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A COMPARATIVE STUDY ON LATERAL LOAD ANALYSIS BY USING ETABS CONSIDERING TWO DIFFERENT VERSIONS OF BNBC

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ABSTRACT

Remarkable changes have been introduced in BNBC 2017 with regard to analysis of lateral loads. Modifications regarding design parameters and analysis methodology were proposed which primarily pivoted around analysis of seismic loads. In case of wind load, changes were introduced by modifying method of analysis and load projection, basic wind speed, gust response factor, external and internal pressure co-efficient, topographic effect, exposure and enclosure classification. For seismic analysis, design spectral acceleration had been reformulated. To identify the changes in design and analysis of various structures a comparative study is necessary between existing code and the previous one. This study aims at the comparison of provisions of earthquake and wind load analysis only given in BNBC 1993 and BNBC 2017. The lateral drift, torsional effect, wind and seismic base shear are obtained by BNBC 2017 vary significantly from the obtained value by BNBC 1993. Then the analysis and design of a typical 8 story residential building situated in Dhaka city with same number of stories using two codes are presented. The basic differences in both seismic base shear and story drift is also made using two versions of BNBC code. Design of reinforced concrete buildings for seismic load in BNBC-2017 is relatively economic than BNBC-1993 since amount of reinforcement required is less in BNBC-2017.

***Keywords**: BNBC-1993, BNBC-2017, Applied wind & earthquake load, Inter story drift, Maximum lateral displacement, Base shear, Overturning moment.*

1. INTRODUCTION

Bangladesh National Building Code 2017 has been developed for the further advancement of more rational design of structures to ensure improved serviceability and safety. The primary differences between BNBC 1993 and 2017 are based on the analysis of seismic and wind loads which are relatively more complicated than static gravity load. In terms of analysis, significant changes have been introduced to wind and seismic loads. The sole purpose of this study is to investigate these changes from structural and economic point of view. So, a typical structural analysis of 8 story residential building has been conducted in accordance with both versions of code. For seismic base shear, maximum lateral displacement and inter story drift is higher in BNBC 2017 than BNBC 1993. Design of reinforced concrete buildings for lateral load in BNBC-2017 is relatively economic than BNBC-1993 as the amount of reinforcement requirement is less in BNBC-2017. The main objectives of this study are: Determination of the base shear, base moment, story shear and inter story drift according to BNBC 1993 and BNBC 2017. Comparison of base shear, story shear, base moment and inter story drifts by preparing an identical model to understand the comparison between the two codes. Analysis and design of a corner column and an interior column for both BNBC 1993 and BNBC 2017. Comparing the column axial forces, column dimensions and reinforcement requirement. The proposed changes to BNBC 1993 was first brought up by the research team [5]. They conducted a thorough study on Peak ground acceleration (PGA), spectral acceleration, soil classification system, site-dependent response spectrum and worked extensively in defining seismic design category. They showed that BNBC 1993 needs a major update in term of provision for design and structural analysis. Atique and Wadud (2001) presented Comparison of BNBC-93 with other building codes with respect to Earthquake and Wind analysis. Research conducted by Bari M.S., Das T (2014) had been one of the most compressive studies where a detailed parametric comparison was put forth based on BNBC-2017, BNBC-1993, and code of India 2005 (NBC-India 2005).

2. METHODOLOGY OF THE PRESENT STUDY

A typical 8 storied residential building (22.5m X 22.5m) situated in Dhaka city is selected for the comparison of BNBC 2017 and BNBC 1993.The buildings are assumed to be fixed at the base and the floors act as rigid diaphragms with a 3m height for each story, regular in plan is modeled. Finally, the buildings have been modeled by using ETABS software version-2017.

3. ANALYSIS RESULTS AND FINDINGS FROM BNBC 1993 AND BNBC 2017

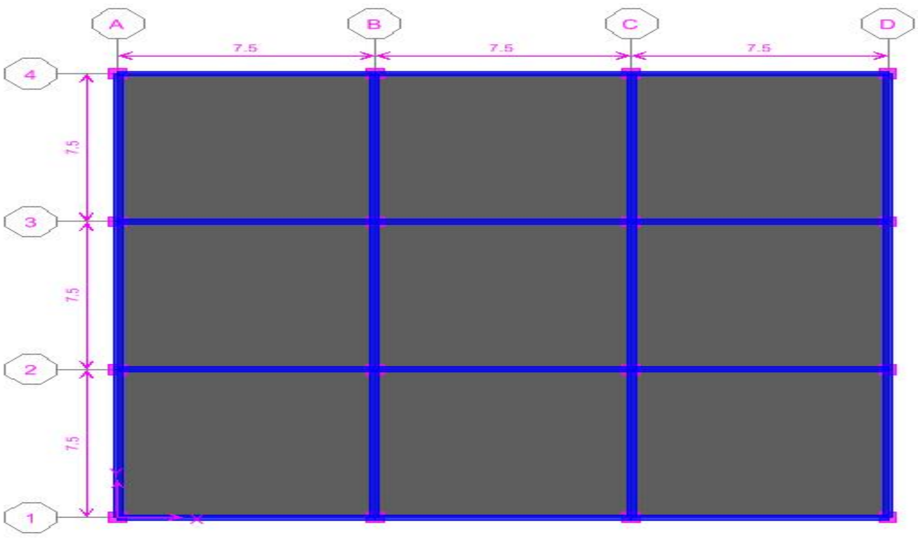

Figure 1: Plan of a typical storey

Table 1: Analysis parameter - seismic load analysis

Parameter	BNBC 1993	BNBC 2017
Seismic Zone Coefficient – Z	0.15	0.28
Site Classification	S3	SD
Site Coefficient – S	1.5	1.35
Importance Factor – I	1	1
Time Period – *T*	$T=C_t h_n^m$, C_t=0.035	$T=C_t h_n^m$
Reduction Factor – R	R=8	R=6
ETABS Analysis Algorithm	UBC 94	User Coefficient

Table 2: Analysis parameter – wind load analysis

Parameter	BNBC 1993	BNBC 2017
Analysis Method	Surface Area Method	Analytical Procedure
Basic Wind Speed – VS	Fastest mile speed: 210 km/hr	3 sec Gust wind: 232km/hr
Exposure Category	A (Urban area)	A (Urban area)
Standard Occupancy Structure IF	1	1
Max Deflection Limit	h/500 for 100% wind effect	h/500 for 70% wind effect
Other factors	Combined height and exposure coefficient Cz	Topographical Factor Kzt -1.00 Directionality Factor Kd - 0.85 Velocity exposure coefficient Kz
ETABS Analysis Algorithm	UBC 94	ASCE 7-05

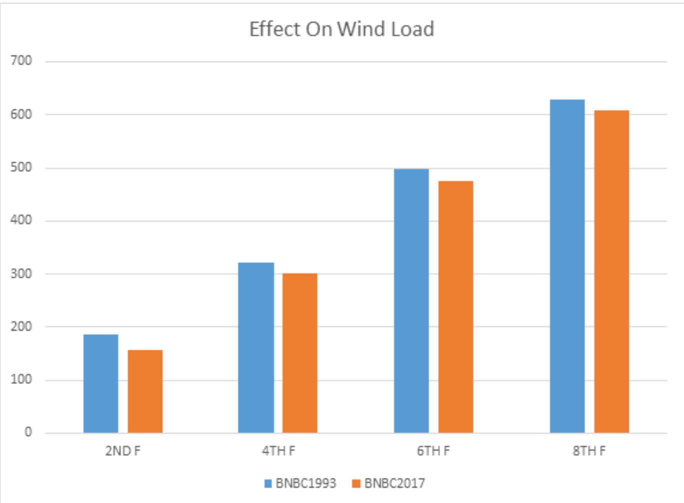

Figure 2: Wind load vs. No. of Story

To ease to understand how much storey shears are varying for two different codes the shear forces are represented together as diagrams below:

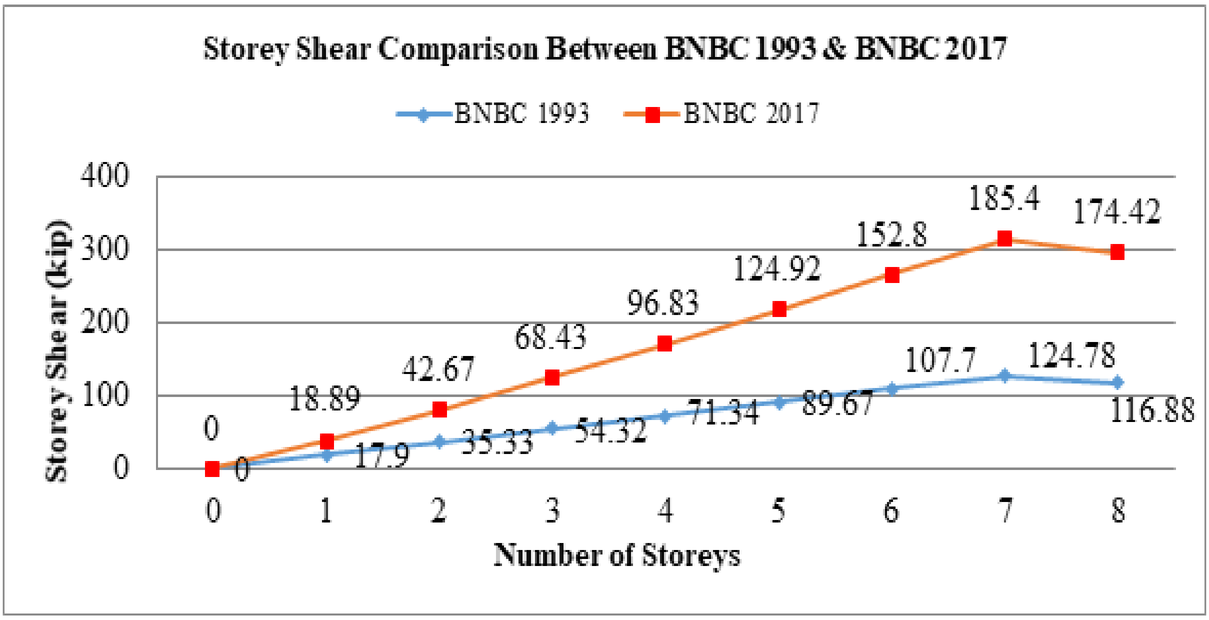

Figure 3: Storey shears comparison between BNBC 1993 and BNBC 2017

To understand how much base shears are varying for two different codes the base shears are represented together as bar charts below:

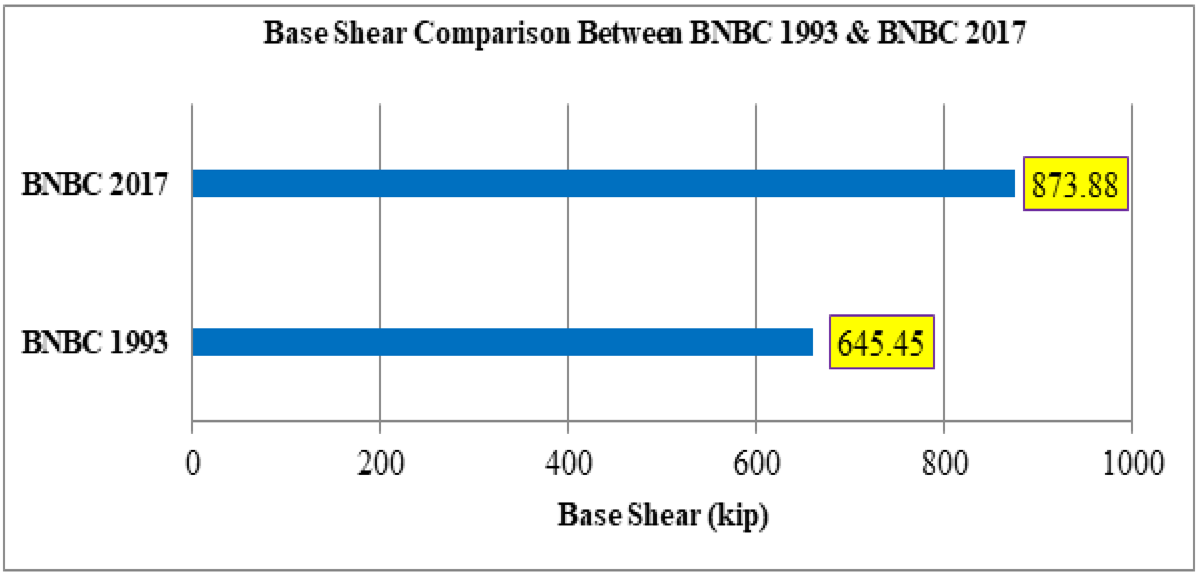

Figure 4: Base shears comparison between BNBC 1993 and BNBC 2017

3.1 Storey Displacement and Drift Analysis

The drift analysis is done for every floor to see the gradual displacement of the floors. To make it easier to understand how much inter storey drifts and storey displacements are varying for both codes some figures are given below:

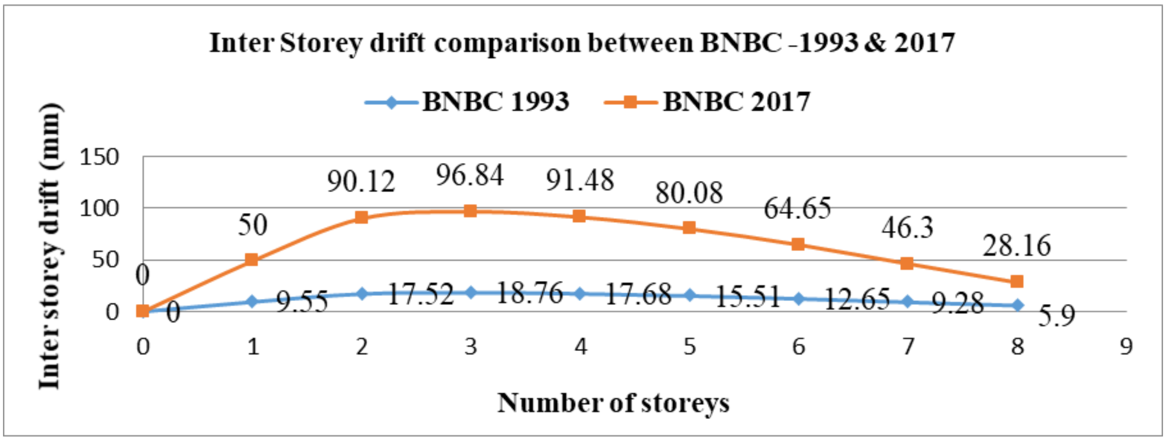

Figure 5: Comparison of inter storey drifts (mm) according to BNBC-1993 and BNBC-2017

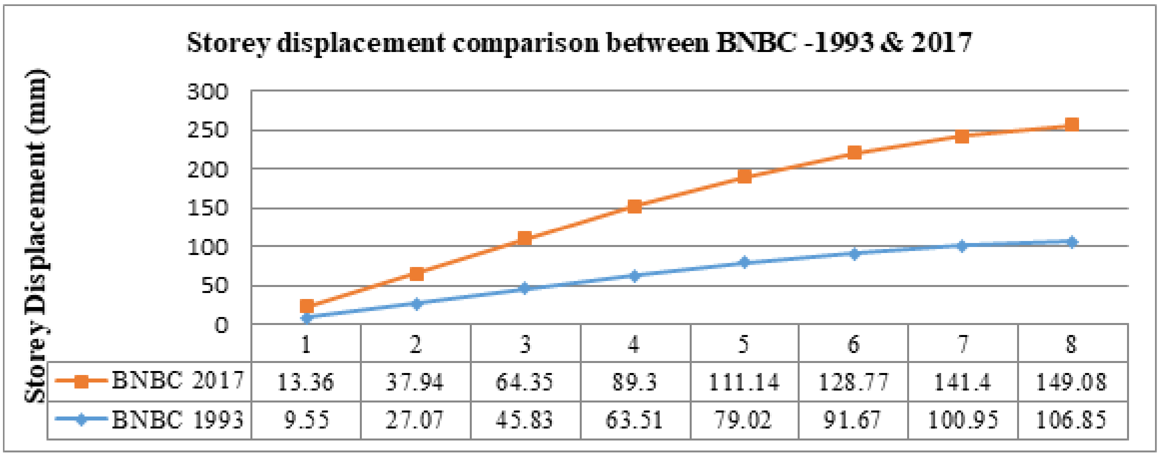

Figure 6: Comparison of storey displacement (mm) according to BNBC-1993 and BNBC-2017

3.2 Corner and an Interior Column Analysis and Design

For analysing and design purpose a corner column and an interior column have been selected for both BNBC-1993 and 2017 so that we can make a clear comparison of column dimensions and number of bar requirements as well as bar diameters. Here are the tables showing differences of findings of columns forces and steel area (in^2).

Table 3: Column forces in kip according to BNBC-1993 and BNBC-2017

BNBC-1993		BNBC-2017	
Corner column force (kip)	**Interior column force (kip)**	**Corner column force (kip)**	**Interior column force (kip)**
554.45	1639	380.33	1317.45

Table 4: Column dimensions (in x in) according to BNBC-1993 and BNBC-2017

BNBC-1993		BNBC-2017	
Corner column size (in x in)	**Interior column size (in x in)**	**Corner column size (in x in)**	**Interior column size (in x in)**
18x18	30x30	15x15	30x24
Steel area required (in²)			
3.27	9.3	2.19	7.18

Table 5: Required bar diameter (mm) for columns according to BNBC-1993 and BNBC-2017

BNBC-1993		BNBC-2017	
Corner column	**Interior column**	**Corner column**	**Interior column**
8-20mmΦ	16-22mmΦ	6-20mmΦ	12-22mmΦ

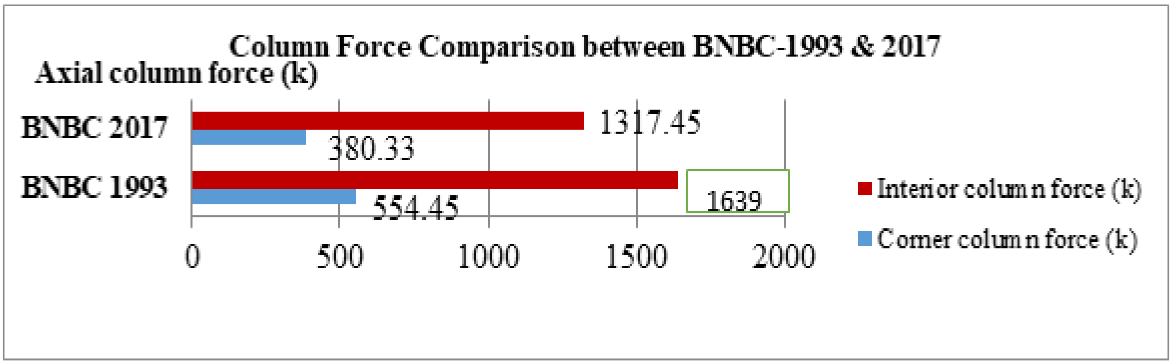

Figure 7: Comparison of column forces (kip) according to BNBC-1993 and BNBC-2017

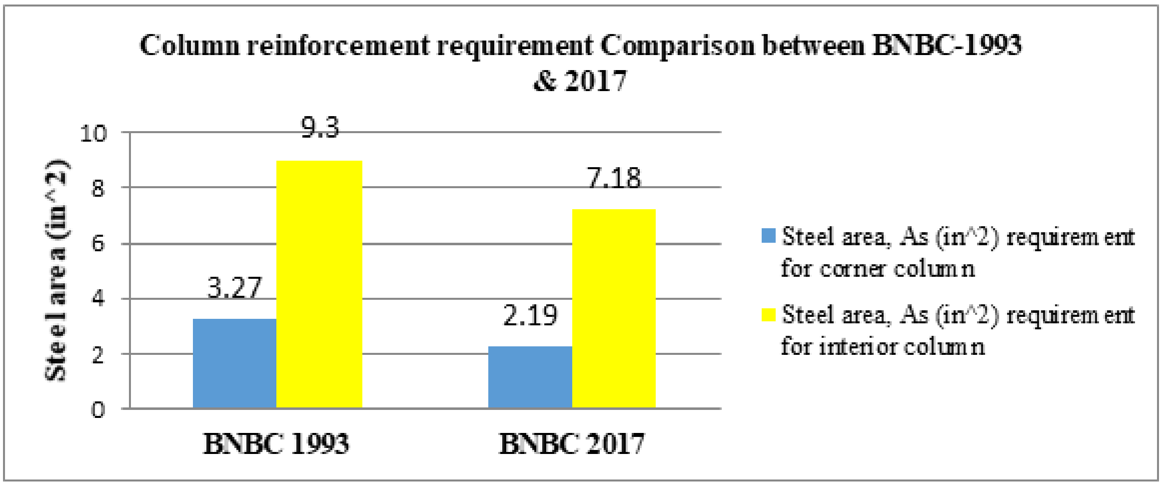

Figure 8: Comparison of steel area (in²) requirement for a corner and an interior column according to BNBC-1993 and BNBC-2017

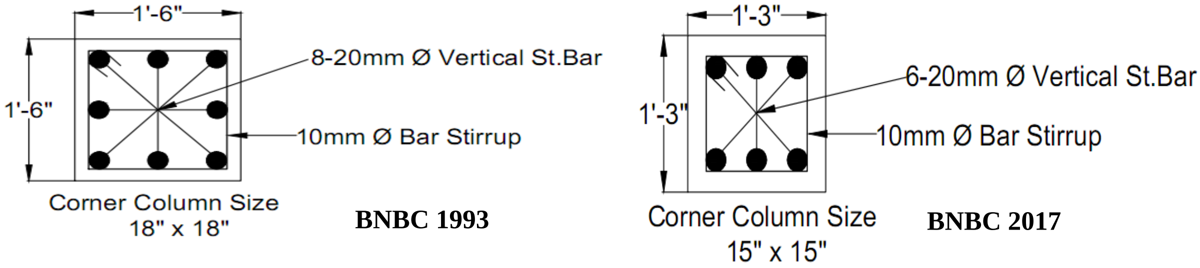

Figure 9: Comparison of column area (in^2) and bar diameter (mm) for corner columns according to BNBC-1993 and BNBC-2017

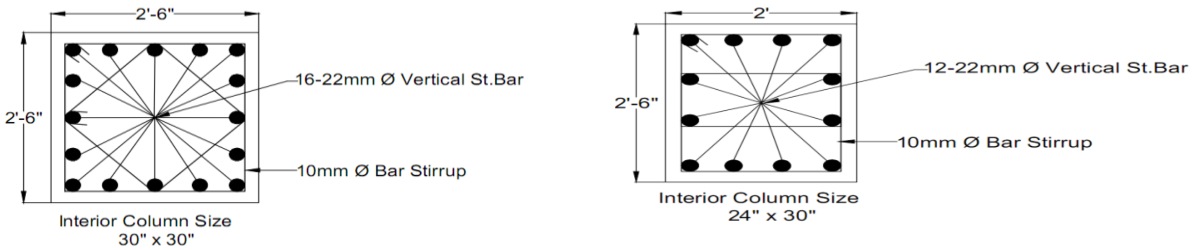

Figure 10: Comparison of column area (in^2) and bar diameter (mm) for interior columns according to BNBC-1993 (Left) and BNBC-2017 (Right)

4. CONCLUSION

Base shear is increased in BNBC-2017 than BNBC-1993 due to increase in zone coefficient (z), structural system factor(R) and self-weight (W). The design basis earthquake is not properly defined in BNBC-1993. The design basis earthquake is 0.67 times of the maximum earthquake in BNBC-2017. In BNBC-1993 load factor 1.4(0.75*1.7*1.1) is used with earthquake load. It means the earthquake load is increased 40% because of the uncertainty of load. This factor is not quite needed because the maximum earthquake is taken for design. It is seen that base shear and storey shear are much higher for BNBC-2017 than BNBC-1993 from base shear versus no. of storey graph and storey shear versus no. of storey graph. Maximum lateral drift is also found to be higher for BNBC-2017 than BNBC-1993. Design of reinforced concrete buildings for seismic and wind load in BNBC-2017 is economic than BNBC-1993. As the quantity of reinforcement required is less in BNBC-2017 which is applicable for Dhaka city only.

5. RECOMMENDATIONS

The following recommendations can be made for future research work:

- The case study performed in this research is for Dhaka city only. For different parts of Bangladesh, the seismic zone coefficient varies.
- In BNBC-1993 load factor 1.4(0.75*1.7*1.1) is used with earthquake load. It means the earthquake load is increased 40% due to the uncertainty of load and that’s why the column forces are more in BNBC 1993 compared to BNBC 2017. However, this factor is not needed since the maximum credible earthquake is considered for design in BNBC-2017.
- In this study only column axial forces were taken during analysis. So it is recommended to consider column moments too for future research study.s
- For other types of buildings such as steel frames, ordinary moment resisting frames and masonry structures etc. located in different places with different site condition, similar study can be performed.

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