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Comparative Study of Multistorey RC Building Using Static and Dynamic Analysis Using NBC 105: 2020

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ABSTRACT- Recent high-intensity earthquakes have gained increasing media attention in a number of countries, including Nepal. Buildings' structural insufficiency to handle seismic loads has been brought to light by the ensuing losses, mainly human life, caused by earthquakes. Post-earthquake studies have shown that masonry structures, in comparison to other building types, are the most earthquake-prone and have incurred the greatest damage during prior quakes . Even if many new building methods have been developed in the modern period, masonry still has a significant place in the construction business. As Nepal is highly under the sesmic forces no any codal provision is there before the 1992 A.D Earthquake. With the importance, Nepal introduced the code on 1994 A.D which on dealed mostly with the Sesmic Behaviour. After the Massive Earthquake on 2015A.D, there was the challenge on Upgrading the Codal Provision on NBC, which incorporated both the sesmic and dynamic forces, which results on NBC 105:2020. The primary purpose of the research is to examine multi-story reinforced concrete building models using static and dynamic analysis of the same design utilising the latest version of Nepal's building code (NBC:105:2020). The Comparative study of the Static and Dynamic forces on G+9 Multistory RC Building is considered of the analysis.

KEYWORDS- Base Shear; Storey Shear; Seismic Analysis; Storey Drift.

I. INTRODUCTION

The style of building is used to its full potential in rural, urban, and hilly locations because to the wide availability of materials for masonry construction, as well as for economic reasons and the qualities described above. There are still some concerns regarding seismic safety, despite the fact that this is the most popular and favoured style of building. The components might be anything from laterite blocks to stones to country burned or wire cut bricks to precast blocks to interlocking blocks, etc. They're put to work constructing the building's skeleton, including the footings, walls, and columns

Criteria for Earthquake Resistant Design of the Structure's seismic analysis methodologies are used to establish the required lateral forces for existing structures to meet seismic standards. Buildings can be made more earthquake resistant by following the recommendations in NBC 105:2020 and other similar code on the seismic zones. Static and dynamic forces, or loads, may operate on a structure.

Different country had made their own code for designing building according to suitability of their country weather, geology, topography. As we know that Nepal and India are neighboring countries and Northern part of India and Nepal weather, geology, topography are similar Nepal is following Indian building design code for designing building. Nepal has also developed its own country building code design NBC 105:2020. This thesis aims for comparing the building design with Indian building code with that of Nepal Building code. Previously Nepal has old building code designers use to follow that code for designing the building now government has implemented new code for design and analysis of the building In this study RCC building models having G+9 storey is taken for comprative analysis on Static and Dynamic behaviour on the building.

II. OBJECTIVES OF THE STUDY

The primary purpose of the research is to examine multi-story reinforced concrete building models using static and dynamic analysis of the same design utilising the latest version of Nepal's building code (NBC:105:2020). The following is a list of the goals that this research aims to accomplish:

- Using ETABS to model a G+9 building with both a static and dynamic floor plan.
- To conduct an analysis of the models using both static and dynamic approaches by contrasting the values.
- To see the differences in observations from the outputs of analysis (displacement, storey drift, storey shear, overturning moment, stiffness, base shear, time period, forces in column) in order to have a comprehensive understanding of the behaviour of the building with Static and Dynamic Analysis.
- To examine the findings, and from there, to draw the appropriate conclusions and have a discussion on the data that was gathered.

III. LITERATURE REVIEW

Rao S. et al. [3] they comparing static and dynamic analyses of high-rise buildings with and without an open ground floor. In this analysis, a frame structure with many levels (G+14) was used. It was decided that the difference in displacement values between static and dynamic analysis is still small for lower stories, but it has grown for higher stories, and static analysis, including the response spectrum method, has given higher values than dynamic analysis.

Manchalwar S. [2] he is using ETABS 2015 and IS Code 1893:2002 (part 1), used the response spectrum process to do a seismic analysis of a 10 story RC frame building with a normal and an irregular plan. Three models, one regular and two not, were looked at for analysis. All of the models have different shapes, but the same amount of space. When making the comparison, things like overall storey displacement, storey drift, storey stiffness, mode times, and earthquake frequencies were taken into account.

Verma S.K et al. [3] they looked at the stability of frames with and without shear walls in different earthquake zones. It was found that the story drift and base shear of a structure get worse as the seismic zone gets higher, that they get worse as the number of bays in the same zone goes up, and that they get worse for frames with shear walls compared to frames without shear walls.

Dr. Shaik Yajdhani et al. [4] Using the STAAD-Pro software, earthquake and wind analyses were done on buildings with 15, 30, and 45 floors that had circular, rectangular, square, or triangular floor plans. It has been decided that a 15-story building with a maximum earthquake load and maximum wind load should have a circular shape or a triangular shape. If a house has 30 stories, it is most stable if it is shaped like a rectangle. In the case of a 45-story building, a circular shape is most stable for maximum earthquake load, while a rectangular shape is most stable for maximum wind load. Manchalwar Setal did a study in 2016 that compared the seismic analysis of three-story RC frames. Using SAP-2000, the structure was analysed using the equivalent static method and the response spectrum approach to measure seismic loads. Based on this research, the equivalant static method is easier to use than the response RSP. Almost the same values were found when the same static method and the response spectrum method were used with SAP-2000. The authors came to the conclusion that the Response spectrum method is more reliable than ESM. So, the suggested static analysis is not good for high-rise buildings. Instead, a dynamic analysis is needed.

Yajdhani S. et al. [5] compared the static and dynamic seismic performance of a building with several floors. STADD PRO looks at the construction of a G+9 (Rigid standard joint frame). For static analysis, the equivalent lateral force method is used, and for dynamic analysis, the response spectrum method is used. Authors have come to the conclusion that the values for moments found with dynamic analysis are 35–45% higher than the values found with static analysis. Static and dynamic analyses of the RCC structure don't give very different results for the axial forces. When you do a dynamic analysis, the values for column displacement are 40–45% higher than the values you get from a static analysis. When beams and columns are shaken by earthquakes, the nodal displacement and bending moments are much higher than when they are under static loads.

Dr. Vinod Hosur [6] They planning and analysis of a multi-story G+4 building i Salem, Tamil Nadu, India, has been talked about. Using two programmes called STAAD.PRO and RCC Design Suit, the invstigation includes the planning and testing of footings, columns,beams, and slabs.

In the 2015 study by Dr. S. Suresh Babu, he did a straight static analysis and a dynamic analysis on multi-story buildings with irregular floor plans to make sure they could handle lateral loads, base shear, storey drift, and storey shear. The paper also talks about how the variety of the building plan affects the basic response building. A dynamic response to a noticeable earthquake, linked to IS 1893–2002 (part1).

STAAD pro [7] to study a G+9 structure for both static and dynamic analysis. We found that the nodal displacements and bending moments caused by seismic excitation are greater in beams and columns than those caused by static loads. For dynamic analysis, the nodal displacements in the Z direction are 51% greater than for static analysis. When you do a dynamic analysis instead of a static analysis, the column displacements are between 43% and 47% higher. When you do a dynamic analysis, you get higher values for Moment than you do when you do a static analysis.

Seismic behaviour[8] of three concrete intermediate moment-resisting spatial frames of non-symmetrical planes on the fifth, seventh, and tenth floors. In each of these three cases, the design of the structure has corners that go back into themselves. Both nonlinear static and linear dynamic methods were used to look at these structures. The accuracy of these two methods was tested with a non-linear dynamic analysis. Even though the differences between the results of the nonlinear static approach and the nonlinear dynamic approach are pretty big, it has been decided that the linear dynamic analysis is slightly better than the nonlinear static analysis.

IV. METHODOLOGY

Here, two 10 stroey building is taken for the analysis. The building consist of 3 bay in both the direction. It has regular plan and the dimension of the building is kept constant. Here In this study following models are prepared for the study:
First Model1.Building model with Static Analysis using NBC 105:2020
Second Model 2. Building model with Dynamic Analysis using NBC 105:2020

A. Loads

Dead loads Brick masonry : Unit Weight 20KN/m3
Finishes (Floor Finishes) :1.5 KN/m2
Reinforced Concrete Elements: Unit Weight 25KN/m3
Live load :3KN/m2 on all floors except roof.
Lateral loads: Earthquake Loads as per NBC:105:2020

B. Lateral Load

Parameter considered for Static Analysis using NBC code are as follows:

- Zone factor (Z) = 0.3
- Importance factor (I) = 1.00
- Response Reduction Factor (R) = 5(SMRF)
- Soil Type = C

Load Combination considered in the analysis are mentioned below:

1.2 Dead Load+1.5Live Load
Dead Load +0.3Live Load+EQX(Service limit State)
Dead Load +0.3Live Load -EQX(Service limit State)
Dead Load+0.3Live Load +EQY(Service limit State)
Dead Load+0.3Live Load -EQY(Service limit State)
Dead Load+0.3Live Load+EQX(Ultimate Limit State)
Dead Load+0.3Live Load-EQX(Ultimate Limit State)

Dead Load+0.3Live Load+EQY(Ultimate Limit State)
Dead Load +0.3Live Load-EQY(Ultimate Limit State)

Parameters considered for Dynamic Analysis using NBC code are as follows:

- Zone factor (Z) = 0.3
- Importance factor (I) = 1
- Response Reduction Factor (R) = 5 (SMRF)
- Soil Type = C"

Load Combination considered in the analysis are mentioned below:
Combo1 = 1.5Dead Load
Combo2 = [1.5(Dead Load+Live Load)]
Combo3 = [1.2(Dead Load+Live Load+EQX)]
Combo4 = [1.2(Dead Load+Live Load-EQX)]
Combo5 = [1.2(Dead Load+Live Load+EQY)]
Combo6 = [1.2(Dead Load+Live Load-EQY)]
Combo7 = [1.5(Dead Load+EQX)]
Combo8 = [1.5(Dead Load-EQX)]
Combo9 = [1.5(Dead Load+EQY)]
Combo10= [1.5(Dead Load-EQY)]
Combo11= [0.9Dead Load+1.5EQX]
Combo12= [0.9Dead Load-1.5EQX]
Combo13= [0.9Dead Load+1.5EQY]
Combo14= [0.9Dead Load-1.5EQY]

C. Material Properties

- Grade of concrete: M20 for beam and Slab M 20for Column
- Grade of steel : Fe 500
- Modulus of Elasticity of concrete (Ec): 5000√fck N/mm2
- Modulus of Elasticity of Steel (Es): 2x105 N/mm2

D. Element Dimensions

Following are the element diemension considered in the building for analysis:
Slab = 125 mm
Wall thickness exterior = 230 mm
Interior wall thickness= 115mm
Size of column= 550mmX550mm
Size of beam= 355.6mm x 609.6mm

E. Model Generated in ETABS

Here figure 1 is showing the 3D view of model for both models, figure 2 shows the elevation of model, which is similar for both models,

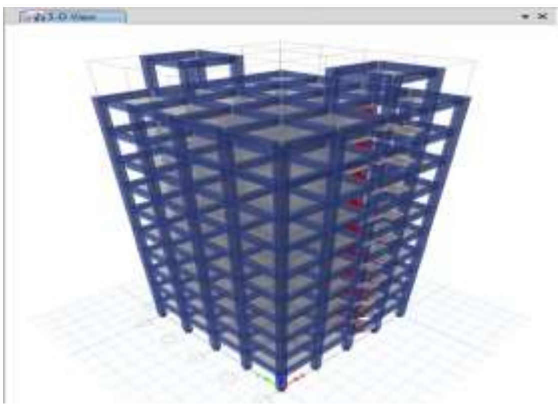

Figure 1: 3D view

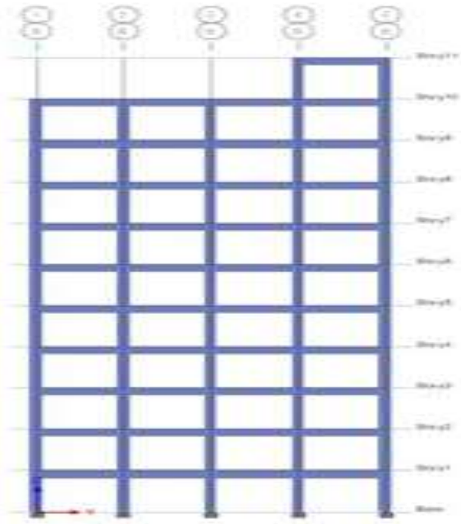

Figure 2: Elevation View

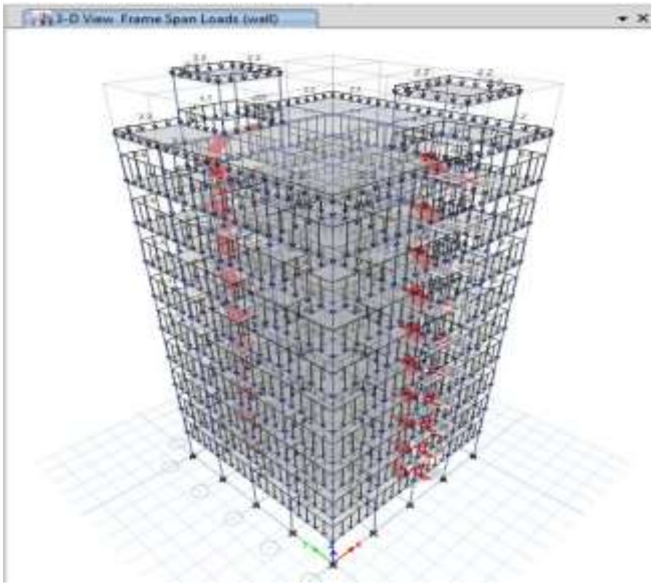

Figure 3: Wall load

figure 3 represents the wall load acting in the models ,figure 4 shows the live load of both models and figure 5 represents the floor finish load for the both models.

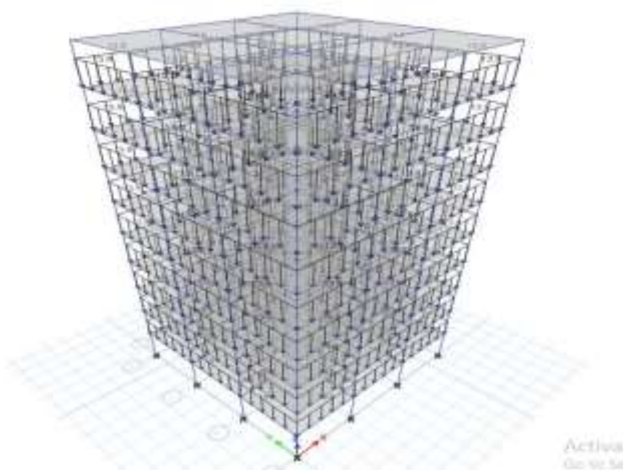

Figure 4: live load

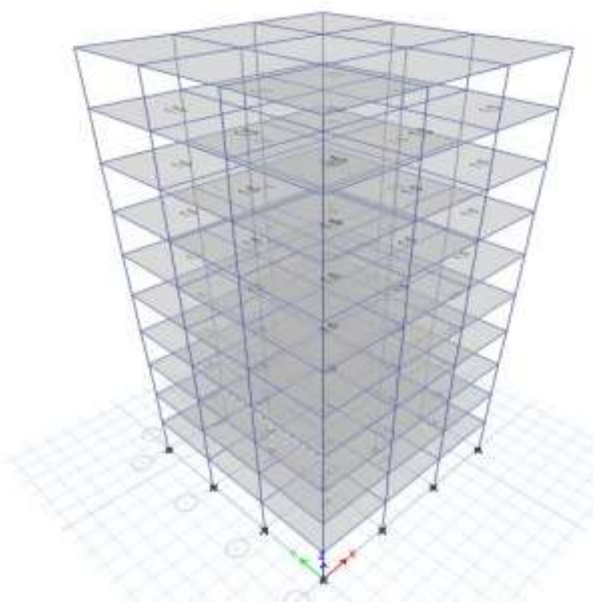

Figure 5: Floor Finish load

V. EXPERIMENTAL RESULTS

A. *Displacements*

Table no.1 shows displacement of models in the longitudinal direction (EQX) has no significant variations. The displacement values obtained for dynamic analysis are 0.25-0.27% greater than the values obtained for static analysis.

Displacement of models in the transverse direction (EQY) has no significant variations. The displacement values obtained from static analysis are 0.18-0.20% greater than the values obtained from dynamic analysis.

Table 1: Displacements of models

Models	Displacement in mm	
	EQX(ULS)	**EQY(ULS)**
Model 1	**106.547**	**120.671**
Model 2	**106.833**	**120.691**

Figure 6 is showing the graph of displacement for both models which shows that building analyzed by dynamic is more than static by NBC 105:2020.

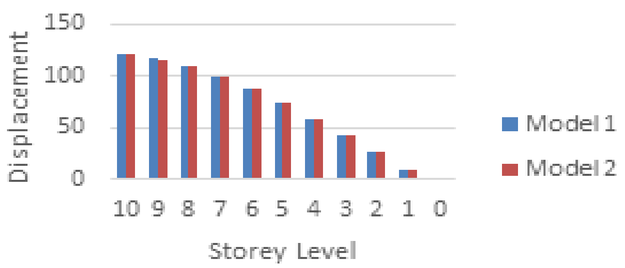

Figure 6: Storey Displacements

B. *Drift*

Table no.2 shows Model drift occurs along the longitudinal direction. The values of drift for dynamic analysis are 2.0-2.5% greater than the values for static analysis.

Models drift in a transverse direction. The values of drift for dynamic analysis are 2.2-2.4% greater than the values for static analysis.

Table 2: Drift of Models

Models	Drift	
	EQX(ULS)	**EQY(ULS)**
Model 1	**0.004609**	**0.005222**
Model 2	**0.004613**	**0.005204**

Figure 7 is showing the graph of displacement for both models which shows that building analyzed by dynamic is more than static by NBC 105:2020 .

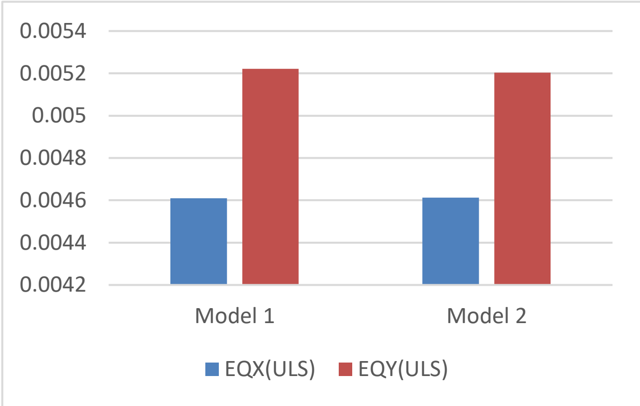

Figure 7: Storey Drifts

C. *Storey Shear*

Table no.3 shows that the data in the table above show that the direction of the applied force does not matter, whether it is transverse or longitudinal. If you look at Figure 8, we can see that the static forces have a greater value than the dynamic ones.

Table 3: Storey shear of models

Models	Storey shear in kN	
	Rx	**Ry**
Model 1	**-4911.8495**	**-4911.8495**
Model 2	**-4899.5017**	**-4899.5017**

Figure 8 is showing the graph of storey shear for both models, which shows that building analyzed Static forces have a greter value than the dynamic ones by NBC 105:2020.

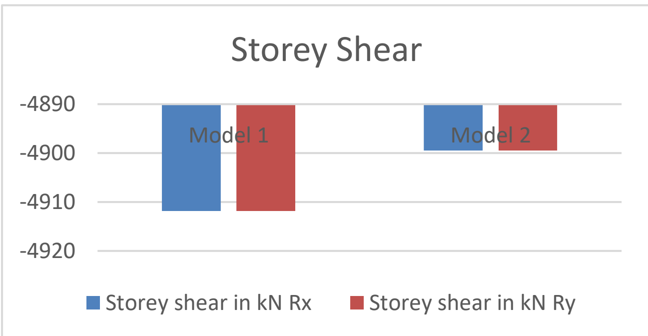

Figure 8: Storey Shear

D. *Overturning Moments*

Table no. 4 is showing the longitudinal and transverse overturning moments for Model 2 are shown to be larger than those for Model 1 in Figure 5.4. This means that dynamic analysis places greater emphasis on the overturning moment than static analysis does.

Table 4: Overturning moment of models

Models	Overturning moment in kN-m	
	EQX(ULS)	EQY(ULS)
Model 1	-110339.681	110339.681
Model 2	-110928.6325	110928.6325

Figure 9 is showing the graph of overturning moment for both models which shows that building analyzed by dynamic has more value than the static one.

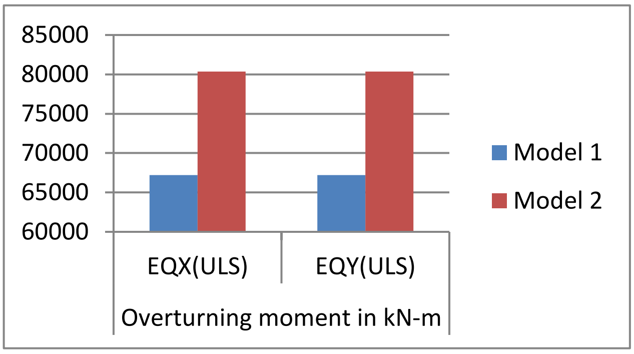

Figure 9: Overturning moment

E. Base Shear

Table no.5 shows Model 2 has the higher base shear than model 1. This shows that building analyzed by static is more than the dynamic.

Table 5: Base shear of models

Models	Base shear in kN	
	EQX(ULS)	EQY(ULS)
Model 1	-4899.8495	-4899.8495
Model 2	-4911.5017	-4911.5017

Figure 10 is showing the graph of base shear for both models which shows that building analyzed static is more than the dynamic.

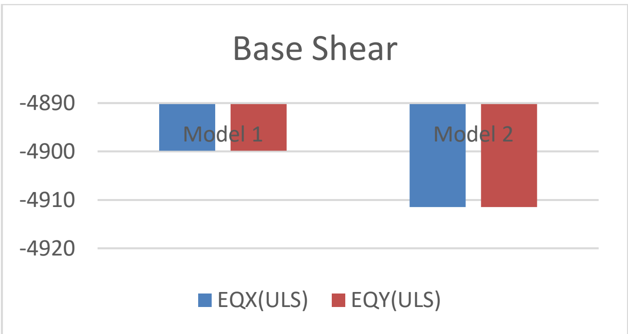

Figure 10: Base Shear

F. Time Period

Table no.6 shows that Model 2 has the higher base shear than model 1. This shows that building analyzed by static is more than the dynamic.

Table 6: Show that Model2

Mode	Time periods	
	Model 1	Model 2
1	1.433	1.436
2	1.339	1.343
3	1.229	1.231

Figure 11 is showing the graph of time period for both models which shows that building analyzed by dynamic has more value than the static one.

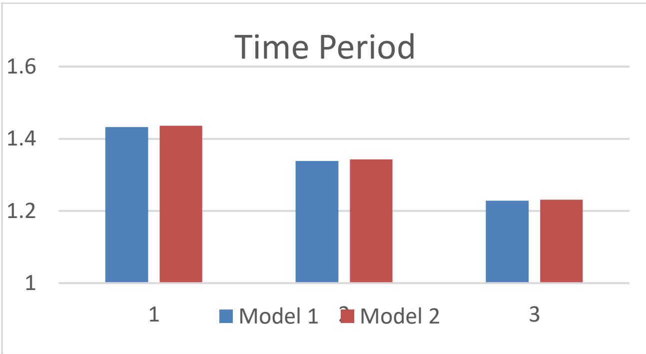

Figure 11: Time Period

VI. CONCLUSIONS

After analyzing the buildings we get following conclusion:

- The displacement of G+9-storey building analyzed using NBC 105:2020 there is minor changes in the Static and Dynamic analysis.
- The drift of G+9-storey building analyzed using NBC 105:2020 there is the change of 2-2.5% between the Static and Dynamic analysis..
- The storey shear of 10-storey building analyzed using NBC 105:2020 static forces is more than the Dynamic forces.
- The fundamental time period of the building between the static and dynamic analysis is seen minor with NBC 105:2020.
- The overturning moment in building analyzed with NBC code, with static analysis has more value than the dynamic one.
- The base shear of model analyzed with Static analysis possess less than the Dynamic analysis.

From above we can see that Static analysis has higher value in displacement , drift ,storey shear and base shear in comparison with dynamic analysis.

CONFLICTS OF INTEREST

The authors declare that they no conflicts of interest.

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