International Journal of Innovative Research in Engineering & Management (IJIREM)
ISSN: 2350-0557, Volume-9, Issue-5, October 2022
https://doi.org/10.55524/ijirem.2022.9.5.21
Article ID IJIRD-1207, Pages 151-158
www.ijirem.org

Comparative Study on Seismic Analysis of Multi Storey RCC Building with Mass Irregularities Using NBC 105:2020 and IS 1893:2002

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ABSTRACT- Today there is increasing population and demand of housing is increasing day by day, because of which multi storied buildings are constructed. These buildings are vulnerable to earthquake because of non-uniform distribution of loads as well as no uniform stiffness in building. As the form of building depends upon the requirements of the client the building may be subjected to the mass irregularity as well as stiffness irregularity. The building which have mass irregularity and stiffness irregularity must be safe during earthquake .Building should be able to withstand the earthquake force and should perform better when earthquake hit that building.In Nepal both IS code and NBC is use for analyzing the building for its performance against earthquake. Because of similar topography of India and Nepal. Nepal allow the use of IS code as well as its own code for the seismic analysis of structure. In Nepal new code is implemented removing the defects of old NBC 1994. In Nepal now NBC 105:2020 is followed for analysis of building .Nepal is located in earthquake prone zone seismic performance of building must be done for the design of any building within its territory. Hence, for the optimum performance of building regarding seismic performance, it has been seen that designers undertake the design considering both IS Code and NBC code.

Here, we study the performance of building comparing Nepal building code with that of IS 1893:2002. In this paper, regular building G+7 with plan area 15mX15m is taken for the analysis and beam and column size are taken constant. The building is analyzed using ETABS 2016. Comparison is made for the displacement,drift,store shear, storey stiffness and base reaction.

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

I. INTRODUCTION

Due to the many possibilities afforded by today's building methods, multi-story structures with complex geometries and systems of construction are the norm. Problems with construction, such as implementing different architectural designs, site conditions, barriers, operating needs, and many others, give rise to inherent variation across structures. After conducting an earthquake survey and analysis, it was determined that asymmetric structures were the most at risk of collapse. The most difficult parts of side load have to do with how a modern building with uneven floors is set up.

Less-loading elements like wind and earthquakes may cause damage to a structure, just as they do in reality. Any faults in the structure's strength or mass induce a steady decline in the stability of the structure, which may lead to its ultimate collapse if left unchecked. A symmetrical construction will have a straight and precisely centred centre, as well as a smooth surface aligned with a vertical axis. All floors need to go through this process. As a corollary, this is a very unusual state to have reached, as buildings are often not uniformly spaced with respect to design, height, and shape. The same applies to the distribution of weight on the floor. Large earthquake regulations make a difference between systemic problems and height problems, but it's common for mixed buildings to have structural problems.

Unevenness in the geometry, strength, or stiffness of a building's higher stories is referred to as vertical irregularities. Real buildings, of course, have many differences or variations in weight, durability, or power distribution near height or directional designs, so structural or structural irregularities are also often a common sense thing. With today's building methods, it's possible to create multi-story structures with complex geometries. There are a lot of factors that might cause a building to be unique, including the structure's location, any impediments in the way, the kind of work being performed, and more. A number of seismic surveys and an examination of how buildings collapsed in the most recent catastrophic quake have shown that asymmetric structures are particularly at risk. Modern buildings have the most complicated side load features when the way the weight is distributed isn't even. .

When a structure is much taller than its neighbours, or when its proportions are so slim that it seems to be tall, we refer to it as a high-rise. As a result of progression, high-rise development in Chicago began around the end of the 19th century. The safe elevator, invented in 1853, and the telephone, invented in 1876, made this feasible by allowing the delivery of construction materials and the establishment of communication between floors. Steel frames replaced heavier masonry walls, and wood and stone were abandoned in favour of these newer, lighter materials. The inherent weight of earlier structures made of brick prevented them from rising above a particular height. If steel frames were used, buildings with thinner brick walls that were only used as a facade or weather protection could be made taller. Warehouses, factories, and other multi-story structures were in high demand throughout the European industrial revolution. New materials like glass, reinforced concrete, and steel all owe a great deal to Europe's contributions to the field. It wasn't until after World War II that Europe saw an increase in the construction of high-rise structures, which were previously scarce and well below the 100-meter limit. This was due to the increased demand for commercial and residential space, as well as the need to rebuild all previously devastated cities.

When the twentieth century began, Sweden still had a severe housing shortage and poor living conditions. New residential development did not surge until 1960. The government has planned to construct 100,000 new homes annually over the next decade. What we have here is the "million-program," and its goal is to give away a million dollars. To keep up with the demands of higher output, prefabricated building materials saw a rise in use. The lowered cost was expected to result in a cheaper cost of living, in addition to speedier manufacturing. The quantity of prefabs produced grew by a factor of six between 1963 and 1969. Twenty percent of homes built at the time were prefabricated, and four major concepts were followed when building homes with prefabricated oncrete materials. As a result of the recession and oil crisis of the 1970s, the million-rogram was scrapped, and the number of new homes built dropped dramatically. In 1986, output had dwindled down to a mere 30,000 domiciles. Production picked back up by the end of the 1980s, when it reached a peak of about 60,000 homes per year. The Turning Torso, located in Malmö, is now the highest building in Sweden at 190 metres (54 floors). The facade of Turning Torso, an in-situ cast concrete structure, rotates 90 degrees from top to bottom. Precast concrete structures are often substantially shorter than their in-situ cast counterparts. The Breaker Tower in Seef, Bahrain, is the world's highest skyscraper composed of precast concrete. The building has a height of slightly over 150 metres and 35 storeys. In contrast, the Burj Khalifa in Dubai, United Arab Emirates, at 828 metres and 163 floors, is the world's tallest in-situ cast concrete structure. Skyscrapers not only give more people a place to live in a smaller area, but they also show how powerful a country or city is and point the way for visitors.

II. OBJECTIVES OF THE STUDY

The primary objective of this research is to analyse a model of a multi-story R.C. building in accordance with the Nepal Building Code (NBC:105:2020) and the Indian Standard (IS) 1893:2002. The research aims to accomplish the following:

- In order to use ETABS to simulate a G+7 structure.
- Adopting Equivalent Static method for analyzing the buildings.
- The impact of earthquake loads on the behaviour of a structure with and without a shear wall may be better understood by seeing the results of the study (storey shears, drifts, displacements, storey stiffness, reinforcements).

III. LITERATURE REVIEW

Kara, Vasilis et al. [1]- Examined the inelastic response to seismic loading of planar steel moment-resisting structures with vertical mass irregularity. The results of this investigation indicate that the distribution and amplitude of inelastic deformation demands, from a height perspective, are substantially determined by the number of floors, the quantitative connection between beam and column strength, and the location of heavier mass. The mass quantitative link has no effect on the response either.

Valmundsson and colleagues [2]- Examined the seismic resistance of frame buildings with varying heights (5, 10, and 20 stories) and non-uniform distributions of mass, stiffness, and strength. UBC's ELF system was used as a benchmark for the analysis's predicted response. It was hoped that by making this comparison, it would be possible to determine whether or not the building now satisfies the criteria for being designated regular under the relevant ELF laws. Elastic response and vertically irregular building categorization are governed primarily by building regulations. The majority of the evaluation has focused on two sorts of anomalies: those in the first story's soft and weak framework, and those in the foundation's setback. While the tower component of set-back buildings has a number of different explanations, most appraisals admit the rise in drift demand.

Poonam et al., [3]- The results of many numerical studies show that the first story, in particular, should not be weaker than the stories above or below it. Increases in mass distribution anomalies may also cause a structure to react more strongly. If the differences are seen as unavoidable, there will need to be a thorough study and design.

According to Sadashiva et al. [4]- The current New Zealand standard for seismic design, NZS 1170.5 (SNZ 2004), is based on international standards in that it requires both vertical and horizontal regularity to be provided. This research provided a unique way of assessing irregularity limitations for buildings assessed utilising the simpler analysis processes controlled by design codes. The new approach was presented using vertical mass irregularity for three and nine-story frames. The application of mass ratios of 1.5, 2.5, 3.5, and 5 times the floor mass of a conventional building was carried out at the bottom, mid-height, and highest levels of a modified structure to find the median will increase in interstorey drift reactions. The influence of irregularity was found to depend on the structural model that was utilised during the evaluation, the irregularity sites involved and thus the analytical approach carried out for the design. The acceptable irregularity limits to be established from an acceptable rise in a given response are authorised by this suggested technique. Hence, this approach is generally adaptable and may be built in numerous ways and employed in the design process but is easy to apply.

According to research by Tremblay et al. [5]- In this publication, the seismic(earthquake) forces and resulting deformations measured using the equivalent static force approach and dynamic analysis procedure for the projected 2005 NBCC for multistory structures in Vancouver and Montréal are compared. The continuous braced steel frame concept aided in the earthquake resistance of the four-, eight-, twelve-, and sixteen-story structures.

The "Valmundsson et al., ASCE:" The North Carolina

State University department of civil engineering supported and housed the researchers. This research investigated uneven distributions of mass, stiffness, and strength in frame structures of varying heights. The structures were modelled using a two-dimensional shear structure. The results from the TH study were compared to what was predicted by the ELF approach embodied in UBC. The goal, backed up by prior comparison, was to assess the current requirements under which a structure may be considered generic and, by extension, the ELF arrangements that are pertinent.

Based on research by Seon Lee and colleagues in 2004 [6]- Many Korean RC building structures designed for a wide range of purposes exhibit torsion and sensitivity at their foundation levels. The purpose of this analysis is to use shaking table experiments to learn more about the seismic response of skyscraper RC bearing-divider systems that have three distinct types of irregularity at the basement level. Therefore, a triply structured 1:12 scale 17-storey strengthened structure with a solid model was made in accordance with the comparability law; the top fifteen stories have a direction divider framework, and the bottom two stories have a casing framework with different formats in design. The opposing casing framework (Model 1) was discovered in the first to be one minute, the other second has the focal casing with an infilled shear divider (Model 2), and the remaining tweener stories have a tetragonal (Model 3). Following this, these models were exposed to a simulation of seismic tremors.

Shear dividers cut shear deformation at the lower outline by a lot, but they have almost no effect on disturbing deformation, base shear, and OTM.

Sarkar et al. [7]-In terms of seismic activity, stepped fault outlines fall into a category of vertical irregularity that is less than ideal when the current situation is investigated and the code is formed. Here, a thorough investigation was conducted to record this shortcoming.

Based on research conducted by Dhamge et al. [8]-In this context, the issue is about how important the mass irregularity factor is to be regarded with other appropriate joint diasplacement and how the base shear and storey drift might assist in the efficiency of the construction. All in all, the following are the main takeaways from the chapters' analyses and studies:

In this work, we compare models to understand behaviour and find that changes are not very noticeable overall, but their size varies between ecological zones.

Second, RSA findings indicate that storey shear is highest at the ground floor and typically decreases with the floors until it is at its lowest on the topmost floor

According to ISI1893 (part1)-2002It is estimated that 14 mm is the maximum allowable amount of storey drift. After conducting extensive research and analysis of the G+10 level structure, it was determined that the maximum storey drift of the RCC structure was 14.726mm in the X direction and 16.617mm in the Z-direction. The fourth and fifth floors were found to be particularly vulnerable to storey drift.

Poncet et al., 2005)[9]:-Using an eight-story steel layout supported by a common centre, we examine the effect of irregular mass distribution on the building's seismic response, focusing on the designs' ability to achieve abrupt decreases in design measurements and the applicable load's (seismic weight's) action aligned with the structure's height. A 25%, 50%, and 75% seismic weight extent, as well as a 25%, 50%, and 75% mass discontinuity zone (200 and 300 percent), are considered.A standard regular structure was used for evaluation. Both the equivalent static force method and the response range examination strategy, both from the 2005 National Building Code of Canada (NBCC), were utilised to complete the plans for each building. Static analysis found that the mass irregularity circumstances investigated here had a negative effect on the seismic performance of the buildings designed to withstand such conditions. Implementing a dynamic analysis technique during the design phase has the potential to enhance the performance of irregular structures in practise. However, not to the point where it violates standard reference structure.

Darshan et al. [10]- The following findings were gleaned from the analysis of the 12-story building model:

TORSION OF THE BASE

Model 3's bulk increased base shear. Model 3, which shows base shear expansion when the mass goes up, was put up against other models.

MODERN TIME

The mode duration of Model 5, with mass anomalies on the top four floors, was determined to be the longest of all the models tested. Model 3, which has uneven mass in the basement levels, has the shortest mode period when compared to the others.

RENEWAL OF THE STORY:

Examination (RS and TH) shows that model-3 implies larger storey drift in both the X-X and Y-Y directions compared to other models. Although both models 1 and 2 show less tale drift than other models, Thus, there should be no significant difference in mass distribution across floors since this would result in less storey drift.

TORSION

The torsion of a model is established by how its mass is distributed. Compared to the other models, Display 3 has more twist because the mass anomaly goes from the first floor to the third floor to the fourth floor.

Guruprasad et al. [11]- This study focuses on how different kinds of vertical deformities affect the seismic response of a building. It is sometimes hard to eliminate irregularities in buildings caused by a shift in the position of a building's centre of mass and centre of stiffness due to design constraints. The goal of this project is to perform novel research on RC building frames with adjustable vertical alignment. This was done so that the research and design outputs for non-standard buildings could be compared to those for standard buildings.

Devesh et al [12]-The findings of this research are the most up-to-date and comprehensive to date on the topic of the seismic response of building frames with vertical irregularities. We analysed the requirements for vertical irregularity as they are now defined by building codes. The findings of a study on the seismic performance of buildings with nonstandard vertical orientations have been shared. Following the rules established by the building regulations ensures that any horizontal or lateral pressures exerted on a structure are calculated accurately. It's reasonable to suppose that the effects of vertical abnormalities have been well monitored, both in terms of academic study and governmental building codes. Building codes recommend using either elastic time history analysis or elastic response spectrum analysis to find buildings with uneven heights and figure out how the lateral forces are supposed to be distributed.

According to Ansari et al. [13]- This research presents the notion of using the capacity spectrum approach for seismic assessment of vertically masted uneven reinforced concrete buildings. For the purpose of this research, a 3D analytic model of a twelve-story building was created to represent the vertical mass of irregular building forms. These model analyses were performed in ETABS. The analytical model of the buildings takes into account the effects of the mass at various levels, such as the fourth floor, the eighth floor, and the twelfth floor separately. In addition, the outcomes are considered for models with uneven mass on various levels and normal frames. Also shown are the Equivalent Static Method (LS) and Linear Dynamic Analysis (LDA) results (Response spectrum Analysis).

Ramasco et al.[14]- This article presents the findings of research that looked at the seismic reaction and design of RC frames with strength discontinuities in height. To create an irregular frame, one must apply excessive forces to either the beams or the columns (accepted as reference). Euro code 8 (EC8) High ductility Class (DCH) standards inform the design of the "normal frame." To handle the expected loads of uneven frames, beams and columns on different stories may need to be strengthened more than usual.

For all frames, the criteria of vertical strength irregularity from a wide range of seismic regulations and international norms are implemented. Therefore, there are two methods for calculating storey strengths, one of which just takes into account column flexural resistance and the other of which also takes into account beam flexural resistance. Nonlinear analysis is done both in a static and a dynamic way. The mechanical nonlinearity is focused on the ends of the elements.

Based on research by Sehgal et al. [15]- This study explores the differences between planned structural irregularities and vertical structural irregularities. Some of the constraints and standards for such inconsistencies as are outlined in various codes of practise have been briefly discussed (IS 1893:2002, EC8:2004, etc.). It was found that the recommendations for height variations and plot boundaries between the two codes were quite comparable. When structural irregularities are present, the seismic response is changed, and the way it is changed depends on the kind of structural irregularity. According to research comparing works in terms of plan and vertical irregularity, strength abnormalities had the greatest influence on seismic response, while mass irregularities had the least.

The results showed that the seismic response was least affected by mass anomalies in the vertical direction and most affected by strength irregularities. The MPA (Modal Pushover Analysis) method was shown to be less precise than dynamic assessment, even after substantial adjustments were made. Seismic response to vertical abnormalities was shown to be mostly influenced by mass irregularity and strength irregularity. In terms of research strategy, the MPA (Modal Pushover Analysis) method was shown to be less accurate than dynamic inquiry. This was true even after major improvements were made.

Dileshwar, A., et al. [16]- The properties of earthquakes considered include shear force, bending moment, storey drift, storey displacement, and sectional displacement. The most crucial characteristics are considered in every circumstance. There is some thought given to the shear force acting in the Z-axis and the bending moment. Maximum storey nodal displacement and storey drift in the X and Z axes are recorded. The purpose of this research is to determine the variation of these values among the five studied frame configurations. These findings are first analysed for the same number of stories as before, and then generalisations are made for any number of stories. Basic characteristics that are most common in all load scenarios are selected. It is possible to predict the seismic performance and behaviour of any building frame with these criteria in mind.

IV. METHODOLOGY

Here, two 8 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.
In this study following models are prepared for the study:
First Model 1.Building model using IS Cod IS 1893:2002
Second Model 2. Building model using NBC: 105:2020

A. Loads

Dead loads
Brick masonry : Unit Weight 20KN/m^3
Finishes (Floor Finishes) : 1.5 KN/m^2
Reinforced Concrete Elements : Unit Weight 25KN/m^3
Live load : 3 KN/m^2 on all floors except roof.
Lateral loads : Earthquake Loads as per NBC: 105:2020

B. Lateral Load

Equivalent static method use for analysis of the building. Parameter considered using NBC code are as follows:

- Zone factor (Z) = 0.4
- Importance factor (I) = 1.25
- Response Reduction Factor (R) = 5(SMRF)
- Soil Type = A”

Load Combination considered in the analysis are mentioned below
1.2Dead 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 using is code are as follows:

- Zone factor (Z) = 0.36
- Importance factor (I) = 1
- Response Reduction Factor (R) = 5(SMRF)
- Soil Type = Medium soil (Type II)”

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: M25 for beam and Slab M 25for 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 analysi:
Slab =125 mm
Wall thickness exterior =230 mm
Interior wall thickness=115mm
Size of column=700mmX700mm
Size of beam=350mmX650 mm

E. Model Generated in ETABS

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

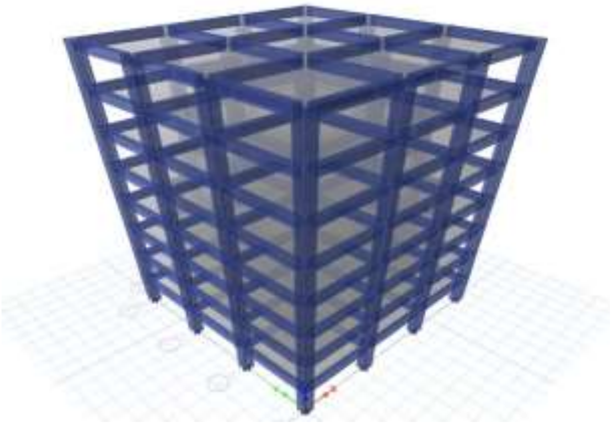

Figure 1: 3D view

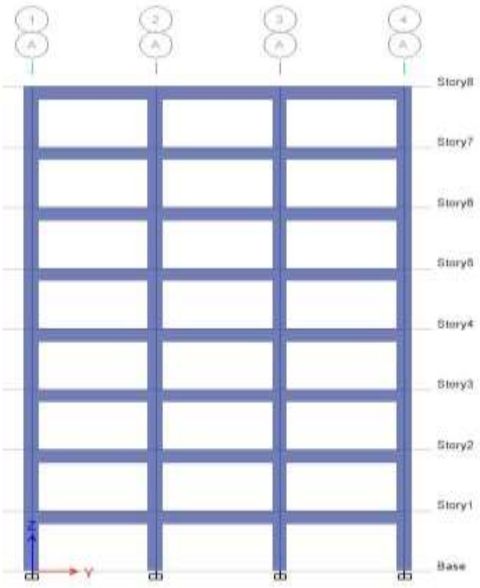

Figure 2: Elevation View

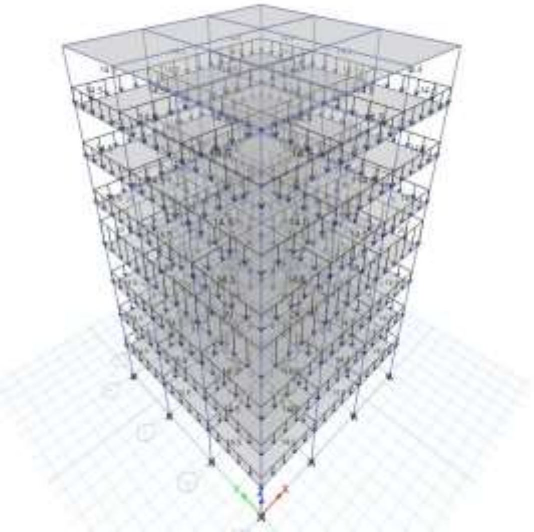

Figure 3: Wall load

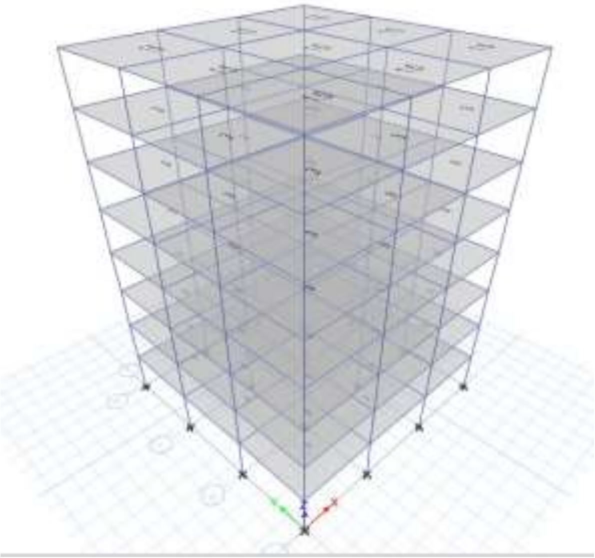

Figure 4: live load

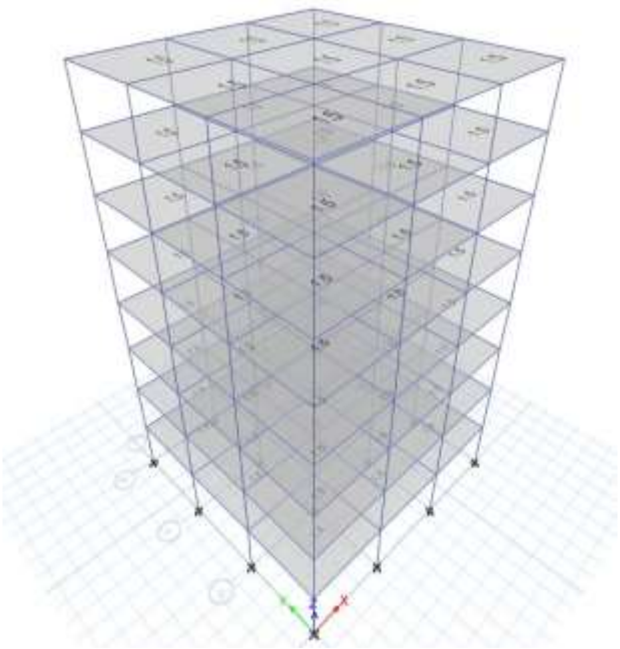

Figure 5: Floor Finish load

V. RESULTS

A. Displacements

Table no.1 shows that Model 1 has the higher displacement than model 2. This shows that building analyzed by NBC 105:2020 has higher displacement value than building analyzed with IS Code.

Table 1: Displacements of models

	Displacement in mm	
Storey Level	**Model 1**	**Model 2**
8	31.76	20.839
7	30.501	19.841
6	28.167	18.044
5	24.747	15.536
4	20.362	12.502
3	15.091	9.079
2	9.316	5.507
1	3.606	2.102
0	0	0

Figure 6 which is the graph of displacement for both models which shows that building analyzed by NBC 105:2020 has higher displacement value than building analyzed with IS Code.

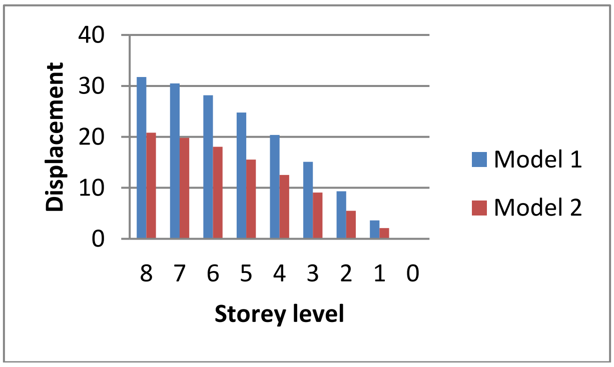

Figure 6: Storey Displacements

B. Drift

Table no.2 shows that Model 1 has the higher drift than model 2. This shows that building analyzed by NBC 105:2020 has higher drift value than building analyzed with IS Code.

Table 2: Drift of Models

	Drift	
Storey Level	**Model 1**	**Model 2**
8	0.000422	0.000334
7	0.000778	0.000599
6	0.00114	0.000836
5	0.001462	0.001011
4	0.001757	0.001141
3	0.001925	0.001191
2	0.001907	0.001137
1	0.001202	0.000701
0	0	0

Figure 7 which is the graph of drift for both models which shows that building analyzed by NBC 105:2020 has higher drift value than building analyzed with IS Code.

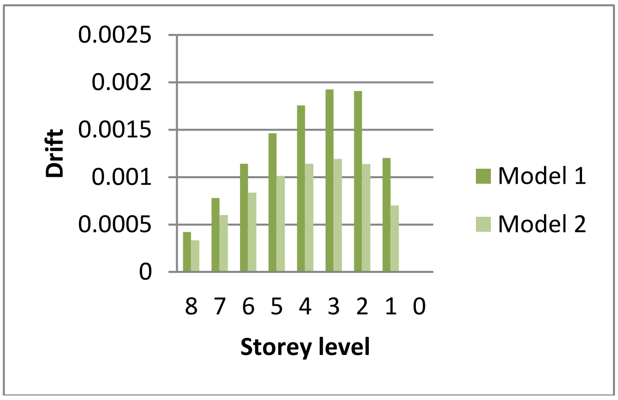

Figure 7: Storey Drifts

C. Storey Shear

Table no.3 shows that Model 1 has the higher storey shear than model 2. This shows that building analyzed by NBC 105:2020 has higher storey shear value than building analyzed with IS Code.

Table 3: Storey shear of models.

	Storey Shear kN	
Storey Level	**Model 1**	**Model 2**
8	338.1085	294.1589
7	944.7807	755.9951
6	1464.786	1095.303
5	1898.123	1330.934
4	2388.763	1544.366
3	2648.766	1629.193
2	2822.1	1666.894
1	2908.768	1676.319
0	0	0

Figure 8 which is the graph of storey shear for both models which shows that building analyzed by NBC 105:2020 has higher storey shear value than building analyzed with IS Code.

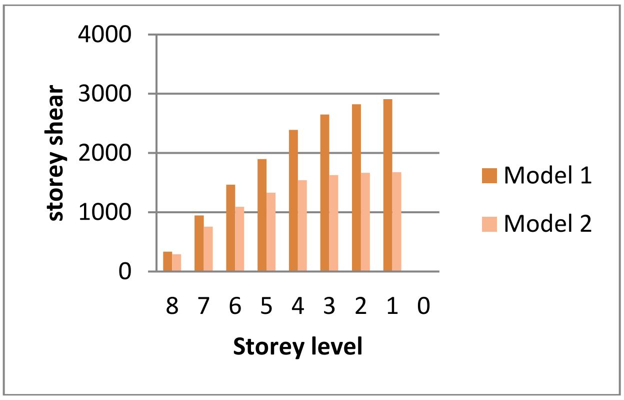

Figure 8: Storey Shear

D. *Overturning moments*

Table no.4 shows that Model 2 has the higher overturning moment than model 1. This shows that building analyzed by NBC 105:2020 has higher overturning moment value than building analyzed with IS Code.

Table 4: Overturning moment of models

	Over turning moment **kN-m**	
Storey Level	**Model 1**	**Model 2**
8	0	0
7	-1014.3254	-882.4766
6	-3848.6675	-3150.462
5	-8243.024	-6436.3723
4	-13937.3925	-10429.1749
3	-21103.6818	-15062.2728
2	-29049.9784	-19949.852
1	-37516.2797	-24950.5339
0	-46242.5834	-29979.4915

Figure 9 which is the graph of overturning moment for both models which shows that building analyzed by NBC 105:2020 has higher overturning moment value than building analyzed with IS Code.

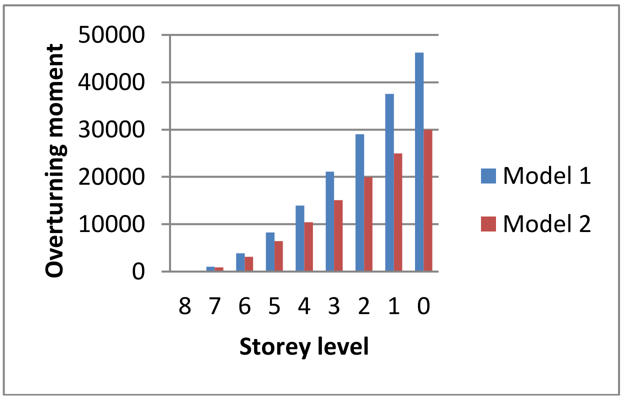

Figure 9: Overturning moment

E. *Base Shear*

Table no.5 shows that Model 1 has the higher base shear than model 2. This shows that building analyzed by NBC 105:2020 has higher base shear value than building analyzed with IS Code.

Table 5: Base shear of models

Models	**Base shear in kN**	
	EQX	**EQY**
Model 1	2908.7679	2908.7679
Model 2	1676.3192	1676.3192

Figure 10 which is the graph of base shear for both models which shows that building analyzed by NBC 105:2020 has higher base shear value than building analyzed with IS Code.

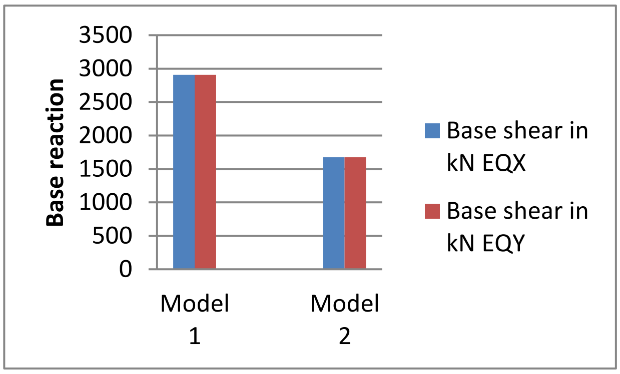

Figure 10: Base Shear

VI. CONCLUSIONS

After analyzing the buildings we get following conclusion:

- Comparing the displacement of an 8-story structure assessed using NBC to that of a building studied with IS code reveals that the NBC analysis results in a greater displacement.
- The displacement of an 8-story structure calculated using NBC is 52.41% more than the displacement calculated with IS code for the same building.
- The drift of an 8-story structure assessed using NBC has 53.9877% greater drift when compared to the drift of an IS code-analyzed building.
- When compared to the structure that was examined using IS code, the storey shear of an 8-story building that was studied with NBC has 24.97% greater.
- When compared to the structure that was examined using IS code, the 8-story building that was studied with NBC had 52.47% greater overturning moment.
- When compared to the structure that was examined using the IS code, the storey stiffness of the 8-story building that was analysed with NBC has 2.47% greater.
- When compared to the structure that was examined using IS code, the building that was studied using NBC has a base reaction that is 73% greater in magnitude.
- It may be deduced from the findings presented above that the seismic performance of buildings constructed using NBC gives a greater value than the value determined by the IS code. Buildings that are examined using the IS code tend to have lower operating costs when compared to those that are analysed using the NBC code.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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