	2-16mm diameter top bars and 2-12mm diameter bottom bars. 2-legged 8mm@100mmc/c spacing at edge and 200mm c/c spacing at middle
3	Slab	5613*6752	8mm Dia. @ 150mm c/c spacing along shorter side. 8mm Dia. @ 200mm c/c spacing along longer side.
4	Column	650*650	20mm diameter corner and inner bar 4L-8mm dia@300mm c/c spacing
5	Foundation(Raft Foundation)	380.85m2	20mm diameter @ 150mm c/c at top and bottom in both direction
6	Staircase	Riser=180mm Tread=300mm	16mm diameter @130mm c/c main bar 10mm diameter @ 200mm c/c

| 7 | Basement Wall | 230 | 12mm@200mm c/c spacing on front face and12mm@200mm c/c for side face for horizontal reinforcement
16mm@150mm c/c spacing for vertical reinforcement |
| 8 | Lift wall | 300 | Vertical reinforcement
Of 25mm @200mm c/c
And Horizontal reinforcement of 16mm bars @ 300mm c/c in x direction.
Vertical reinforcement
Of 16 mm @225mm c/c
And Horizontal reinforcement of 16mm bars @ 300mm c/c in y direction. |
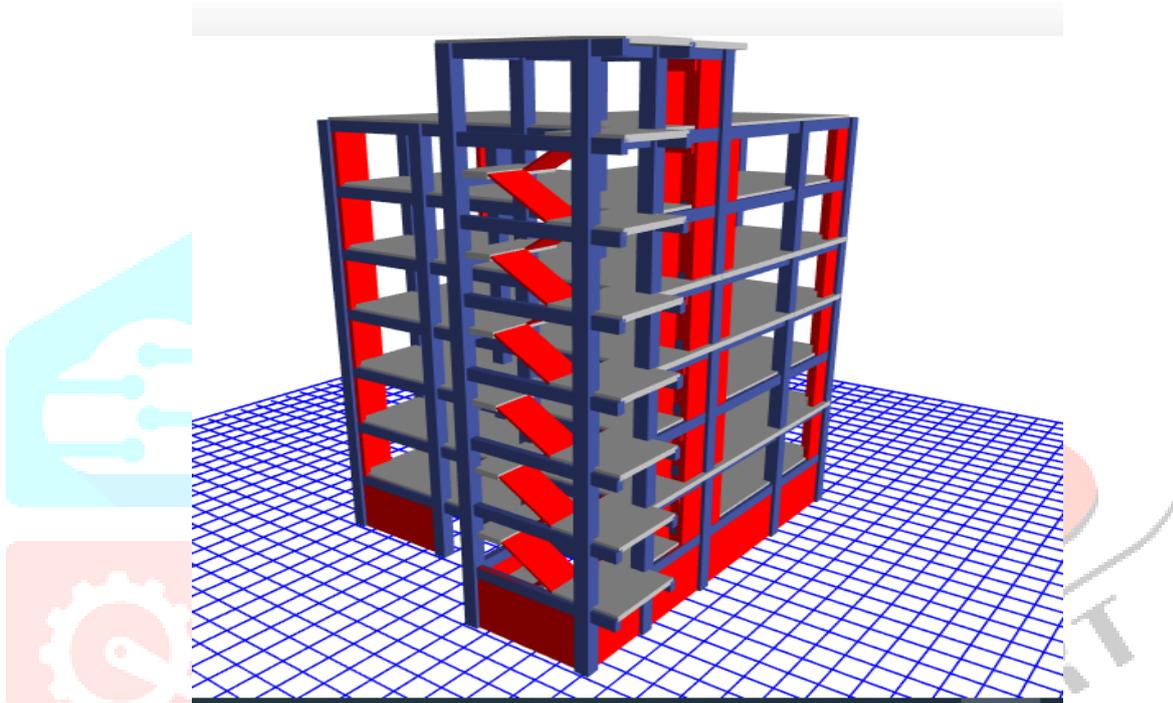
Figure 1:*3D modelling of building using ETABS*

V. COMPARISON OF BASE SHEAR AND AREA OF REINFORCEMENT USING IS 1893(PART 1):2016 AND NBC105:2020

Table 1: Base shear from IS1893(2016) part I

Criteria	According to IS 1893(Part 1):2016	According to NBC 105:2020
Lumped mass	29198.28KN	23825.3KN
base shear coefficient	0.116	ULS=0.214 SLS =0.175
Base shear	**3387.46 KN for 0.64 sec** **3715.09 KN for 0.58 sec**	ULS= **5787.7 KN** SLS=**4733 KN**
Reinforcement	Column, Ast = 3380 mm^2 Beam, Ast = 487 mm^2	Column, Ast = 3471 mm^2 Beam, Ast = 493 mm^2

Result: From above table it is observed that base shear obtained using code NBC 105:2020 is greater than IS 1893 (part I): 2016 which is increased approximately by 35%.

The value of area of reinforcement of beam and column obtained from ETABS using NBC 105:2020 is higher than the value obtained using IS 1893 (part I): 2016.

VI. *Comparison of* Displacement using IS 1893(part I):2016 and NBC 105:2020
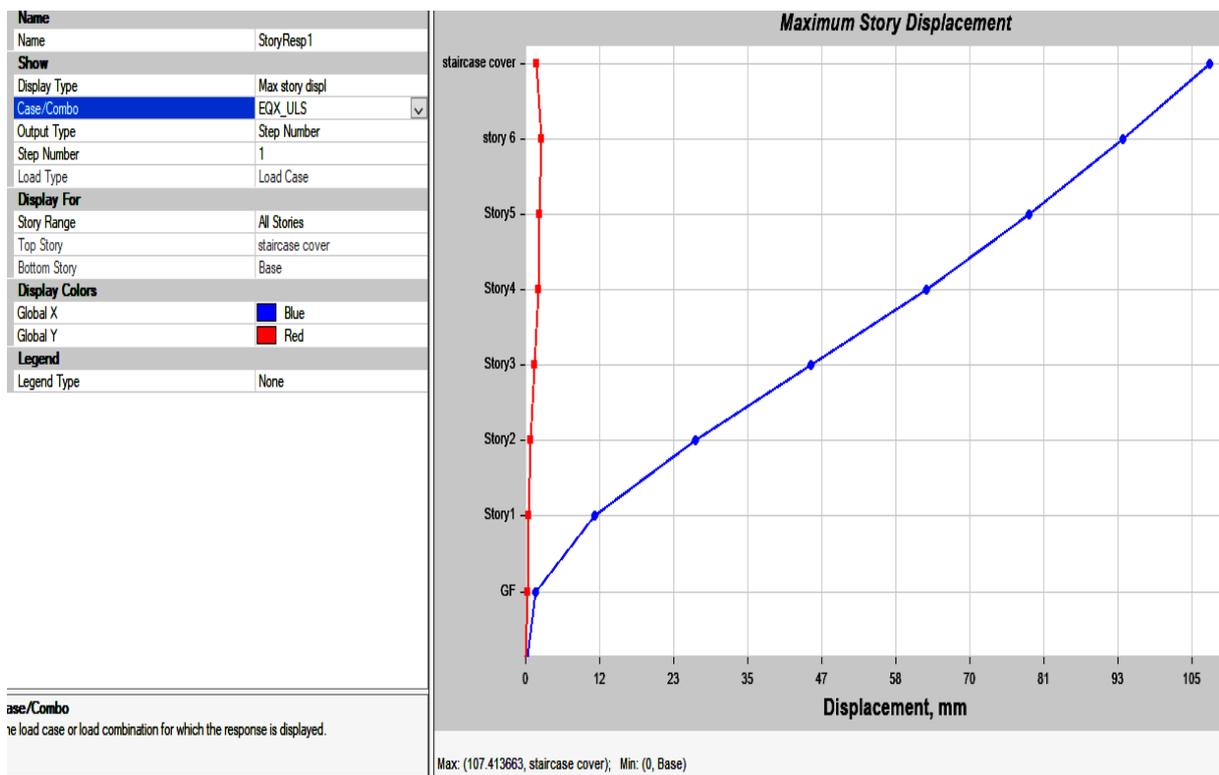
Displacement check using NBC 105:2020

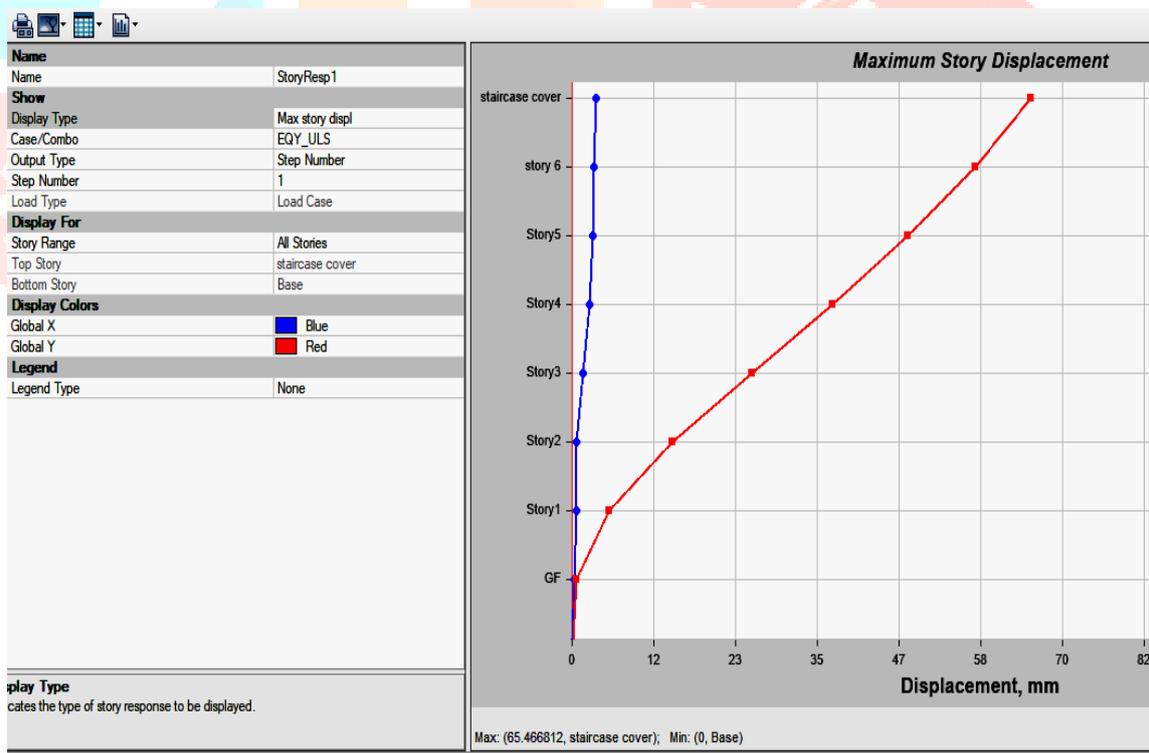*Figure 2: Maximum story displacement along EQX_ULS (NBC105:2020)*

Figure 3: Maximum story displacement along EQY_ULS (NBC105:2020)

Allowable ratio ULS = 0.025

Allowable Displacement ULS

$d_{max} = 0.025H/R\mu = 205.7142857mm$

Design displacement from ETABS in ULS,

Along EQX_ULS =107.413663 mm (at staircase cover) <205.7142857mm (OK)

Along EQY_ULS =65.466mm (at staircase cover) <205.7142857mm (OK)

Displacement check using IS 1893(part I):2016
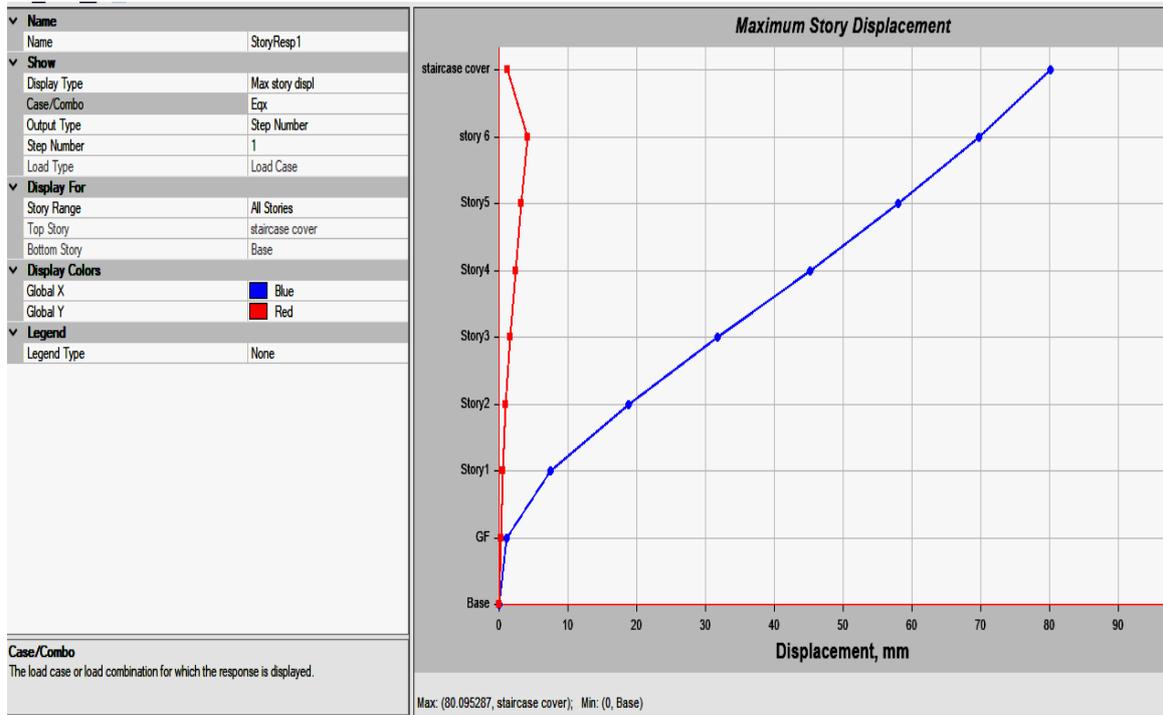
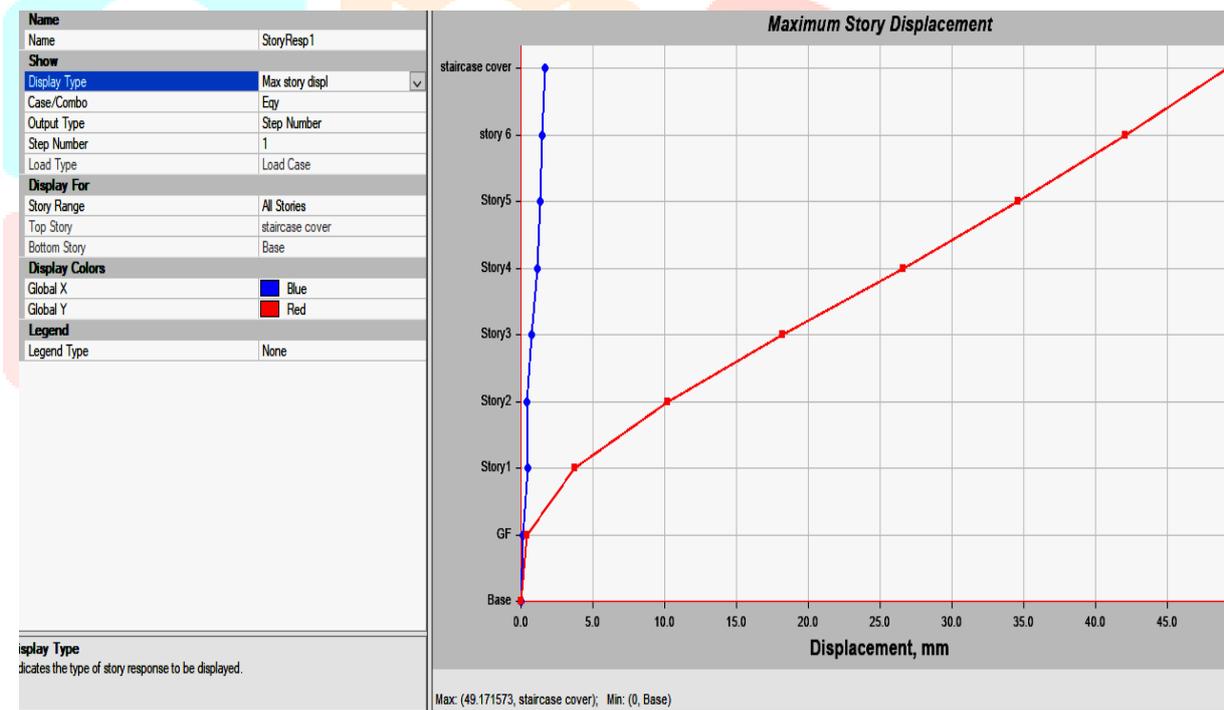***Figure 4:*** *Maximum story displacement along EQX (IS 1893(part I):2016*

Figure 5: *Maximum story displacement along EQY (IS 1893(part I):2016)*

From Etabs, maximum story displacement is at staircase = 80.095287 mm

Result: From above result it is observed that the displacement and drift of story obtained using IS1893 part I: 2016 and NBC105 :2020is within the limit .Story displacement is maximum in staircase cover according to both codes but the story displacement value obtained from NBC 105:2020 is higher i.e. 80.095287mm.

VII. *Comparison of Drift* using NBC 105:2020 *and* IS 1893(part I):2016

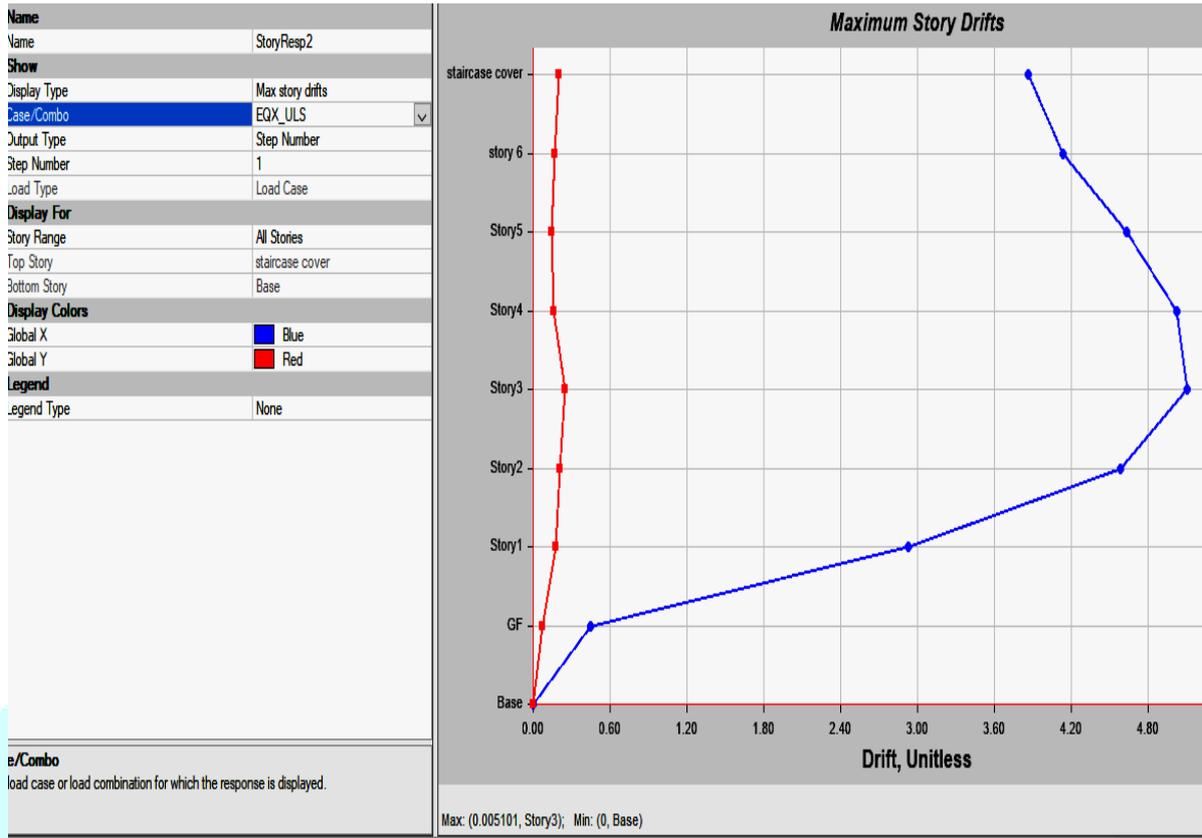### Drift check usingNBC105:2020

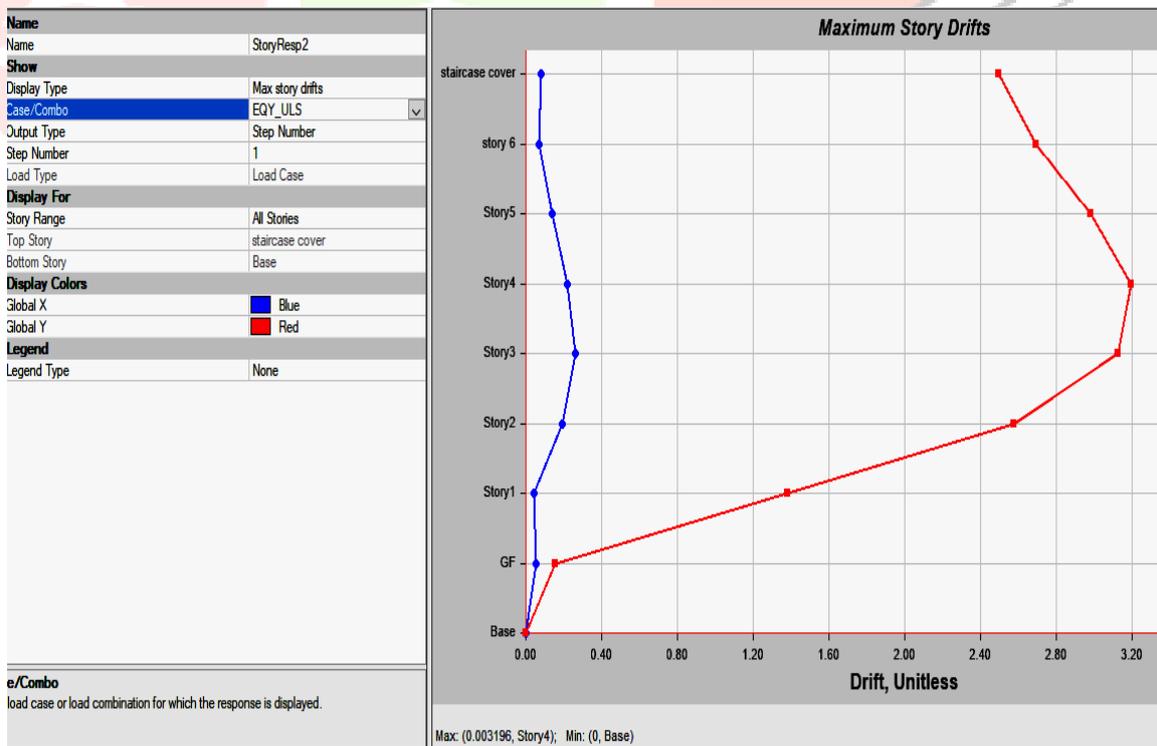**Figure 6:** *Maximum story drift along EQX_ULS (NBC 105:2020)*

Figure 7: Maximum story drift along EQY_ULS (NBC 105:2020)

Allowable Drift Ratio, ULS

$d_{max} = 0.025/R\mu = 0.007142857$

Design drift from Etabs in ULS,

Along EQX_ULS = 0.005101(at story 3) < 0.007142857 (OK)

Along EQY_ULS = 0.003196 (at story 4) < 0.007142857 (OK)
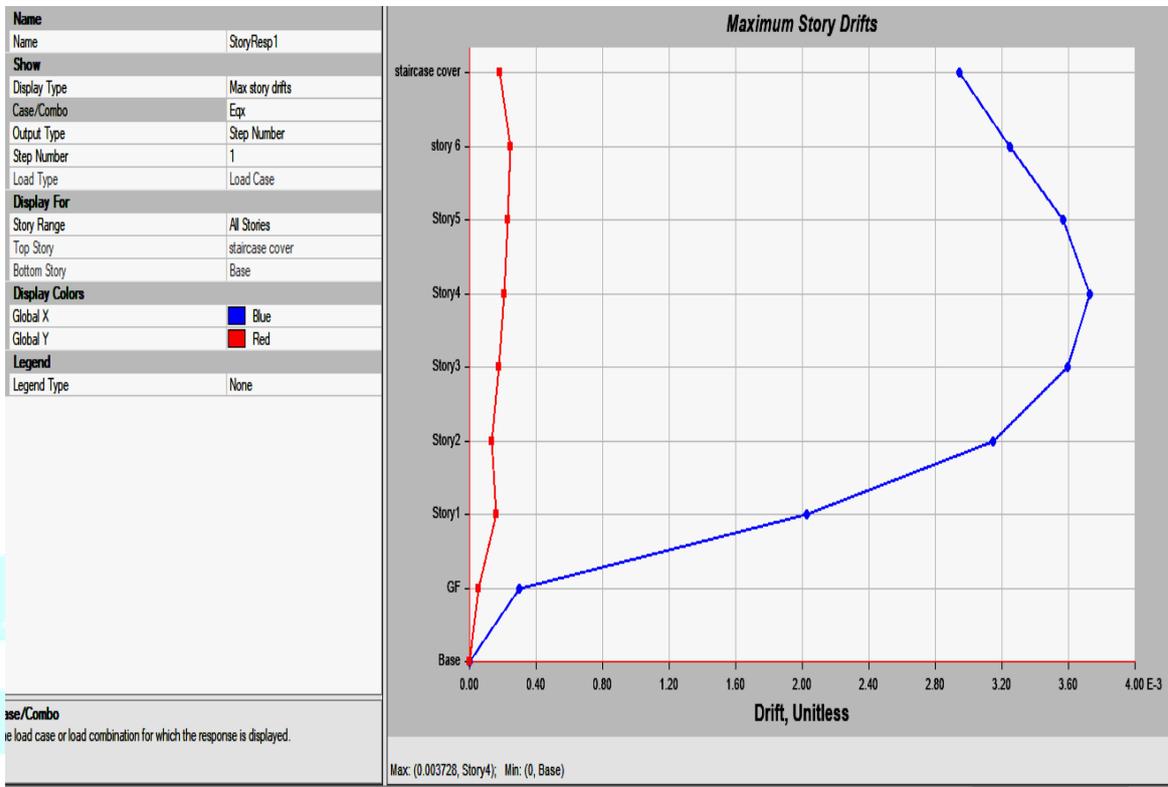
Drift check using IS 1893(part I):2016

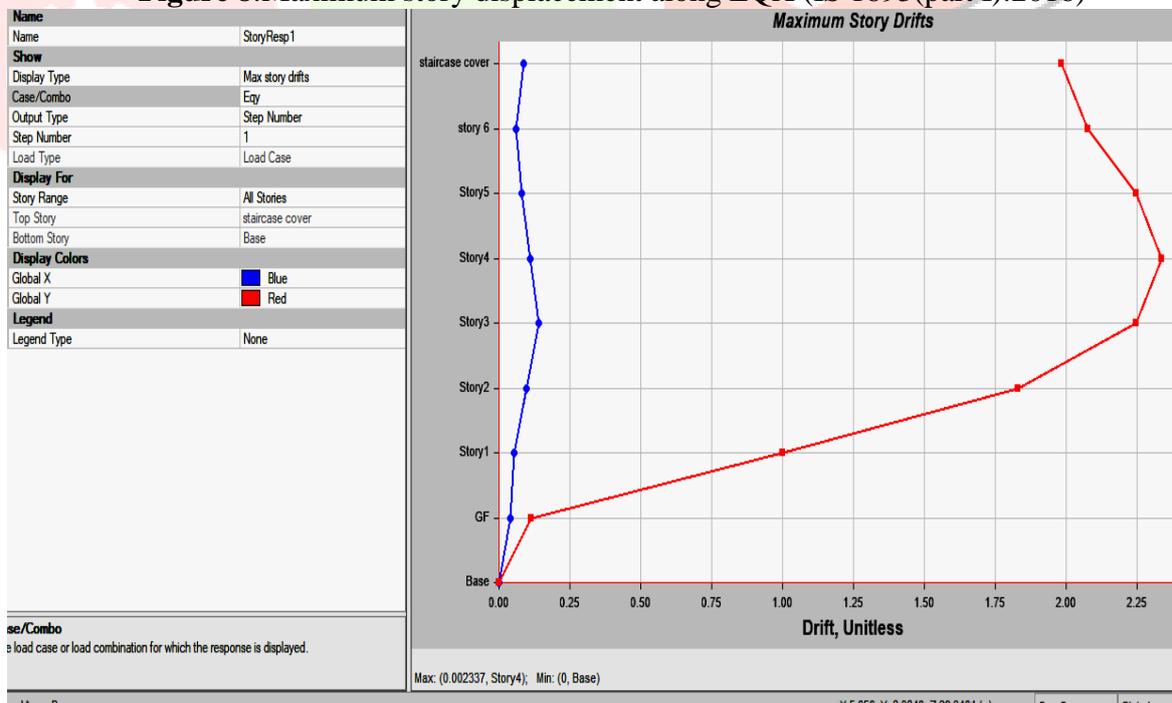**Figure 8**:Maximum story displacement along EQX (IS 1893(part I):2016)

Figure 9 : Maximum story displacement along EQY (IS 1893(part I):2016)

According to IS 1893 part I: 2016 clause no. 7.11.1.1, Story drift should not exceed 0.004 times story height =0.004 *3.6 = 0.0144.

Design drift from ETABS, Maximum story drift along EQX = 0.003782 (at story 4) < 0.0144 (OK)

Maximum story drift along EQY = 0.002237 (at story 4) <0.0144 (OK)

Result: From above result it is observed that drift of story according to IS **1893 part I: 2016 and NBC 105** :2020 is within the limit. Story drift obtained using NBC 105 :2020 is maximum in story 3 along EQX_ULS and story 4 along EQY_ULS. The story drift obtained using IS 1893 part I: 2016 is maximum in story 4 along EQX and EQY and story drift value obtained from NBC 105 :2020 is higher i.e. 0.005101.

VIII. *Conclusion*

From comparative analysis of the building for IS 1893(part 1):2016 and NBC105:2020 for medium soil category, it is concluded that:

- The base shear obtained using NBC **105:2020** is higher than IS 1893(part 1):2016, increasing by 35%.
- Area of reinforcement obtained using NBC **105:2020** is greater because the code specifies higher base shear value.
- The drift and displacement of the building obtained using NBC105:2020 are higher.

Since, Nepal lies on earthquake prone zone, NBC code has focused more on resistance against seismic load in comparison to the
IS 1893:2016(Part-I). NBC105:2020 leads to conservative design and it often results a safer structure which leads to uneconomical sections.

IX. References

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