Journal of Civil, Construction and Environmental Engineering
2022; 7(5): 93-101
http://www.sciencepublishinggroup.com/j/jccee
doi: 10.11648/j.jccee.20220705.12
ISSN: 2637-3882 (Print); ISSN: 2637-3890 (Online)

Performance Assessment of Residential Building for Different Plan Configurations in Different Seismic Zones of Bangladesh Using ETABS

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To cite this article:

J. M. Raisul Islam Shohag, Kowshik Mozumder. Performance Assessment of Residential Building for Different Plan Configurations in Different Seismic Zones of Bangladesh Using ETABS. *Journal of Civil, Construction and Environmental Engineering*. Vol. 7, No. 5, 2022, pp. 93-101. doi: 10.11648/j.jccee.20220705.12

Received: August 1, 2022; **Accepted**: August 17, 2022; **Published**: November 4, 2022

Abstract: Computer aided analysis using ETABS according to BNBC 2020 has carried off a phenomenal attention for various specialized cases recently. ETABS software harmonizes every small aspect of civil engineering designing and also the production of diagrammatic sketches. To resist all imposed loads on structures, a significant structural analysis and design might be geared up. There is a challenge for the structural engineers to design buildings for ultimate efficiency and economy with accuracy. ETABS software with the guidelines of BNBC 2020 plays a vital role for these cases. In this study, analysis of a G +12 storied building for H shape, L shape and Rectangular shape configuration has been performed accompanied by ETABS software. BNBC 2020 guidelines have been followed for achieving the ultimate goals. For getting desired outcomes different types of lateral loads have been imposed & afterwards analysed. Three desired parameters like maximum story displacement, maximum story drift, overturning moment have been inspected and compared among four seismic zones in Bangladesh according to BNBC 2020 for different plan configurations. A dramatic phenomenon of the three desired parameters of regular and irregular shaped building has been established for several seismic zones. In this study, there is a significant change of maximum storey displacement of H shaped and Rectangular shaped building has been observed at specific zones on the scale of L shaped building. Similar cases have been studied for maximum storey drift and overturning moment. Therefore a significant economic design aspects has been focused on L shaped building.

Keywords: Different Plan Configurations, ETABS, BNBC 2020, Story Displacement, Story Drift, Overturning Moment

1. Introduction

Buildings are such type of structures having a variety of components like walls, columns, footings, lifts etc. A structure is designed to resist all applied loads without failure during its intended life with structural analysis and design. For structural analysis and design ETABS software is one of the ultimate integrated software. ETABS is an engineering software that is used to multi-story building analysis and design. Modeling tools and templates, code-based load prescriptions, analysis methods and solution techniques, all coordinate with the grid-like geometry unique to this class of structure. Basic or advanced systems under static or dynamic conditions may be evaluated using ETABS. ETABS software has been used for the analysis and design purposes of G + 4 hostel building. To obtain utmost results IS: 456 (2000) guidelines have been followed and M25 concrete has been used. This thesis has been observed that the results obtained from model are standard and secured against manual calculations and software results. [1]

ETABS, AUTOCAD, REVIT software have been intensively used to analyse multi-storeyed residential building analysed with lateral loading effect of earthquake. This study has been followed to the guidelines of IS 1893 (part2, 2002), IS 456 (2000). Several gravity loads and different load combinations according to IS guidelines have been considered. Manual calculation & software design have

been focused based on shear force and bending moment analysis. In this study there is lack of irregular shaped building analysis, storey displacement, storey drift, overturning moment consideration. [2]

We are now facing challenges of 21st century and to cope with the situation complex and irregular structure have to design. Bangladesh is recognized for its earthquake proneness. All structures must be earthquake resistant with proper planning and structural design. New housing in Bangladesh appears to be built to meet social demand in most situations, although the impact of earthquakes is rarely thoroughly considered. Urbanization is rapidly advancing in Bangladesh, but there is no clear plan for quickly applying this knowledge to the design and construction costs of structures in distinct seismic zones. For this seismic analysis is a subset of structural analysis and it calculates the response of a building structure to an earthquake. Therefore, seismic analyses can provide insight into how a structure will respond during an earthquake. A building's structural design depends on the loads placed on structural elements such as lateral and axial loads.

BNBC 2020 has played a vital role for the advancement of residential building analysis by ETABS software. The main objective of this paper is to analyse residential building of different plan configuration by ETABS software. In this paper BNBC 2020 guidelines have been applied. This study also focuses on lateral load effect based on several parameters of residential building analysis in different seismic zones of Bangladesh.

2. Literature Review

G+5 residential building, comparison between manual & software analysis and several irregular shaped building analyses has been observed using ETABS software. The analysis has been followed by IS 875. Several parameters like shear force, deflection, bending moment etc have been analysed and M20 concrete has been considered. The theory of Limit state method has been applied as this method gives sufficient strength, serviceability and durability based on considering ultimate economic conditions. [3, 10, 12, 14]

G+4 residential building has been analysed using ETABS software. The analysis has been followed by IS 1893 (part 2, 2002), IS 456 (2000). Seismic analysis has been performed and severe seismic zone, type II soil condition, medium stiff has been considered. In this thesis a rectangular shaped building placed at Panaji has been analysed by ETABS software. Basically analysis and design of regular and irregular shaped of multi storied building in several seismic zones using ETABS software has been performed. In this study lateral force has increased from bottom floor to top floor, maximum shear force and maximum bending moment have found at top floor of building. In this study there is lack of analysis of storey drift, overturning moment, analysis of other irregular shape like H shaped building, L shaped building etc. For obtaining more relevant results ETABS & STAAD Pro software needs to be used. [4]

Analysis of residential building has been performed with STAAD. Pro & ETABS software. The analysis has been followed by IS 456 (2000), SP 16. The building placed at Hyderabad has been analysed focusing on different types of load cases, load combinations, support reactions and reinforcement of column and beam. Lateral forces imposed on structures have been considered. It can be performed for various irregular configurations. [5]

Several parameters like displacement and drift of the R.C.C. frame having shear wall with respect to different wind speed for a high-rise building have been analysed according to BNBC 2006 using ETABS software. The building located at Barisal has been focused based on different wind speed variation from 150-260 km/hr. For the betterment of storey drift shear wall have been used in several cases. With the increase of wind speed the storey drift and storey displacement have increased. In this study there is lack of analysis of storey overturning moment, several irregular configurations, BNBC 2020 guidelines. These considerations may improve the paper. [6]

G+5 storey commercial building have been considered for this thesis. Static method has been applied and IS 456 (2000) guidelines have been followed. The design and analysis of RCC frame members such as beam and column has been performed using ETABS V9.2. Using different plan configurations of residential building can be analysed with the STAAD Pro, SAP software. [7]

This paper has investigated a G + 50 multi-storied high-rise building focusing on different combinations of moment resistant frames, shear walls, seismic conditions to find out the effectiveness during ground motion against soft soil conditions. Several parameters such as displacements, drifts, base shear, stiffness and torsion have been analysed. In this study numerical results have showed that applying dampers at the base level can be the utmost effective against seismic control as well as applying an outrigger bracing system at the middle and top end with shear wall can be the most useful for controlling displacements and drifts of storey. For getting this results finite element modeling and analysis have been generated with the guidelines of BNBC 2020. Several irregular plan configurations might have been used to enhance more accuracy. [8]

3. Methodology

Design of RCC building according to BNBC 2020, 1993, 2015 guidelines has been introduced focused on LRB Isolator. Several parameters such as moment, base shear have been analysed. [9, 11, 13, 15]

In this paper analysis of G+12 residential building of different plan configuration have been performed based on the guidelines of BNBC 2020, part VI, chapter 2.

Table 1. *Design load consideration according to BNBC 2020.*

Property Name	Symbol	Value
Compressive Strength of Concrete	f_c'	2.7 ksi
Yield Strength of Steel	f_y	60 ksi
Floor Finish	FF	18 psf
Partition Wall	PW	25 psf
Roof Slab Live Load	---	65 psf
Floor Slab Live Load	---	42 psf
Live load on stair	-	102 psf
Parapet Wall	---	150 psf

Table 2. *Load combination for design of residential building according to BNBC 2020.*

SL No	Load combination
1	1.4 D
2	1.2 D + 1.6 L + 0.5 Lr
3	1.2 D + 1.6 Lr + L
4	1.2 D + 1.6 Lr + 0.8 W
5	1.2 D + 1.6 W + L + 0.5 Lr
6	1.2 D + 1 E + 1 L
7	0.9 D + 1.6 W
8	0.9 D + 1 E

Table 3. *Basic wind speed consideration according to BNBC 2020.*

Seismic Zone	Speed (mph)	District
1	110.208	Rajshahi
2	147.168	Dhaka
3	148.96	Gazipur
4	146.944	Netrokona

Table 4. *Wind load consideration according to BNBC 2020.*

Property Name	Symbol	Value
Exposure Type	B	
Importance Factor	I	1
Topographical Factor	K_{zt}	1
Gust Factor	----	0.85
Directionality Factor	K_d	0.85
Windward Coefficient	C_{pw}	0.8
Leeward Coefficient	C_{pl}	0.5

A 3500 sq. ft of H shaped, L shaped and Rectangular shaped residential building have been considered. Shear wall, different column such as rectangular, square and circular column have been introduced with different shaped building. AUTOCAD software has been used to plan of different shaped building. This analysis has been performed for four seismic zones in Bangladesh. Several parameters such as storey displacement, storey drift, overturning moment have been focused in this paper.

Table 5. *Earthquake load consideration according to BNBC 2020.*

Property Name	Symbol	Value
Site Class	F	
Site coefficient	Fa = Fv	1.15 = 1.725
Occupancy Importance	I	1.25
Response Modification Factor	R	6
System Over strength	Ω	2.5
Deflection Amplification	Cd	5.5
Time Period	T	1.137
Long-Period Transition Period		2 sec

The steps have been followed effectively:

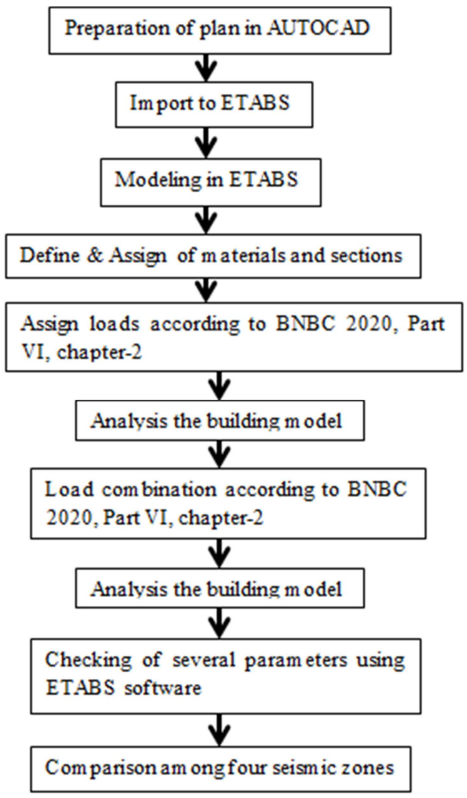

Figure 1. *Flow diagram of design procedure.*

4. Results and Discussions

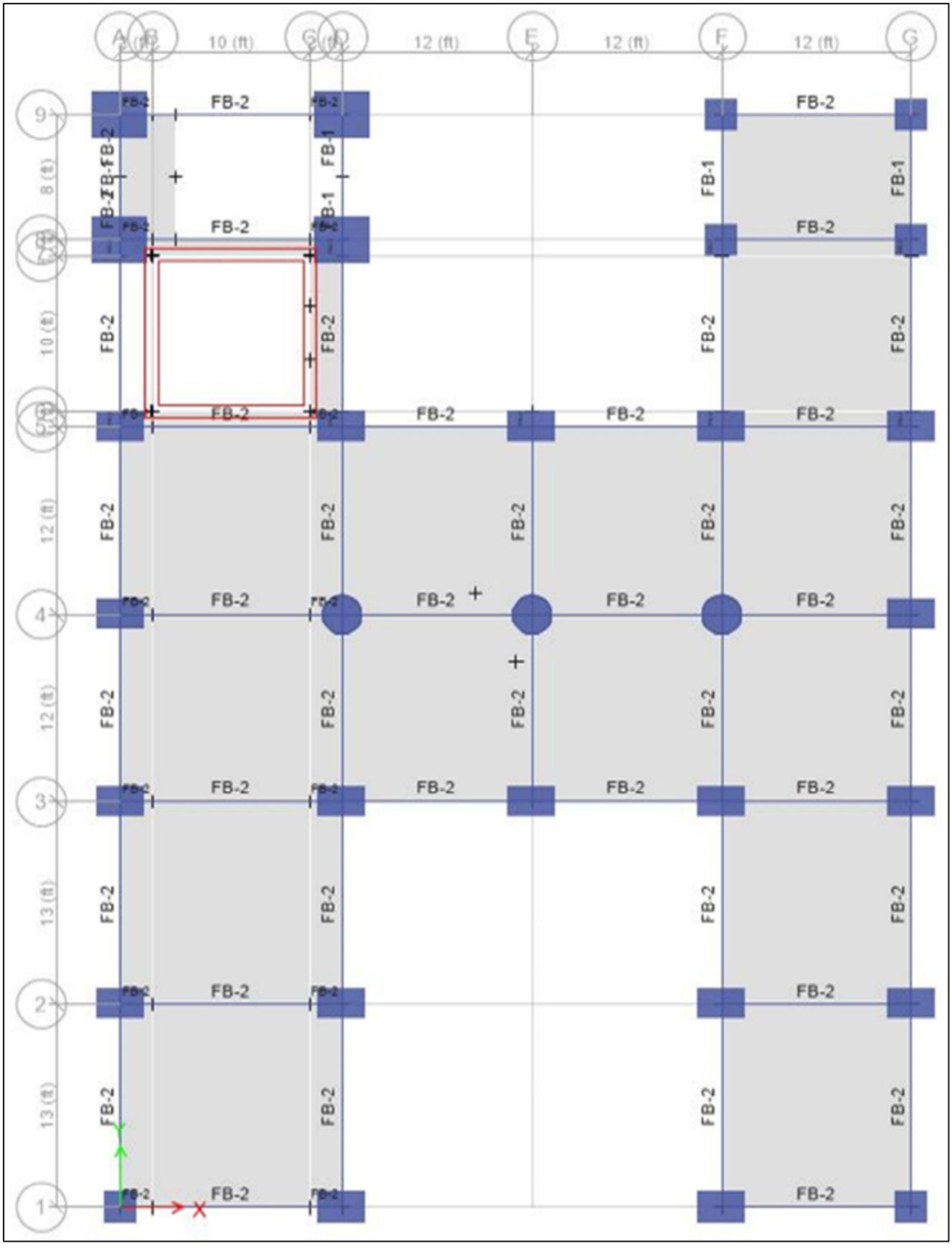

Figure 2. *Plan of H shaped building using ETABS software.*

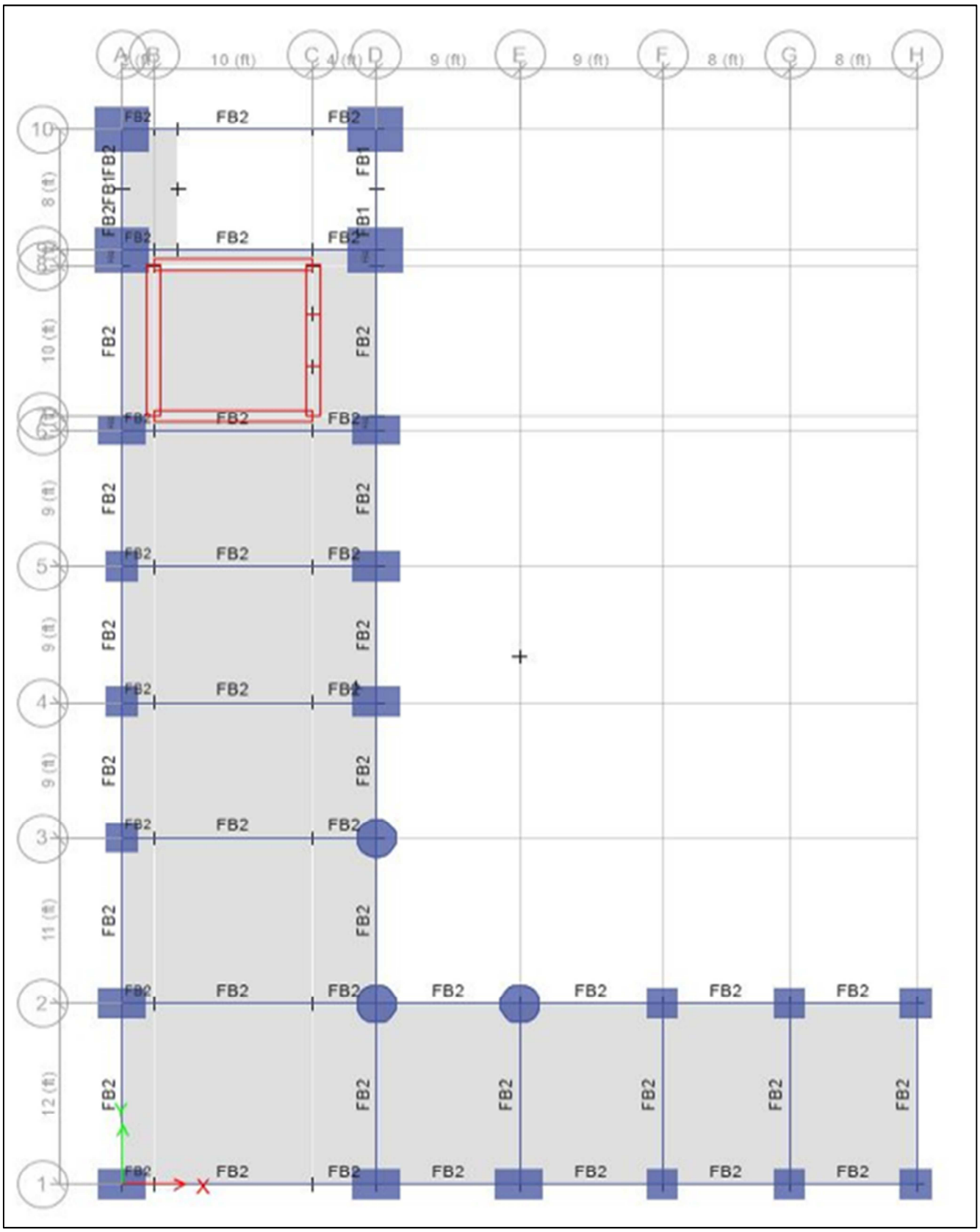

Figure 3. *Plan of L shaped building using ETABS software.*

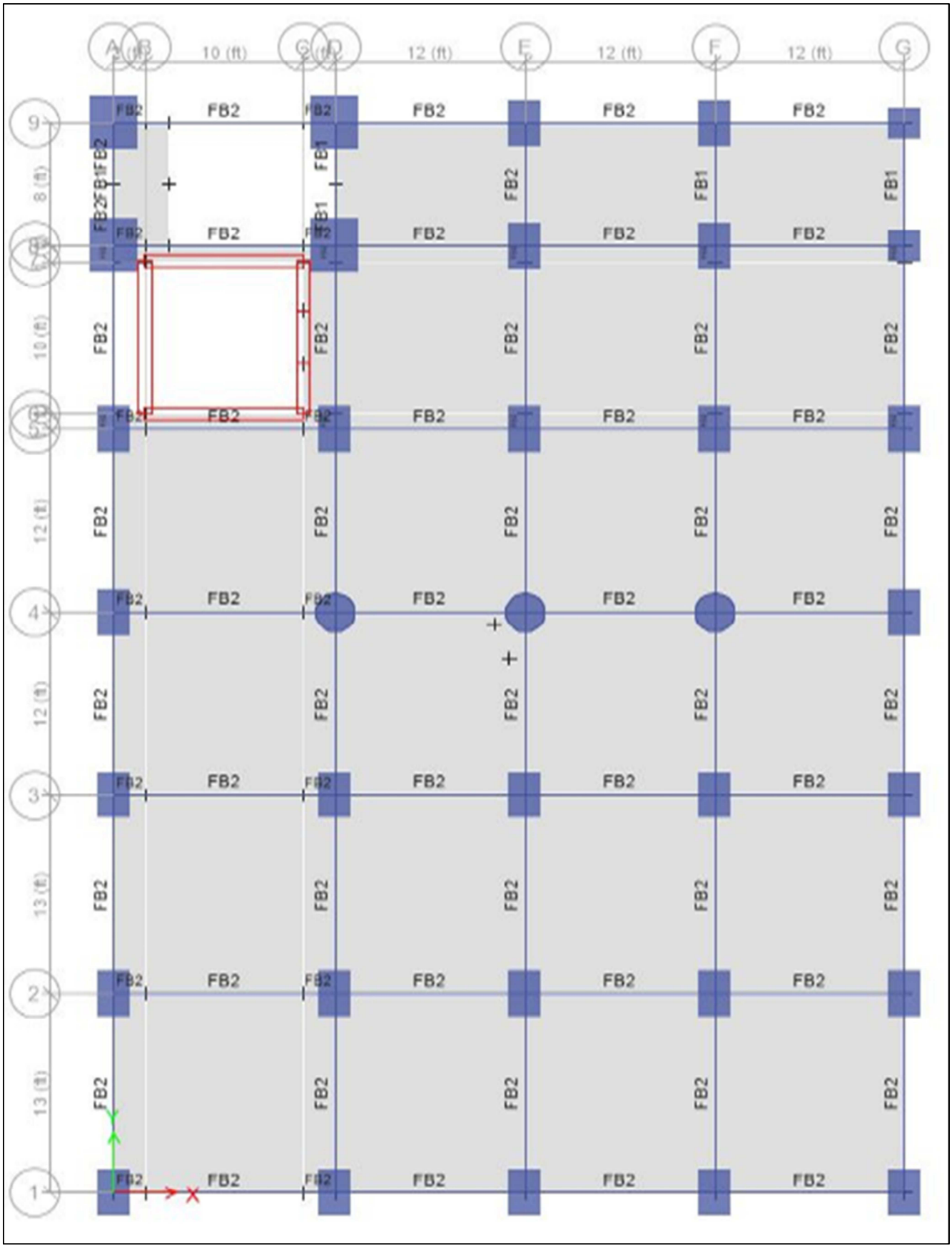

Figure 4. *Plan of Rectangular shaped building using ETABS software.*

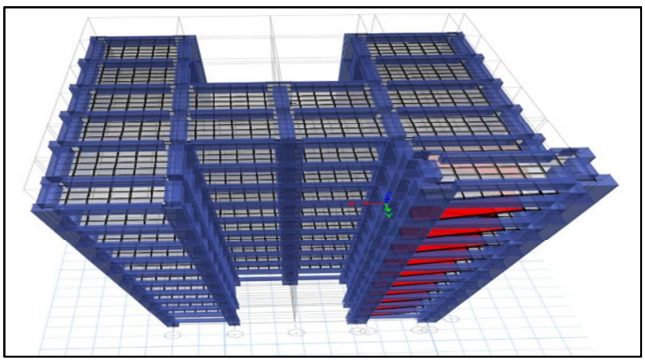

Figure 5. *3D model of H shaped building using ETABS software.*

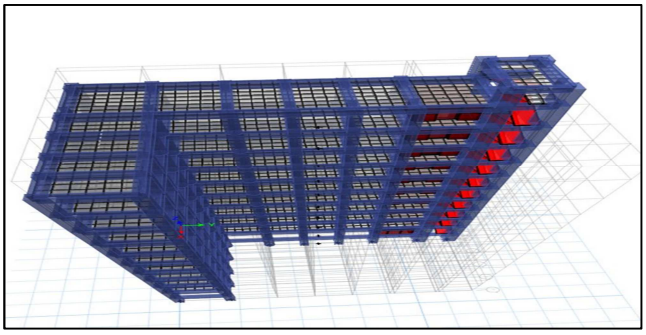

Figure 6. *3D model of L shape building using ETABS software.*

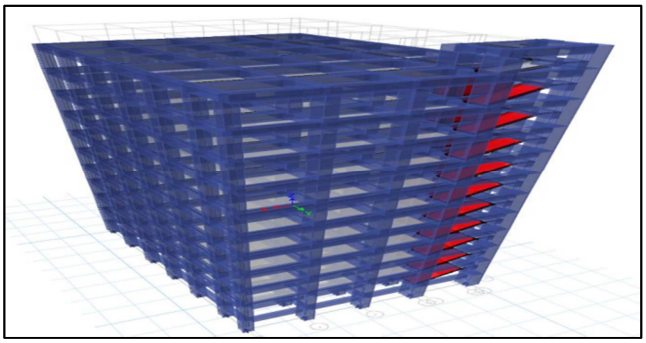

Figure 7. *3D model of Rectangular shaped building using ETABS software.*

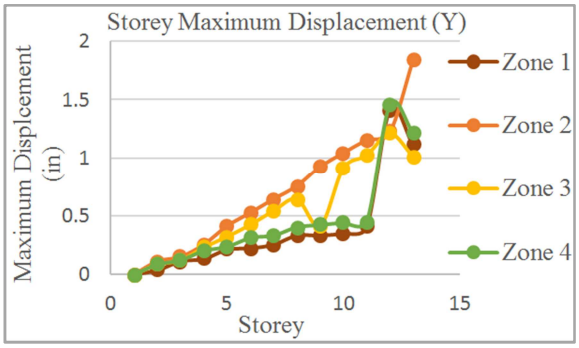

Figure 8. *Variation of maximum storey displacement with respect to storey of H shaped building.*

2D & 3D model of different plan configurations [Figure 2, Figure 3, Figure 4, Figure 5, Figure 6, Figure 7] have been established by ETABS software. It can be seen that maximum displacement and maximum drift of H shaped building [Figure 8, Figure 9] were found for seismic zone 2. A dramatic change of maximum storey displacement and maximum storey drift have been observed among four seismic zones. For the case of overturning moment [Figure 10] seismic zone 1 has played significant role.

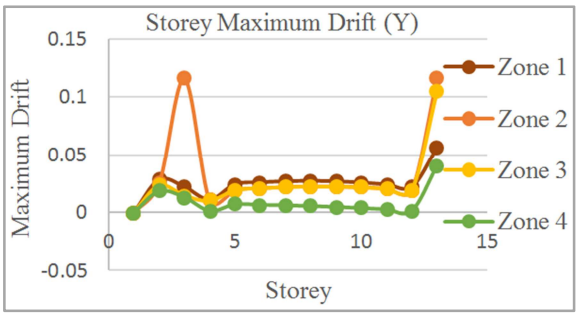

Figure 9. *Variation of maximum drift with respect to storey of H shaped building.*

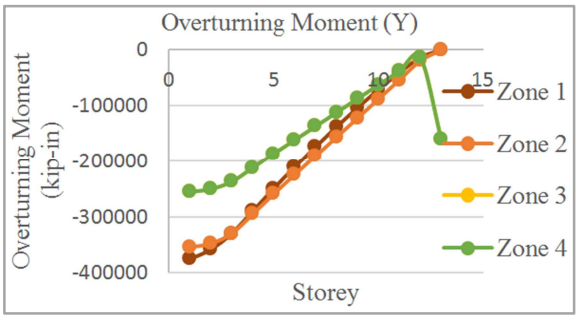

Figure 10. *Variation of overturning moment with respect to storey of H shaped building.*

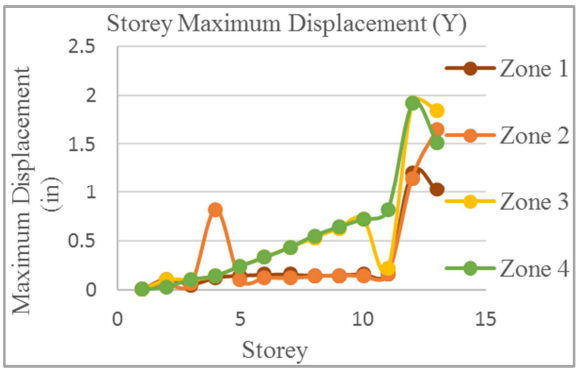

Figure 11. *Variation of maximum storey displacement with respect to storey of L shaped building.*

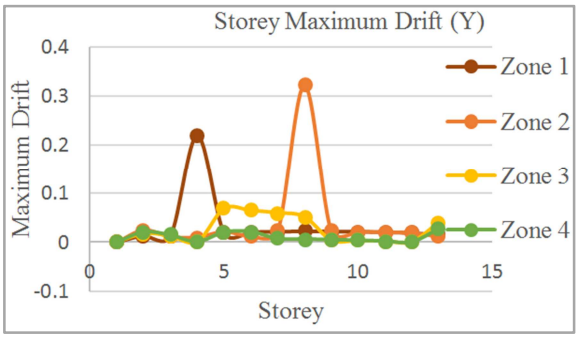

Figure 12. *Variation of maximum drift with respect to storey of L shaped building.*

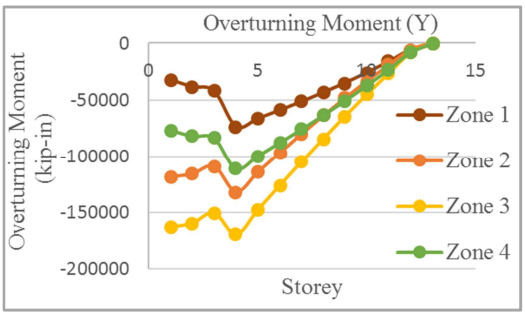

Figure 13. *Variation of overturning moment with respect to storey of L shaped building.*

ETABS analysis has pointed maximum displacement, maximum drift and maximum overturning moment of L shaped building [Figure 11, Figure 12, Figure 13] for seismic zone 2.

Figure 14. *Variation of maximum displacement with respect to storey of Rectangular shaped building.*

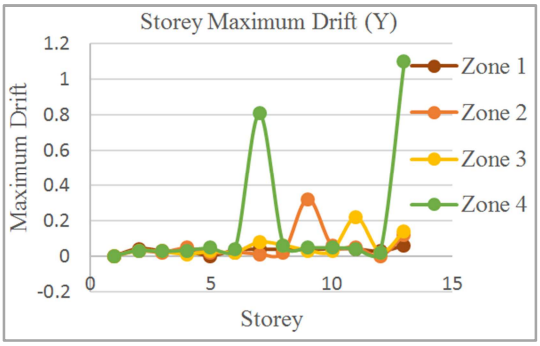

Figure 15. *Variation of maximum drift with respect to storey of Rectangular shaped building.*

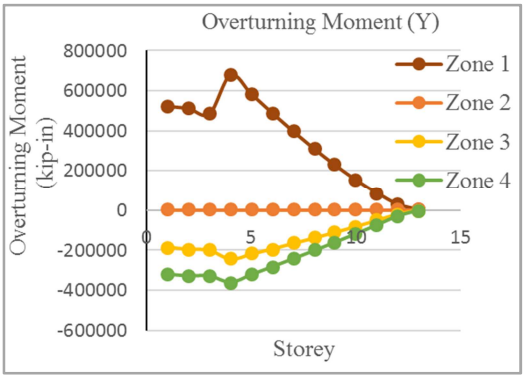

Figure 16. *Variation of overturning moment with respect to storey of Rectangular shaped building.*

It can be observed that seismic zone 1 and zone 2 have executed maximum displacement [14] and maximum drift [15] of Rectangular shaped building respectively. On the other hand, maximum overturning moment [16] has been observed for seismic zone 4. A gradual decrease of maximum displacement among rectangular, L and H shaped building. Maximum storey displacement of H shaped building has been increased by 0.17% on the scale of L shape building and 5.6% increased for Rectangular shaped building. A dramatic increase of maximum drift has been found for Rectangular shaped building with respect to remains. A significant increase of 77.3% for maximum storey drift of H shaped building has been carried off on the scale of L shape building and 1590% increased for Rectangular shaped building. A considerable increase of overturning moment has been found for Rectangular shaped building with respect to remaining two shaped building. A sharp increase by 121.2% has been focused for H shaped building on the basis of L shaped building and 112.2% increase for Rectangular shaped building.

5. Conclusion

In this paper, a significant comparative study of several parameters such as maximum displacement, maximum drift and overturning moment of different shaped building has been carried off on the scale of four seismic zones in Bangladesh according to BNBC 2020. It can be clearly seen that a dramatic decrease of maximum displacement among regular and irregular shaped building. A certain percentage of increase of maximum storey displacement, maximum storey drift and maximum overturning moment of H shaped and Rectangular shaped building has been investigated on the scale of L shape building. Therefore it can be concluded that L shaped building has ultimate economic design aspects.

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