



SEISMIC ANALYSIS AND DESIGN OF PUBLIC BUILDING AND COMPARISON BETWEEN IS AND NBC Code

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Abstract

Nepal located in the seismically active region due to its geographical positions. Its ranks 11th in the terms of vulnerability of earthquake. In order to visualize the response of building during earthquake, it is important to do analysis of buildings for earthquake resistant also to withstand earthquake effect without the losses of life and property. This report on “Seismic Analysis of Public Building” has been conducted by incorporating all the stages of structural analysis and designing the elements. It consists of preliminary design, determination of lateral loads, structural analysis and detail design of structural elements.

Preliminary design consists of assessment of tentative dimension of structural members such as beams, columns and slab. Loads on building have been determined using IS Codes. As Nepal lies on earthquake prone zone, structural analysis is conducted using ETABS. Seismic Coefficient (static) and Response spectrum (dynamic) analysis has been incorporated for analyzing the building. Sizing various members of the structures to resist the forces to which they might be subjected during their effective life span was done.

This report portrays the work needed for the analysis and design of earthquake resistant building systematically.

Introduction

One being a good designer has to deal with various structures ranging from simple ones like the curtailment rods, and electric poles to more complex ones like multi-storied frame buildings, shell roofs, bridges etc. These structures are subjected to various loads like concentrated loads, uniformly distributed loads, uniformly varying loads, internal or earthquake load and dynamic forces which are considered during the design phase. The structure transfers its load to the supports and ultimately to the ground. While transferring the loads, the members of the structure are subjected to internal forces like axial forces, shearing forces, bending and torsional moments which are discussed while analyzing the structures.

The seismic behaviors of the NBC code and IS code was compared as there was the variation of different coefficient

In our context, the analysis of earthquake is based on seismic coefficient design method as described in NBC: 105: 2020 and IS 1893: 2016.

Objective

- To be familiar with seismic resistant design of structure.
- Modeling of the building for structural analysis.
- Sectional design and structural detailing of the members.
- To compare the result of analysis from IS and NBC code.

Scope of the Project

- Identification of the building and requirement of the space
- Determination of the structural system of the building to undertake the vertical and horizontal loads
- Estimation of loads including those due to earthquake
- Calculation of base shear and vertical distribution of equivalent earthquake load
- The structural analysis of the building by ETABS for different cases of loads
- Design of RC frame members, walls, foundation, staircases and other by limit state method of design
- Detailing of individual members and preparation of drawings as a part of working construction document.

Brief description of the proposed project

Type of the Project	: Seismic Analysis of Public Building
Building type	: Public Building
Location	: Makawanpur, Nepal
Structural type	: Special moment resisting RCC framed structure
Plinth area	: 713.224 m ²
No. of storey	: 7

Floor to floor height

Basement	: 3.6 m
Ground floor	: 3.6 m
Type of slab	: Two-way slab
Type of beams	: Rectangular
Type of staircase	: Open Well Staircase
Type of foundation	: Raft Foundation
Design concept	: Limit state design
Concrete Grade	: M25
Reinforcement	: Fe500
Dead load	: As per materials usage in building

Live load : As per materials usage and as specified relevant code

: calculated as per NBC: 105: 2020 and IS 1893:2016 using Seismic coefficient method.

Soil type : medium soil

Bearing capacity of soil :150 KN/m²

Methodology

To proceed any sorts work, various methods or steps are adopted from its initial stage to final stage. The public building (i.e., court) was selected for performing this project. Architectural drawing is the collected. The preliminary design of the building is conducted and the size and thickness of the beam, slab and column are calculated thoroughly with the help of the moment and deflection criteria. After the study of architectural drawing and preliminary design, load calculations were done using the IS 875:1987 as reference. The exact value of unit weights of the materials from the code was used in the calculation. The gravity loads calculation such as Dead load, live load and the lateral load are calculated. The modelling the analysis of the building is done with ETABS program. We adopt the limit state method for the design of the building.

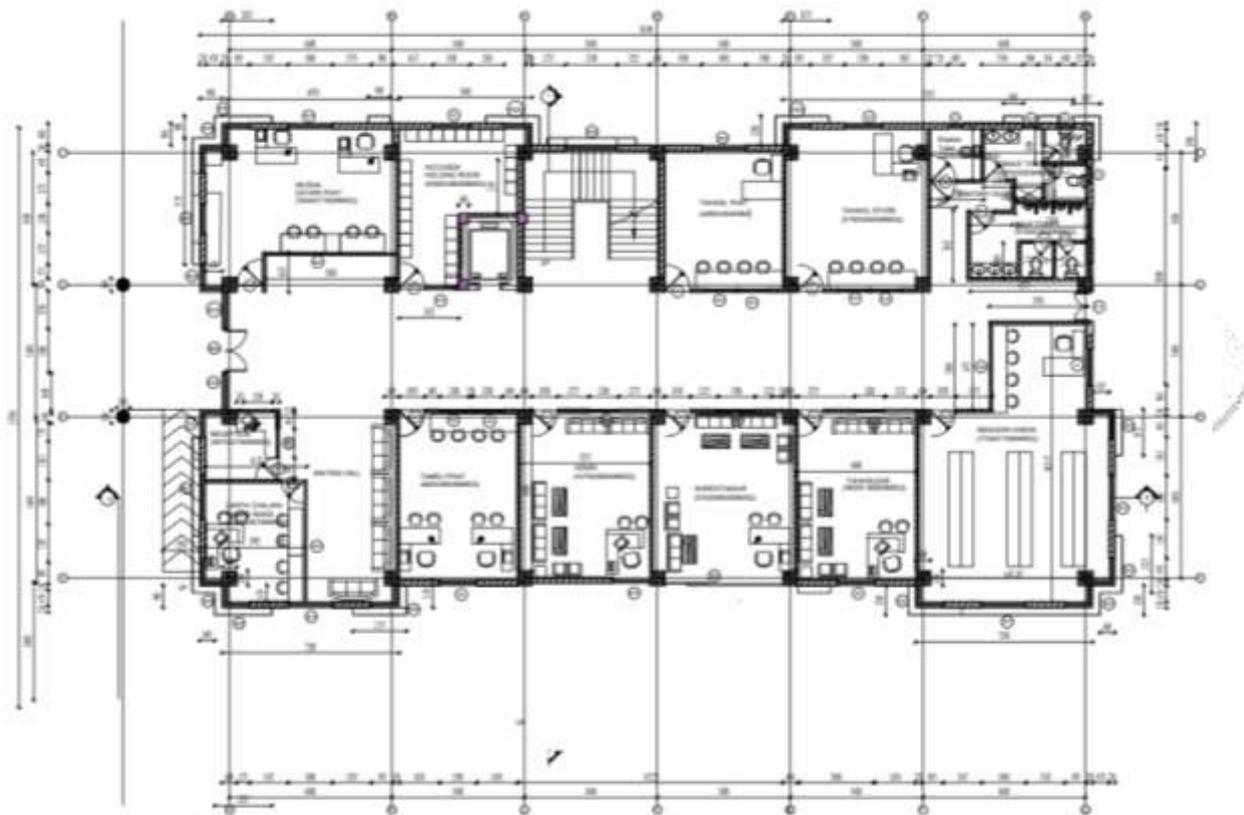


Figure 1: Ground floor plan

Structural Model review

Model analysis was done and represented in the clause no. 4. Seismic load such as the seismic load, seismic coefficient and the base shear are elaborated in the clause 4.2. The results of structural analysis done with ETABS programs is presented in the clause 5.2. the structural analysis is represented in the end of the project. The model is analysis and checked such as model analysis, eccentricity check, displacement and the drift check as per NBC at the section 5.3.3, and the displacement and the drift check as per IS at the section 5.3.4, strong column and the weak beam checked as per IS code and the NBC code at the section 5.4 as well. The detail design of slab, beam, column, staircase, the foundation, lift wall and the basement wall at the section clause 6.

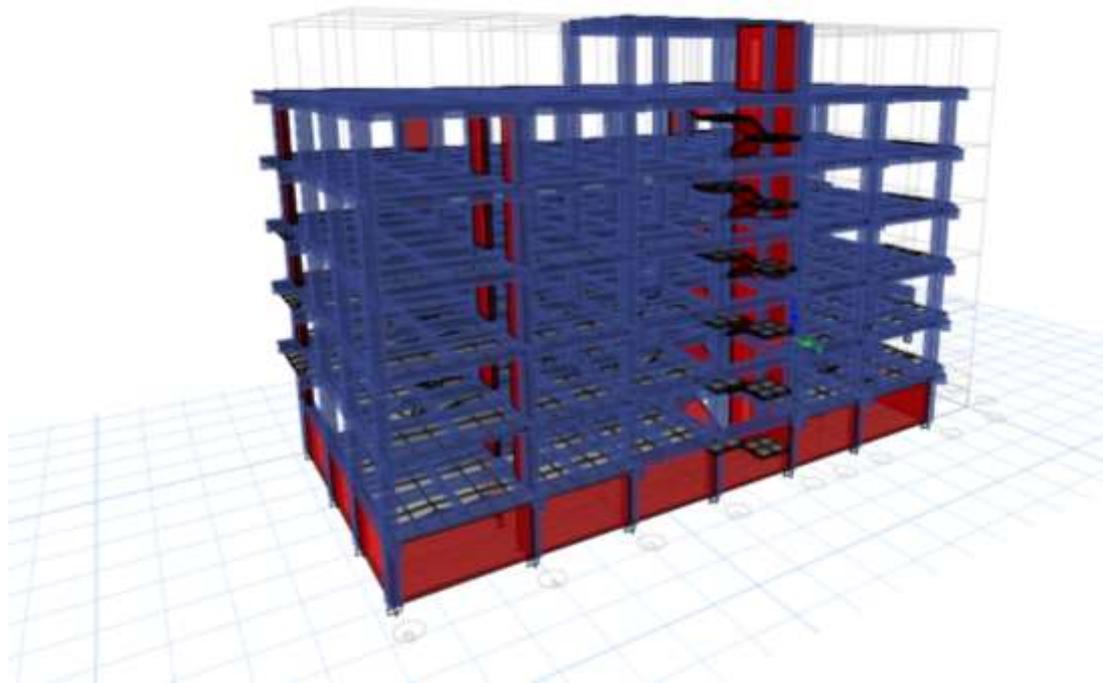
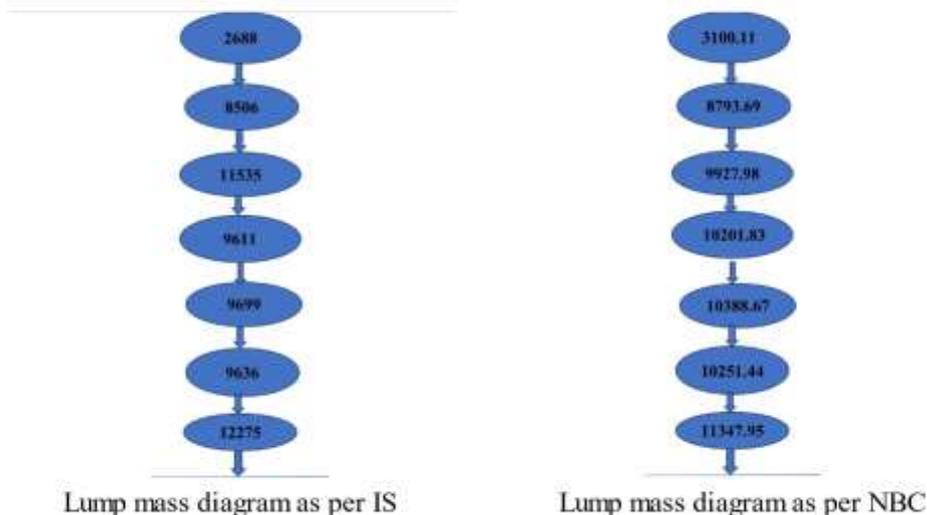


Figure 2: 3D model of proposed building

Preliminary design

The preliminary design of slab, beam and column is calculated. The size of beam is calculated by selecting the critical slab 6.6m*6.6m. The total depth of the slab is found greater than 150mm which is uneconomical. The secondary beam is established. The overall depth of the slab is 125mm. According to IS 456: 2000 clause 23.2.1 for continuous beams, the size of the beam along the numeric grid and alphabetic grid are 400mm*600mm. The size of the secondary beam is 230mm*450mm and the overall size of the column is 600mm*600mm. The irregularity check was done by using the I.S code. Seismic load, seismic coefficient, base shear calculation is represented in the project.

Lump mass diagram



Calculations	IS	NBC
Approximate natural time period	0.751 sec	0.501 sec
Seismic zone Factor(z)	0.36	0.4 for Hetauda
Response Reduction factor(R)	5 for SMRF	5 for SMRF
Importance Factor(I)	1.5 for public Building	1.5 for public Building
design the horizontal Seismic Coefficient, $(z/2)*(SA/g)*(I/R)$	0.098 as per IS	0.306 for ULS 0.25 for sls
Base Shear	6249.93kN as per IS	19546kN (ULS) and 15962.57 (SLS) as per NBC.

Structural analysis

As per IS 1893(part I):2016 clause 7.7.5.2, The first modal time period of the building is 0.881sec. In total, 30modes were considered and 90% mass participation was obtained in 20th mode with frequency corresponding to 30.863Hz.

As per NBC: 105:2020:cl:7.3, The first modal time period of the building is 0.881sec. In total, 30modes were considered and 90% mass participation was obtained in 20th mode with frequency corresponding to 30.708Hz.

According to NBC: 105:2020 cl:5.7, the eccentricity % in both and x and y axis are within limit +/-10%.

Structural design

The design of the structural elements should be done for durability, construction and use in entire service life of the structure. The detailed design of the slab, beam, column, staircase, basement wall, lift wall, shear wall and the mat foundation are elaborated in section 6.

Structural elements	Cross section (mm*mm)	Length (m)
Slab	3000*3000	1
Beam	400*600	6.6
Secondary beam	230*450	3.3
Column	600*600	3
	500(D)	3
	400*400	3
Staircase	R=150, T=300	Landing 2m

For lift wall, basement wall and foundation here are the design:

Structural elements	Diameter of bar(mm)	Reinforcement detailing
Lift wall	20 12	20mm@100mm c/c spacing on both sides for vertical reinforcement 12mm@300mm c/c spacing on both sides For horizontal reinforcement
Basement wall	12	12mm@280mm c/c at inner face 12mm@280mm c/c at front face
Foundation	10	10mm@100mmc/c for top and bottom reinforcement along both X and Y direction

Dynamic Analysis

For response spectrum analysis the storey displacement and drift in both X and Y direction is given below.

	According to NBC 105:2020 cl:5.6.3,	According to IS 1893(Part 1):2016 cl. 7.11.1.1
Displacement	Allowable displacement ULS= $0.025*(H/R_u) = 154.2857\text{mm}$ Design displacement from ETAB in ULS, X-axis= $40.02\text{mm} < 154.2857\text{mm}$ y-axis= $2.342\text{mm} < 154.2857\text{mm}$ ok (same for SLS)	For EQX Along x-direction= 35.19mm Along y-direction= 2.014mm For EQY Along x-direction= 0.944mm Along y-direction= 36.88mm
Drift	Allowable Drift ULS= $0.025/R_u = 0.007143$ Design Drift from ETAB in ULS, Along X-axis= $0.001748 < 0.007143$ ok Along y-axis= $0.000127 < 0.007143$ ok	$0.004*\text{height of storey} = 0.004*3.6 = 0.0144$ Design Drift from ETABS Along x-axis: $0.001 < 0.0144$ ok Along y-axis: $0.001 < 0.0144$ ok

Result

We compare the reinforcement detailed for the first column at the ground level. Here, the minimum reinforcement from both the codes are same but maximum reinforcement for NBC 105:2020 is more than that of IS. Here, the reinforcement for the beam is maximum at NBC design than that of IS design whereas displacement and drift are minimum in as per the IS code than that of NBC. In base shear calculation the calculated value is greater in NBC than that of IS.

Conclusion

This project is the result of group effort of all group members and the valuable guidance of our supervisor. The project work has enabled us to consolidate the knowledge of analysis and design of structure during our B.E course. Detail structural design of building is important aspect of construction procedure. With the help of ETABS software, we are able to know the building is structurally stable. We are able to compare the different coefficient and factor of the IS code and the NBC code that various the outcomes.

Limitation

Design and layout of the building services like pipeline, electrical appliances, sanitary and sewage system were not covered in this project. The project work was only related with the practical application of the studied courses in the field. Detail cost estimate of the project was not included in this report. We assume the soil type as the medium soil as the site visit is not done. Overall, we applied the limit state method for the design of the building.

Reference:

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