A COMPREHENSIVE ANALYSIS OF LOW RISE AND HIGH RISE BUILDING IN DIFEERENT ZONE FACTOR BASED ON BNBC-2020 BY USING ETABS

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A thesis submitted to the Department of Civil Engineering in partial fulfillment for the degree of Bachelor of Science in Civil Engineering



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147/I, Green Road, Dhaka-1215, Bangladesh

Section: (21-C)

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It is hereby declared that this thesis/project or any part of it has not been submitted elsewhere for the award of any degree or diploma.

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Dedicated

to

"Our Respectful Teachers & Parents"

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ABSTRACT

This study aims to conduct a comparative analysis of low-rise and high-rise buildings drift, stiffness, deflection and base shear according to Bangladesh National Building Code (BNBC) 2020, using the ETABS software. The structural response to ensuring the safety and stability of buildings, especially in different zone. The research methodology involves the use of ETABS, a widely used software for structural analysis and design, to model and analyze low-rise and high-rise buildings. Load calculations are performed according to the BNBC 2020 guidelines, considering the wind speed and terrain characteristics of the study area. The findings can aid engineers, architects, and policymakers in making informed decisions regarding building design and construction practices, especially in regions with similar climatic and seismic conditions. Seismic load calculations are carried out based on the specified seismic design parameters as per BNBC 2020, which considers the seismic zone and soil conditions of the region. The study compares the structural responses of low-rise and high-rise buildings under deflection, base shear, drift and stiffness. Various parameters such as base shear, story drift, bending moments, and shear forces are evaluated to assess the performance of the buildings. The analysis also investigates the influence of building height, aspect ratio, and structural systems on the response to wind and seismic loads. The results of the study provide valuable insights into the relative effects of wind and seismic loads on low-rise and high-rise buildings. It demonstrate the valuable possibilities of building resistance against seismic and lateral loads which is significant according to BNBC-2020.

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CHAPTER 1

INTRODUCTION

In civil engineering projects, sustainability is a very important aspect to consider in designing structures for expected service life. The lateral loading due to wind or earthquake is the major factor that causes the design of high-rise buildings to differ from that of the low-rise to medium-rise buildings. One simple parameter to estimate the lateral stiffness of a tall building is the drift index, defined as the ratio of maximum deflection at the top of the building to the height due to lateral forces. For conventional structures the preferred acceptable range is 0.0015 to 0.003 and sufficient stiffness must be provided to ensure that the top deflection does not exceed the value under extreme loading condition. In addition of estimating drift index, the inter-story drift index gives a measure of possible localized excessive deformation. The control of lateral deflection is of particular importance for modern high-rise buildings in which the traditional reserves of stiffness due to heavy internal partitions and outer cladding have largely disappeared.

In Bangladesh, it is essential to ensure that structures are designed to withstand earthquakes due to its location in a seismically active region. Therefore, the comparative analysis presented in this paper will provide valuable insights into the effectiveness of ETABS software in ensuring the structural integrity and earthquake resistance of buildings in Bangladesh.

By analyzing the results obtained from the manual analysis and ETABS software, this paper will provide valuable insights into the use of modern software in designing and analyzing structures in Bangladesh. It is essential to ensure that buildings in Bangladesh are designed and constructed to withstand earthquakes, and ETABS software can help to achieve this goal. The study will investigate various parameters such as base shear, story drift, bending moments, and shear forces to assess the performance of low-rise and high-rise buildings under wind and seismic loads. It will consider factors such as building height, aspect ratio, and structural systems to analyze their influence on the response to these loads.

Significant improvements were made in BNBC 2020 to incorporate knowledge and advances in structural engineering during the last two decades. BNBC 1993 has been modified and published as BNBC 2020 considering the guidelines of other international building standards.

1.2 Background of the Study

In this regard, Mendes et al. showed that structures which are usually tall or slender, respond dynamically to the effects of wind. In case of tall buildings, the wind load is a major form of lateral loading and plays a vital role as it tends to deflect the whole structure.

The initial goal of this research is to investigate seismic reaction in four different zones of structure for static and dynamic examination in standard minute opposing casing. We considered a residential building with (G+9) and (G+4) stories for the seismic Investigation with loads. The method for establishing the base plan loads that must be acquired for dead loads, forced burdens, and other outside loadings attaches the basic necessities relating to the basic security of structures. The total structure was analyzed on a computer using the ETABS software. In this paper, an analysis done for (G+9=10) and (G+4=5) RCC building under seismic loads for Zone 1, 2, 3 and Zone 4 in Bangladesh. Numerous load combinations are observed in accordance with BNBC 2020.

1.3 Objectives

1. To analyze a high and low rise multi-story residential building in different seismic zone in Bangladesh.

2. To compare the drift, stiffness, deflections and base shear for multi-story structures in different zone in Bangladesh according to BNBC 2020 by using ETABS.

3. To compare the seismic effect on low and high-rise multi-story structures in different zone in Bangladesh according to BNBC 2020 by using ETABS.

1.4 Organization of the Thesis

Chapter 1: Introduction and Objective: This chapter provides the background of study and motivations of the research. The overall objectives and expected outcomes are also described in this chapter.

Chapter 2: Literature Review: This part discusses the previous analysis history about earthquake or seismic wave, recent research on seismic zone, methods for analyzing a frame structures, software used for analysis.

Chapter 3: Methodology: This chapter discusses the analytical process in details step by step. Seismic design requirements as per BNBC-2020, wind load and wind load code provisions as per BNBC-2020, seismic load and seismic load code provisions as per BNBC-2020. The Zonal Parameters, Load principles and types of load acting on the structure are also discussed in this chapter. Different floor plan view and building analysis image are also shown in this chapter.

Chapter 4: Results and Discussion: This chapter describes the results of the proposed buildings load and material properties, building load calculation. Overall and zone to zone maximum story drift and maximum story displacement analysis data and results are also discussed in this chapter.

Chapter 5: Conclusions and Future Work: This chapter summarizes the conclusions and major contributions of this study and provides recommendations for future studies.

CHAPTER 2
Literature Review

2.1 Introduction

Earthquake is a global phenomenon that impacts the livelihood of millions of people every year. The growing frequency of earthquakes has resulted in immense losses of human life and resources, as well as significant disruptions to infrastructure and social organization. It is a sudden release of energy in the lithosphere that results in seismic waves, which cause the earth's tectonic plates to move or tremble. As Bangladesh is located between significant fault lines, the damage due to a major earthquake will be massive. Many researcher's advances in earthquake and wind engineering research have taken place over the last two decades. Researchers have done some different comparison with these earthquake and wind load according to the result of their drift, deflection, stiffness and base shear.

2.2 Previous Background of the Study

The National Building Code (BNBC) has been updated in 2022. Earthquake design provisions are important, since Bangladesh is located in a seismically active region not far from the boundary of the Indian plate and Eurasian plate. Many advances in earthquake engineering research have taken place over the last two decades.

Chowdhury Zubayer Bin Zahid (2023) discussed and analyze high raise building structure. Tall building have a significant amount of resonant dynamic response to wind that complicates the evaluation stiffness, drift, deflection which has significant reactions according to seismic and wind load. This study was performed for a symmetrical structure. This study was performed for a G+15 story regular-shaped building in seismic zone II of Bangladesh. Further study can be carried out for higher-story buildings in other seismic zones of Bangladesh. The optimum location and orientation of the shear walls may vary for unsymmetrical structures.

M.F. Haque (13 Feb 2023) Analyze a high raise RC building according to nonlinear in Bangladesh.it recommends that The drift of this proposed model is minimized after completion of the non-linear time history analysis, and joint acceleration is less than the selected matched input acceleration. In addition, hysteresis behaviors of structural members represent the absorption capacity of selected seismic acceleration. Therefore, site specified selected acceleration for non-linear analysis in Bangladesh is suitable based on the structural performance of the proposed model.

C.Alamin etal (2021) studied the comparative study of seismic load on multi-storied (G+9) residential building for four different zones in Bangladesh. For analysis he used ETABS software with four different zone co-efficient and wind speeds. He performed analysis on 39m building. Evaluation of load patterns and lateral forces according to BNBC 2020 codes were assigned and to investigate the seismic behavior of that building under revised seismic zones and seismic zone coefficients. The deflection of various members, inter story drift, lateral displacement of the whole structure and stress of all members, inter story lateral displacement of the whole structure and stress of all members were checked comparison with limiting value of the design criteria.

2.3 Methods for Analyzing a Frame Structure

There are some methods to analysis a frame. Method of analysis of statistically indeterminate portal frames:

1. Method of flexibility coefficients.
2. Slope displacements methods (iterative methods)
3. Moment distribution method
4. Cantilever method
5. Portal method
6. Matrix method

2.3.1 Methods of Flexibility Co-Efficient

The flexibility coefficient is popularly used to implement the macroevolution of shape, safety, and economy for arch dam. The method of consistent deformations, or sometimes referred to as the force or flexibility method, is one of the several techniques available to analyze indeterminate structures. The following is the procedure that describes the concept of this method for analyzing externally indeterminate structures with single or double degrees of indeterminacy. The method of analysis is Comprises reducing the hyper static structure to a determinate structure form by: Removing the redundant support (or) introducing adequate cuts (or) hinges.

Limitations:

It is not applicable for degree of redundancy>3

2.3.2 Slope Displacement Equations

The slope deflection method is a structural analysis method for beams and frames introduced in 1914 by George A. Many. The slope deflection method was widely used for more than a decade until the moment distribution method was developed.

By forming slope deflection equations and applying joint and shear equilibrium conditions, the rotation angles (or the slope angles) are calculated. Substituting them back into the slope deflection equations, member end moments are readily determined.

Displacement Is Used for Those Cases Which Are Given Below:

1. General Case
2. Stiffness Coefficients
3. Stiffness Coefficients Derivation
4. Fixed-End Moments
5. Pin-Supported End Span
6. Typical Problems
7. Analysis of Beams
8. Analysis of Frames: No Sideway
9. Analysis of Frames: Sideway
10. A solution of simultaneous equations makes methods tedious for manual computations.
11. This method is not recommended for frames larger than two bays and two stories.

2.3.3 Moment Distribution Method

The moment distribution method is a structural analysis method for statically indeterminate beams and frames developed by Hardy Cross. It was published in 1930 in an ASCE journal. The method only accounts for flexural effects and ignores axial and shear effects. From the 1930s until computers began to be widely used in the design and analysis of structures, the moment distribution method was the most widely practiced method.

In the moment distribution method, every joint of the structure to be analyzed is fixed to develop the fixed-end moments. Then each fixed joint is sequentially released, and the fixed-end moments are distributed to adjacent members until equilibrium is achieved. The moment distribution method in mathematical tens can be demonstrated as the process of solving a set of simultaneous equations by means of iteration.

2.3.4 Cantilever Method

The Cantilever Method was devised to calculate and analyze shear forces and moments developed indifferent members, as beams and columns, of a frame or structure due to lateral loads. The lateral loads include wind load and earthquake load which must be taken into consideration while designing the buildings.

The assumptions which are assumed in this method are that the point of contra flexure is located at the mid-point of the vertical members as well as horizontal members and that the direct stresses in the columns are proportional to their distances from the centroid axis. The frame is analyzed in stepwise fashion, and the details can then be described by the diagram at the end. The method is quite versatile and can be used to analyze frame of any number of stories or floors.

The position of the centriole axis is determined by using the areas of the end columns and intermediate columns. The method is considered as one of the two approximate methods for indeterminate structural analysis of frames for lateral loads.

2.3.5 Portal Method

A portal frame is often used in a structure to transfer the laterally directed loads applied along the sides, to the supports at the base of the frame. Portal frames are often designed such that they can confidently withstand lateral loads. This results in many portal frames being statically indeterminate externally; because of the frames ability to support horizontal loading, this type of frame is commonly used in structures like buildings, factories, and bridges.

The approximate analysis of portal frames can be investigated through the portal method. Before the analysis, there are necessary assumptions to be made:

1. A point of inflection is located at the center of each member of the Portal frame.
2. For each story of the frame, the interior columns bear twice as much shear as the exterior columns.
3. Lateral forces resisted by frame action.
4. Inflection points at mid-height of columns.
5. Inflection points at mid-span of beams.
6. Column shear is based on tributary area.
7. Overturn is resisted by exterior columns only.

2.3.6 Matrix Method

As one of the methods of structural analysis, the direct stiffness method, also known as the matrix stiffness method, is particularly suited for computers-automated analysis of complex structures including the statically indeterminate type. It is a matrix method that makes use of the member's stiffness relations for computing member forces and displacements in structures. The direct stiffness method is the most common implementation of the finite element method (FEM). In applying the method, the system must be modeled as a set of simpler, idealized elements interconnected at the nodes. The material stiffness properties of these elements are then, through matrix mathematics, compiled into a single matrix equation which governs the behavior of the entire idealized structure. The structure's unknown displacements and forces can then be determined by solving this equation. The direct stiffness method forms the basis for most residential and free source finite element software.

2.4 Software used

2.4.1 ETABS 19.0.1

ETABS is powerful design software licensed by CSI. ETABS stands for Extended Three-Dimensional Analyses of Building Systems. Any object which is stable under a given loading can be considered as structure. The innovative and revolutionary new ETABS is the ultimate integrated software package for the structural analysis and design of buildings. Incorporating 40 years of continuous research and development, this latest ETABS offers unmatched 3D object-based modeling and visualization tools, blazingly fast linear and nonlinear analytical power, sophisticated and comprehensive design capabilities for a wide-range of materials, and insightful graphic displays, reports, and schematic drawings that allow users to quickly and easily decipher and understand analysis and design results.

Now a day's most of the high-rise buildings are designed by ETABS which makes a compulsion for a civil engineer to know about this software. This software can be used to carry RCC, steel, bridge, truss etc. according to various country codes.

Overall, ETABS 19.0.1 is a powerful tool for structural analysis and design, specifically tailored for the analysis and design of buildings. Its comprehensive features, code compliance, and user-friendly interface make it a popular choice among structural engineers for ensuring the safety, stability, and performance of structures subjected to wind and seismic loads.

2.4.2 AutoCAD 2021

AutoCAD is a commercial software application for 2D and 3D computer-aided design (CAD) and drafting available since 1982 as a desktop application and since 2010 as a mobile web- and cloud based appmarketedasAutoCAD360.

Developed and marketed by Autodesk, Inc., AutoCAD was first released in December 1982, running on microcomputers with internal graphics controllers. Prior to the instruction of AutoCAD, most commercial CAD programs ran on mainframe computers or minicomputers, with each CAD operator (user) working at a separate graphics terminal.

AutoCAD is used across a wide range of industries, by architects, project managers, engineers, designers, and other professionals. We used AutoCAD for drawing the plan, elevation of the building. We also used AutoCAD to show the reinforcement details and design details of staircase, retaining Wall, beam, slab, water tank, foundation etc. AutoCAD is a very easy software to learn and much user friendly for anyone to handle and can be learn quickly. Learning of certain commands is required to draw in AutoCAD.

CHAPTER 3

Methodology

3.1 Introduction

In this chapter methodology of the work has been discussed. This project is mostly based on software,

1. ETABS 2020 (19.0.1)

2. Auto CAD 2016

Required data for analysis and model built-up with ETABS (19.0.1) are discussed details here. Analysis has been done for Zone-1, 2, 3. Design data are picked from BNBC 2020.

3.2 Different Types of Loads in Structure

Structural members must be designed to support specific loads. Loads are those forces for which a given suture should be proportioned. In general, loads may be classified as

1. Dead Loads

2. Imposed loads or live load

3. Wind Loads

4. Earthquake loads

3.2.1 Dead Load

Consist of the permanent construction material loads compressing the roof, floor, wall, and foundation systems, finishes and fixed equipment. Dead load is the total load of all the components of the building that generally do not change over time, such as the concrete columns, concrete floors bricks, roofing material etc. In ETABS, assignment of dead load is automatically done by giving the property of the member. In load case we have option called self-weight which automatically calculates weights using the properties of material i.e.. Density. In this study, dead loads on the slab consist of self-weight of slab, floor finish and partition wall. Total vertical load applied on the slab is 25 psf as floor finish and 30psf as Random wall in addition to self-weight of slab.

3.2.2 Live Load

Live loads are produced by the use and occupancy of a building. Loads include those from human occupants, furnishings, no fixed equipment, storage, and construction and maintenance activities. As required to adequately define the loading condition, loads are

presented in terms of uniform area loads, concentrated loads, and uniform line loads. In ETABS we assign live load in terms of U.D.L. we has to create a load case for live load and select all the slabs to carry such load.

3.2.3 Wind Load: (Institute, 2020)

Building and other structure, including the main Wind-force Resisting System (MWFRS) and all components and cladding therefore, shall be designed and constructed to resist wind load as specified herein.

Allowed procedures: The design wind load for buildings and other structures, including the MWFRS and component and cladding elements therefore, shall be determined using one of the following procedure:

Method 1: simplified procedure specified for building and structure meeting the requirements specified therein;

Method 2: Analytical procedure specified for building and structure meeting the requirements specified therein;

Method 3: Wind tunnel procedure.

3.2.4 Earthquake Load (BNBC-2020)

Earthquake loading as per BNBC-2020 has been calculated by the program and it has been applied to the mass center of the building. This Equivalent Static Analysis of seismic vibration is based on the concept of replacing the inertia forces at various 'lumped masses' (i.e., story levels) by equivalent horizontal forces that are proportional the weight of the body (therefore its mass) and its displacement (therefore its acceleration). The summation of these concentrated forces is balanced by a base shear at the base of the structure.

Design Base Shear:

The total design base shear in a given direction is determined from the following relation: V=S. W

Where,

S. Lateral seismic force coefficient calculated

W Total seismic weight of building defined.

Alternatively, for building with natural period less than or equal to 2.0 sec, the seismic design base share can be calculated using ASCE 7-02 with seismic design parameters as given in Appendix C. However, the minimum value of SA should not be less than 0.044 SDSI. The values of SDS are provided in Appendix C

In this chapter result output of the model bus been shown and discussed, from the result comparison it is seen that comparisons of low rise & high rise building according to BNBC 2020 using by ETABS have huge difference in designing methods and formulas.

3.3 Drift and Building Separation (BNBC-2020)

Drift the Limitation: Story drift is the displacement of one level relative to the level above or below due to the design lateral forces. Except otherwise permitted in story drift shall Include both translation and tensional deflections and confirm the following requirements:

a) Story drift, A shall be limited as follows:

As 0.005h for T <0.7 sec

As 0.004h for T>0.7 sec

A≤0.0025h for unreinforced masonry structures

Where h= height of the building or Structure. The period T used in calculation shall be the same as that used for determining the base shear.

Table 3.1: Importance factors for Buildings and Structures for Earthquake Design

Occupancy Category	Importance factor , I
I, II	1.00
III	1.25
IV	1.50

Table 3.2: Parameters Ss and S1 for Different Seismic Zones as per BNBC-2020

Parameters	Zone 1	Zone 2	Zone 3	Zone 4
Ss	**0.3**	**0.5**	**0.7**	**0.9**
S1	**0.12**	**0.2**	**0.28**	**0.36**

Table 3.3: Seismic Design Category of Buildings

	Occupancy Category I, II, III				Occupancy Category IV			
Site Class	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**
SA	B	C	C	D	C	D	D	D
SB	B	C	D	D	C	D	D	D
SC	B	C	D	D	C	D	D	D
SD	C	D	D	D	D	D	D	D
SE, S1,	D	D	D	D	D	D	D	D

As per BNBC 2020, Chapter 2- Part 6 (Clause 11027.5), following load cases must be considered for analysis:

U= 1.4 DL

U= 1.4 DL+1.7 LL

U= 1.05 D.L. +1.275 L.L+ 1.4025 E.L

U= 1.05 D.L+1.4025 EL

U= 0.9 D.L+1.43 EL

U= 1.05 D.L + 1.275 L.L+ 1.275 WL

U= 1.05 D.L+ 1.275 W.L

U= 0.9 D.LE 1.3 W.L

Earthquake load and Wind Load must be considered for +X, -X, Y and-y directions. Thus, +EL and +WL above implies 24 cases, and in all, 26 cases as per Table 3.6 must be considered. All 26load combinations are analyzed using software.

It is important to consult the specific provisions of the BNBC 2020 and any local design codes applicable to your region for the most accurate and up-to-date load combinations.

3.5 Design data

Load Consideration: BNBC 2020 for Zone 1, 2, 3, 4.

3.5.1. Super imposed Dead Load

- Floor Finish (FF) : 25 psf
- Random Wall (RW): 30psf
- Parapet wall: 150ps f(3ft)
- Partition wall (PW): 450 lb/ft (9.5ft)

3.5.2. Live Load

- Floor: 2KN/m2 or 41.76 psí
- Stair: 4.8KN/m2 or 100 psf
- Roof Life: 4.8KN/m2 or 100 psf
- Head Water Tan: 312 psf (6ft)

3.5.3 Wind Pressure (BNBC 2020)

- Location: Khulna, Dhaka, Gazipur,
- Basic Wind speed V: 147 mph
- Structural Important Coefficient: 1.0
- Expose Category: B
- Gust Factor: 0.85
- Directionally Factor, KD: 0.85

CHAPTER 4
RESULT AND DISCUSSION

4.1 INTRODUCTION

The Bangladesh National Building Code (BNBC) 2020 provides essential guidelines for the design and construction of buildings, addressing safety, sustainability, and aesthetics. Here's an overview of the analysis of low-rise and high-rise buildings according to BNBC 2020

4.2 DATA RESULT FOR ZONE 1, 2, 3 AND 4

This part discussed and showed the every single data for Displacement, Drift, Stiffness and Base shear according to Zone 1, 2, 3 and 4. High rise building **(HRB)** and low raise building **(LRB)** had been discussed and analyzed through ETABES 2016 with the code following through BNBC 2020.

4.3: ANALYSED DATA FOR ZONE 1:

Data Table 4.1: Maximum Displacement for HRB in X-direction.

Story	Load Case/Combo	Direction	Maximum in	Average in	Ratio
9	EQX 1	X	1.121306	0.90008	1.246
8	EQX 1	X	1.074008	0.848996	1.265
7	EQX 1	X	1.001769	0.778852	1.286
6	EQX 1	X	0.907251	0.694008	1.307
5	EQX 1	X	0.794589	0.597254	1.33
4	EQX 1	X	0.667852	0.491705	1.358
3	EQX 1	X	0.530505	0.380636	1.394
2F	EQX 1	X	0.385006	0.267242	1.441
1F	EQX 1	X	0.230875	0.154364	1.496

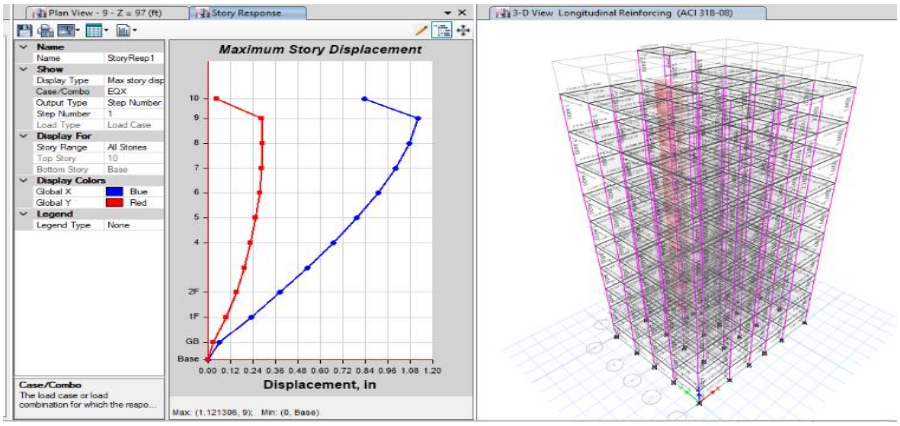


Fig 4.1: Max. Displacement for HRB.

Data Table 4.2: Maximum Displacement for LRB (Low Rise Building)

Story	Load Case/Combo	Direction	Maximum	Average	Ratio
			in	in	
5	Dead	Y	0.032304	0.028288	1.142
4	Dead	X	0.004948	0.002129	2.324
4	Dead	Y	0.024172	0.020619	1.172
3	Dead	X	0.004348	0.001814	2.397
3	Dead	Y	0.016898	0.013704	1.233

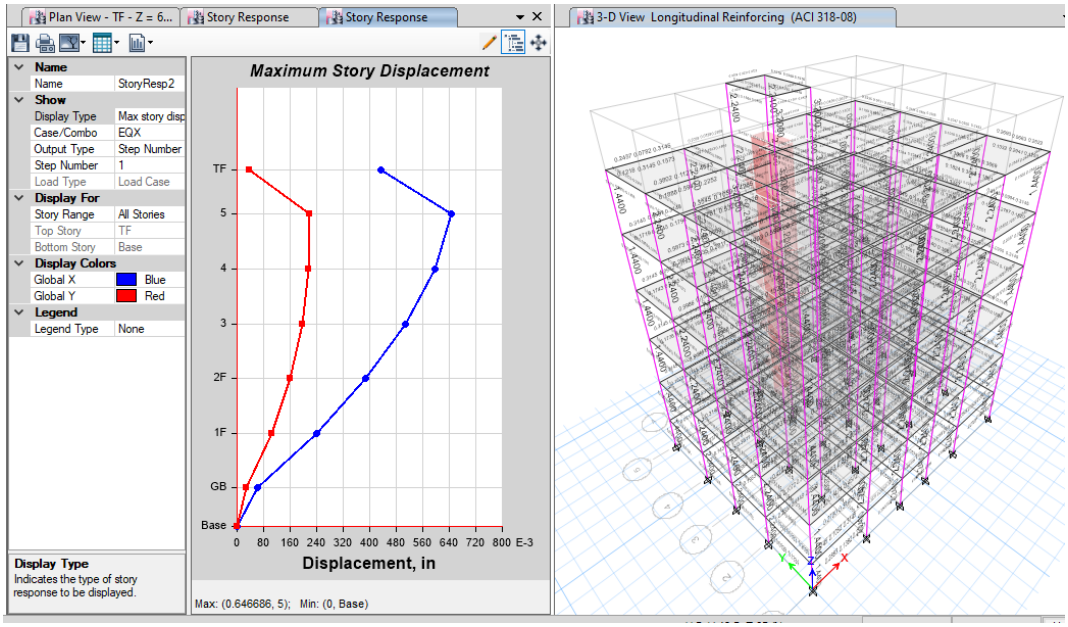


Fig 4.2: Max. Displacement for LRB

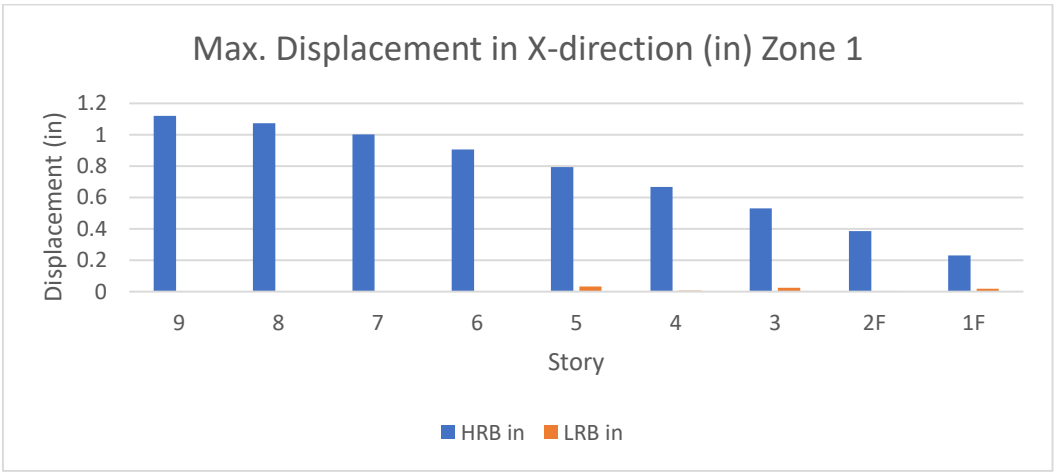


Fig 4.3: Max. Displacement in X-direction for Zone 1

Data Table 4.3: Maximum Drift for HRB in X-direction

Story	Load Case/Combo	Direction	Drift	Label	X	Y	Z
					ft	ft	ft
10	EQX 1	X	0.000396	15	21.25	40	105
9	EQX 1	X	0.000517	46	23.3333	37.9167	97
8	EQX 1	X	0.000602	21	37.5833	0	87
7	EQX 1	X	0.000788	21	37.5833	0	77
6	EQX 1	X	0.000939	21	37.5833	0	67
5	EQX 1	X	0.001056	21	37.5833	0	57
4	EQX 1	X	0.001145	21	37.5833	0	47
3	EQX 1	X	0.001212	21	37.5833	0	37
2F	EQX 1	X	0.001284	21	37.5833	0	27
1F	EQX 1	X	0.001425	21	37.5833	0	17
GB	EQX 1	X	0.000712	1	0	0	7

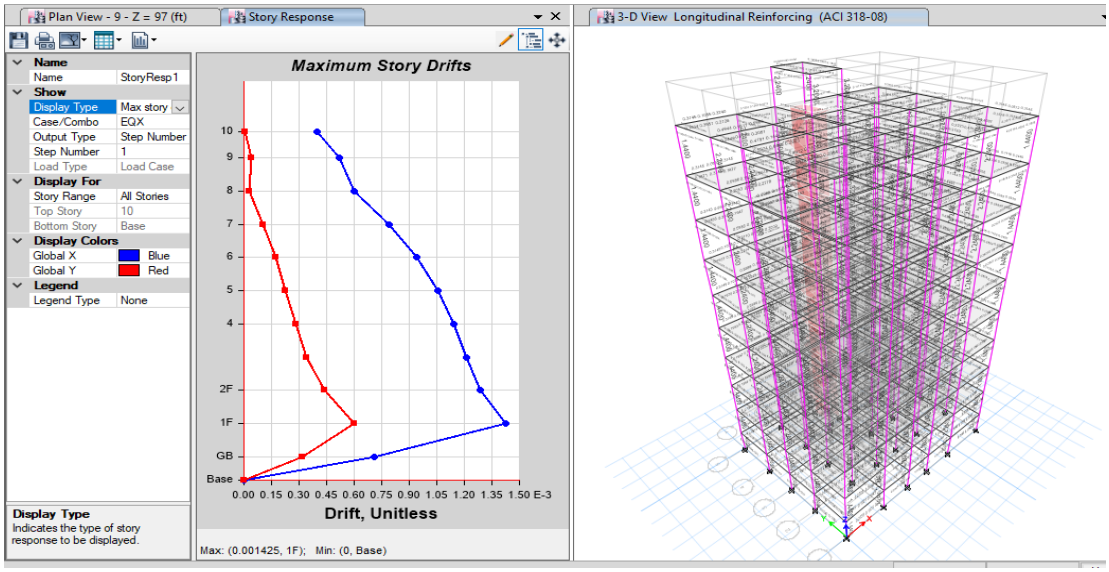


Fig 4.4: Max. Drifts for HRB

Data Table 4.4: Max. Drifts for LRB in X-direction

Story	Load Case/Combo	Direction	Drift	Label	X	Y	Z
					ft	ft	ft
TF	EQX 1	X	0.000354	20	28.75	40	65
5	EQX 1	X	0.000455	46	23.3333	37.9167	57
4	EQX 1	X	0.000733	21	37.5833	0	47
3	EQX 1	X	0.001006	21	37.5833	0	37
2F	EQX 1	X	0.001233	21	37.5833	0	27
1F	EQX 1	X	0.001469	21	37.5833	0	17
GB	EQX 1	X	0.000746	1	0	0	7

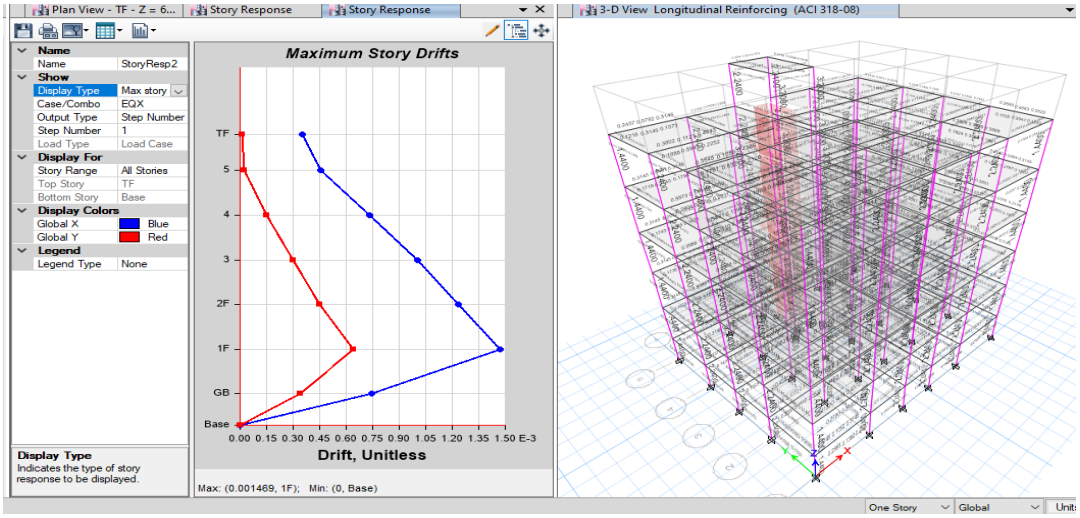


Fig 4.5: Max. Drifts for LRB

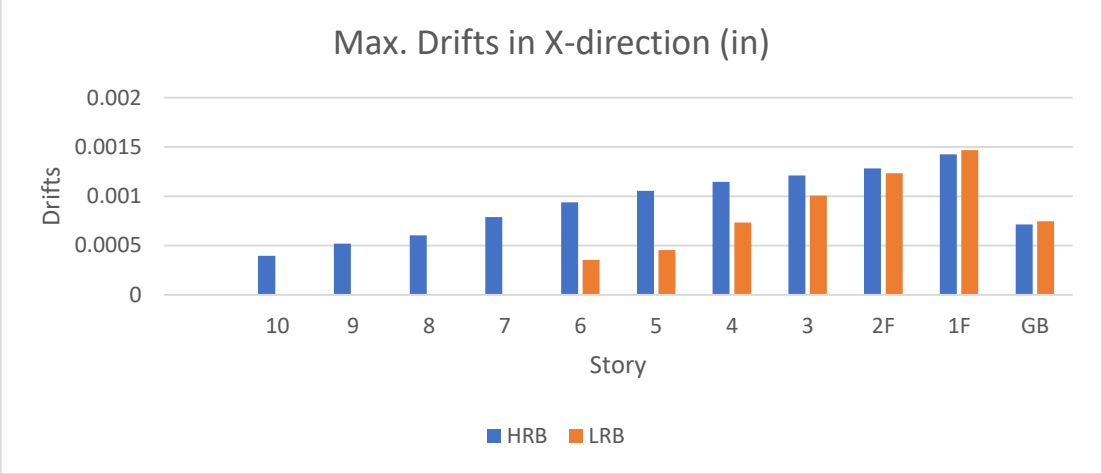


Fig 4.6: Max. Drifts in X-direction for Zone 1

Data Table 4.5: Max. Stiffness for HRB in X-direction

Story	Load Case	Shear X	Drift X	Stiffness X	Shear Y	Drift Y	Stiffness Y
		kip	in	kip/in	kip	in	kip/in
10	EQX 2	1.407	0.040124	35.0777	0	0.000634	0
9	EQX 2	40.519	0.05737	706.2738	0	0.006265	0
8	EQX 2	66.068	0.072167	915.4938	0	0.003976	0
7	EQX 2	87.34	0.085777	1018.214	0	0.00063	0
6	EQX 2	104.604	0.094819	1103.203	0	0.003515	0
5	EQX 2	118.15	0.103078	1146.221	0	0.006158	0
4	EQX 2	128.292	0.107037	1198.584	0	0.009183	0
3	EQX 2	135.375	0.107002	1265.163	0	0.013058	0
2F	EQX 2	139.79	0.10434	1339.756	0	0.019764	0
1F	EQX 2	142.001	0.108462	1309.216	0	0.030693	0
GB	EQX 2	142.138	0.037525	3787.84	0	0.011151	0

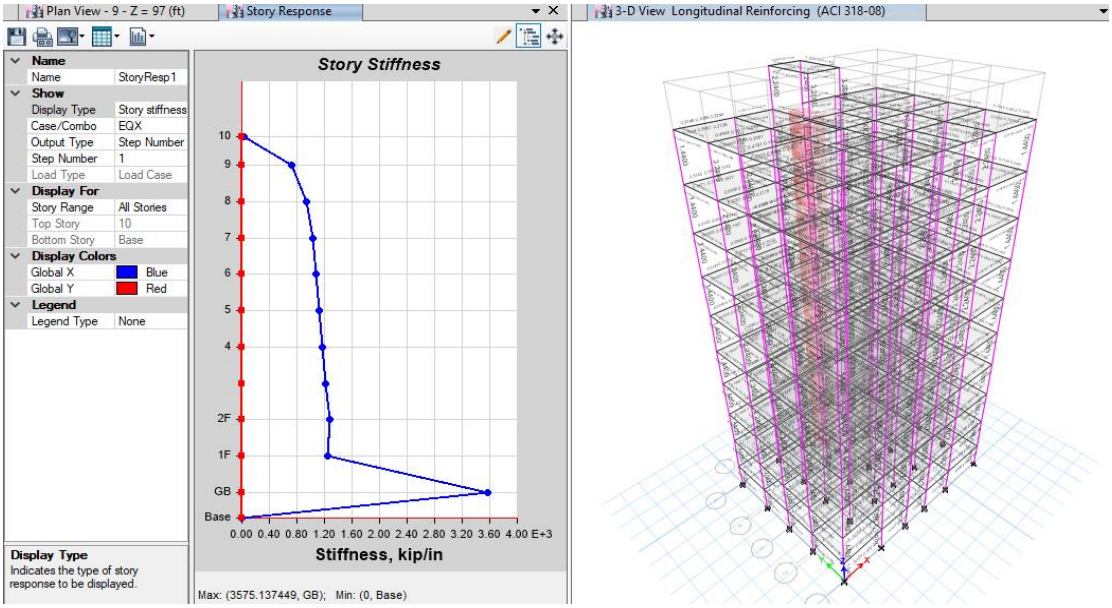


Fig 4.7: Max. Stiffness for HRB

Data table 4.6: Stiffness for LRB in X-direction

Story	Load Case	Shear X	Drift X	Stiffness X	Shear Y	Drift Y	Stiffness Y
		kip	in	kip/in	kip	in	kip/in
TF	EQX 2	2.375	0.034555	68.7256	0	0.001321	0
5	EQX 2	47.441	0.054653	868.0373	0	0.002323	0
4	EQX 2	87.066	0.072315	1203.975	0	0.003892	0
3	EQX 2	117.303	0.089869	1305.266	0	0.011568	0
2F	EQX 2	138.483	0.099191	1396.118	0	0.021023	0
1F	EQX 2	151.069	0.109427	1380.546	0	0.033156	0
GB	EQX 2	152.153	0.038906	3910.746	0	0.012129	0

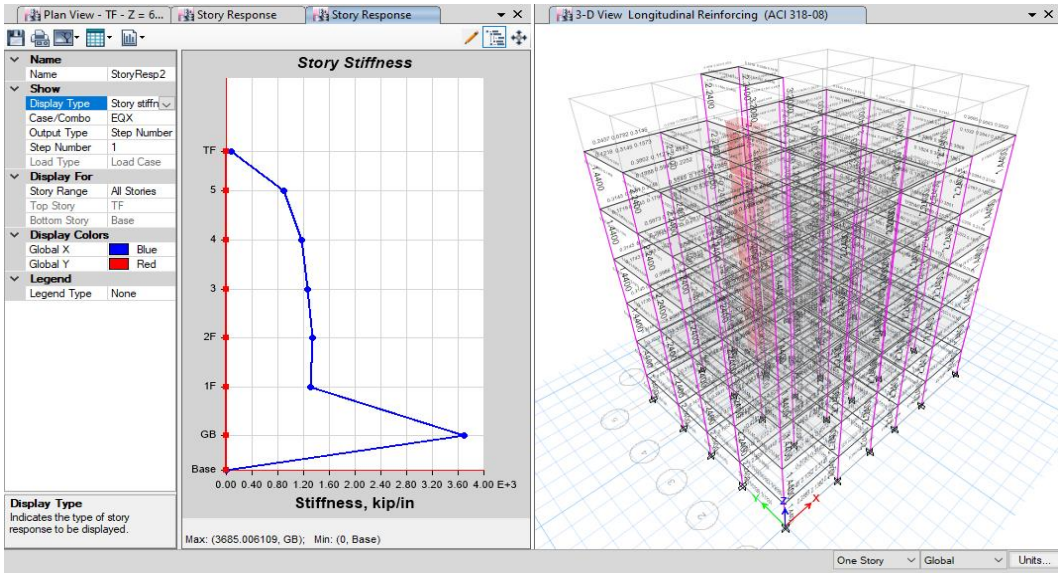


Fig 4.8: Max. stiffness for LRB

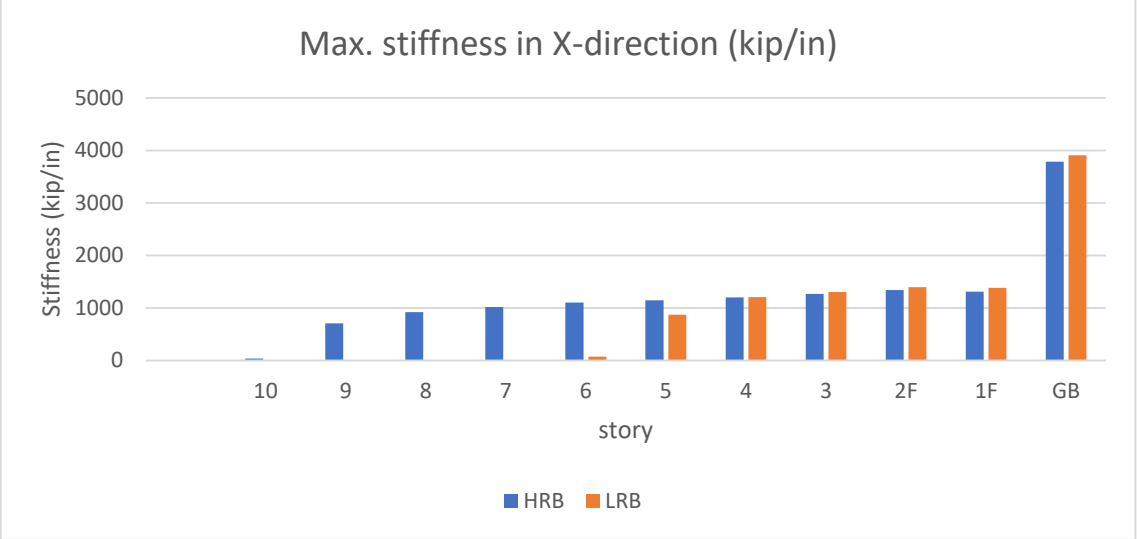


Fig 4.9: Stiffness for both HRB & LRB for Zone 1

4.7: Base Shear for HRB Zone 1

Load Case/Combo	FX	FY	FZ	MX	MY	MZ	X	Y	Z
	kip	kip	kip	kip-ft	kip-ft	kip-ft	ft	ft	ft
p(D+L)	0	0	8305.584	175476.2	-209113	0	0	0	0

4.8: Base Shear for LRB Zone 1

Load Case/Combo	FX	FY	FZ	MX	MY	MZ	X	Y
	kip	kip	kip	kip-ft	kip-ft	kip-ft	ft	ft
p(D+L)	0	0	4711.461	100081.9	-118616	0	0	0

4.4 Analyzed data for Zone 2:

Data table 4.9: Max. Displacement for HRB in X-direction

Story	Load Case/Combo	Direction	Maximum	Average	Ratio
			in	in	
9	EQX 1	X	2.684601	2.15098	1.248
8	EQX 1	X	2.575974	2.032629	1.267
7	EQX 1	X	2.409209	1.869597	1.289
6	EQX 1	X	2.189105	1.671212	1.31
5	EQX 1	X	1.924191	1.443251	1.333
4	EQX 1	X	1.623209	1.192498	1.361
3	EQX 1	X	1.293844	0.926397	1.397
2F	EQX 1	X	0.941764	0.652506	1.443
1F	EQX 1	X	0.565934	0.377861	1.498

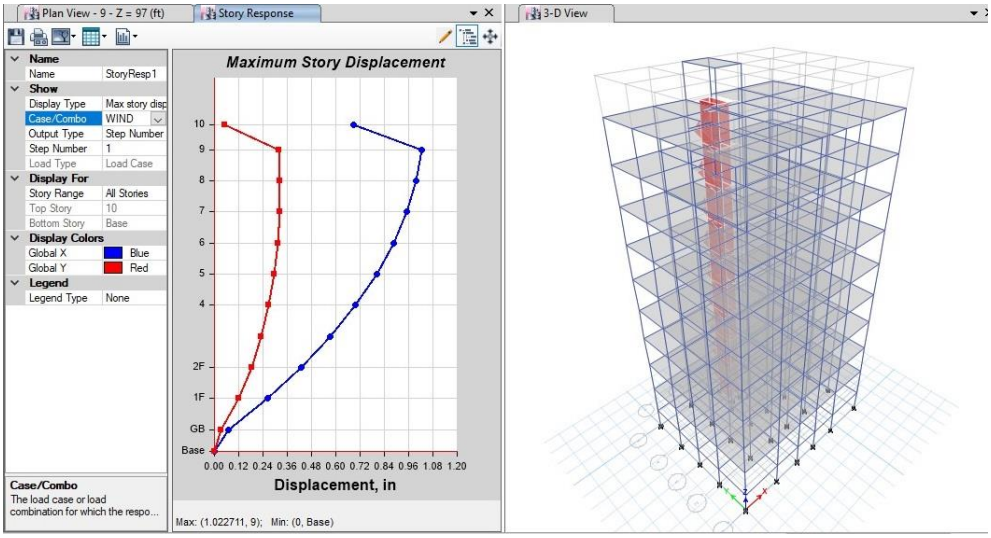


Fig 4.10: Max. Displacement for HRB

Data table 4.10: Max. Displacement for LRB in X-direction

Story	Diaphragm	Load Case/Combo	UX	UY	RZ	Point	X	Y	Z
			in	in	rad		ft	ft	ft
5F	D1	EQX	0.610914	0.007238	0.00088	41	25.2004	19.5912	57
4F	D1	EQX	0.54774	0.007062	0.000867	43	25.195	19.5753	47
3F	D1	EQX	0.452196	0.006017	0.000792	45	25.195	19.5753	37
2F	D1	EQX	0.33302	0.004886	0.000645	47	25.195	19.5753	27
1F	D1	EQX	0.198413	0.003709	0.000424	49	25.2097	19.6336	17

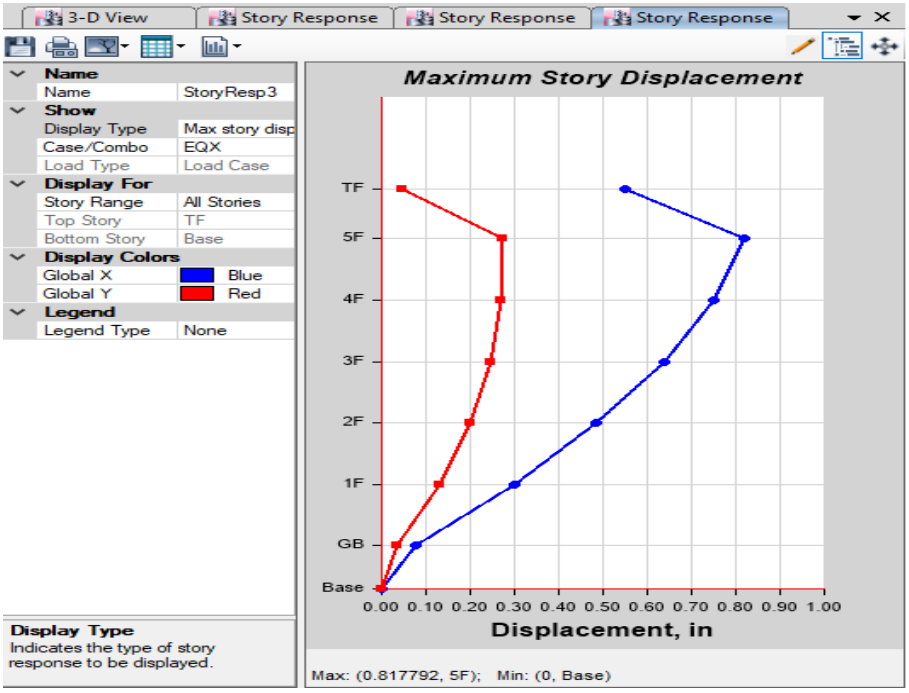


Fig 4.11: Max. Displacement for LRB

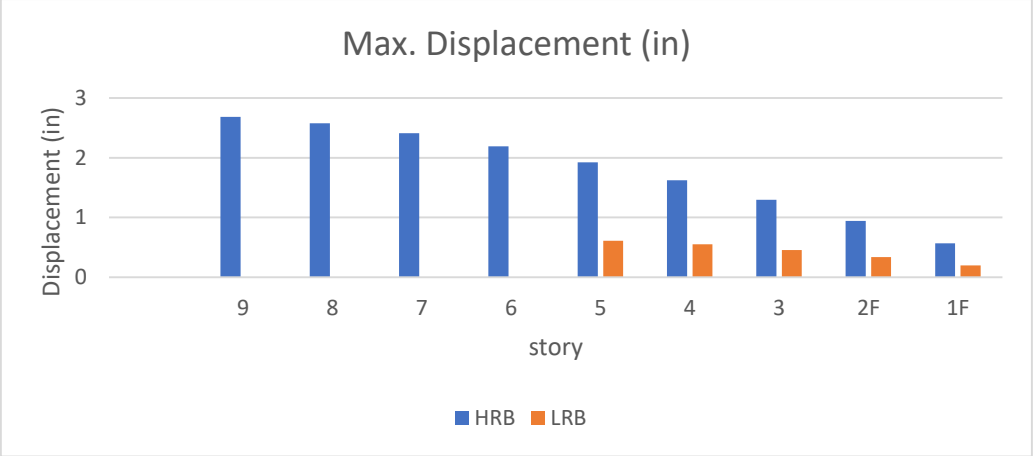


Fig 4.12: Max. Displacement for HRB & LRB in Zone 2

Data table 4.11: Max. Drift for HRB in X- direction

Story	Load Case/Combo	Direction	Drift	Label	X	Y	Z
					ft	ft	ft
10	EQX 1	X	0.000918	15	21.25	40	105
9	EQX 1	X	0.001207	46	23.3333	37.9167	97
8	EQX 1	X	0.000139	21	37.5833	0	87
7	EQX 1	X	0.001834	21	37.5833	0	77
6	EQX 1	X	0.002208	21	37.5833	0	67
5	EQX 1	X	0.002508	21	37.5833	0	57
4	EQX 1	X	0.002745	21	37.5833	0	47
3	EQX 1	X	0.002934	21	37.5833	0	37
2F	EQX 1	X	0.003132	21	37.5833	0	27
1F	EQX 1	X	0.003493	21	37.5833	0	17
GB	EQX 1	X	0.001748	1	0	0	7

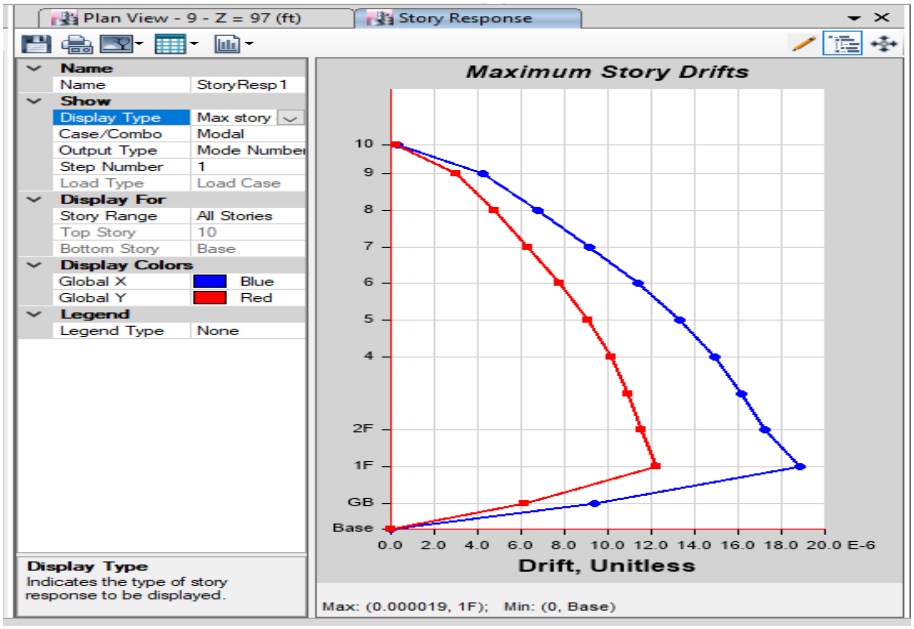


Fig 4.13: Max. Story Drifts for HRB

Data Table 4.12: Max. Drift for LRB in X-direction

Story	Load Case/Combo	Direction	Drift	Label	X	Y	Z
					ft	ft	Ft
TF	EQX	X	0.000461	20	28.75	40	65
5F	EQX	X	0.000584	46	23.3333	37.9167	57
4F	EQX	X	0.000943	21	37.5833	0	47
3F	EQX	X	0.001281	21	37.5833	0	37
2F	EQX	X	0.001552	21	37.5833	0	27
1F	EQX	X	0.001835	21	37.5833	0	17
GB	EQX	X	0.00093	1	0	0	7

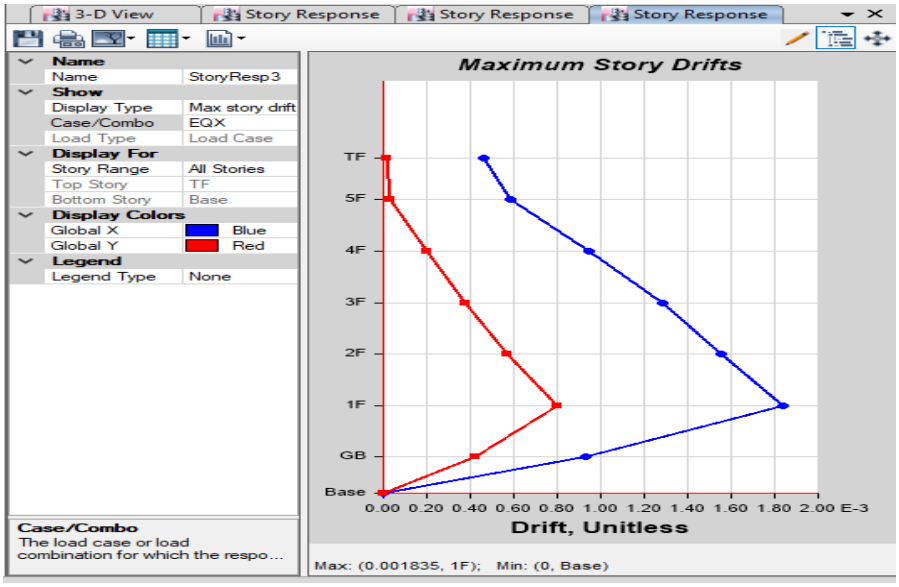


Fig 4.14: Max. Story Drifts for LRB

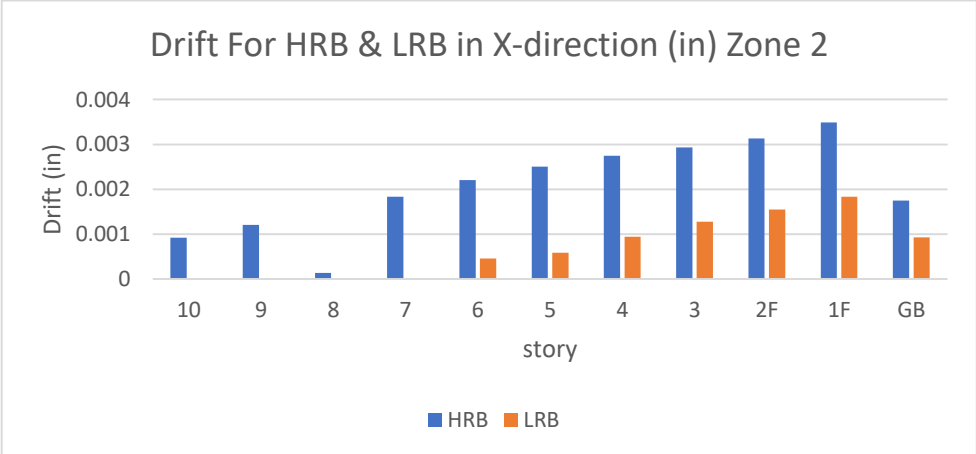


Fig 4.15: Drifts of HRB & LRB for Zone 2

Data table 4.13: Max. Stiffness for HRB in X-direction

Story	Load Case	Shear X	Drift X	Stiffness X	Shear Y	Drift Y	Stiffness Y
		kip	in	kip/in	kip	in	kip/in
10	EQX 1	1.857	0.049278	36.6862	0	0.00053	0
9	EQX 1	53.463	0.074593	702.7236	0	0.003309	0
8	EQX 1	87.173	0.093345	916.8761	0	0.002108	0
7	EQX 1	115.24	0.111946	1023.424	0	0.0085	0
6	EQX 1	138.019	0.127662	1077.129	0	0.014054	0
5	EQX 1	155.893	0.139266	1118.393	0	0.018756	0
4	EQX 1	169.274	0.145291	1164.073	0	0.023288	0
3	EQX 1	178.62	0.14623	1222.501	0	0.028512	0
2F	EQX 1	184.445	0.144149	1281.545	0	0.037029	0
1F	EQX 1	187.362	0.150599	1248.107	0	0.050759	0
GB	EQX 1	187.543	0.052457	3582.137	0	0.018334	0

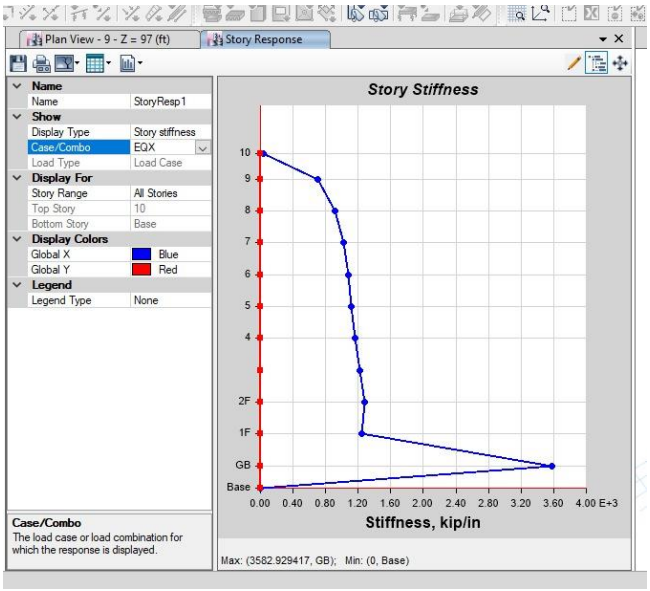


Fig 4.16: Max. Stiffness for HRB

Data table 4.14: Max. Stiffness in LRB in X- direction

Story	Load Case	Shear X	Drift X	Stiffness X	Shear Y	Drift Y	Stiffness Y
		kip	in	kip/in	kip	in	kip/in
TF	EQX	3.165	0.042136	75.1151	0	0.001378	0
5F	EQX	62.097	0.067755	916.4892	0	0.002247	0
4F	EQX	112.484	0.095161	1182.036	0	0.011941	0
3F	EQX	149.625	0.118233	1265.511	0	0.023697	0
2F	EQX	174.478	0.130954	1332.36	0	0.036071	0
1F	EQX	188.29	0.144454	1303.466	0	0.051069	0
GB	EQX	189.336	0.0515	3676.429	0	0.018585	0

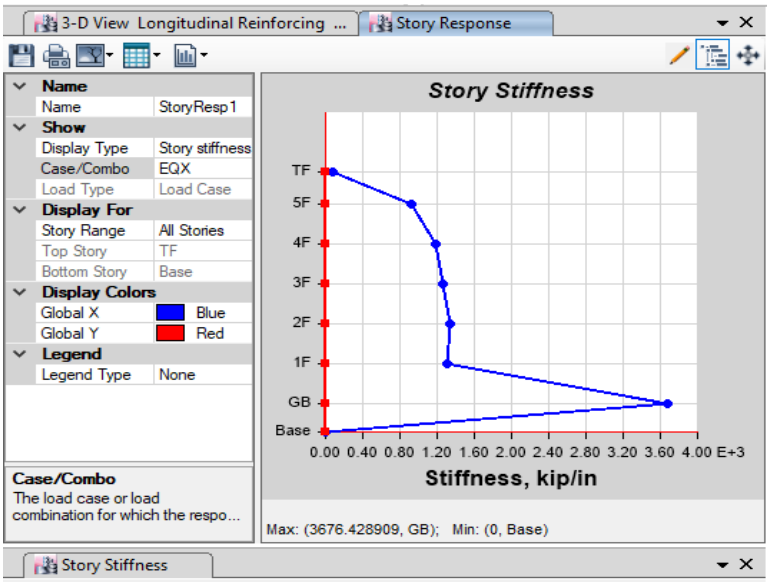


Fig 4.17: Max. Story Stiffness for LRB

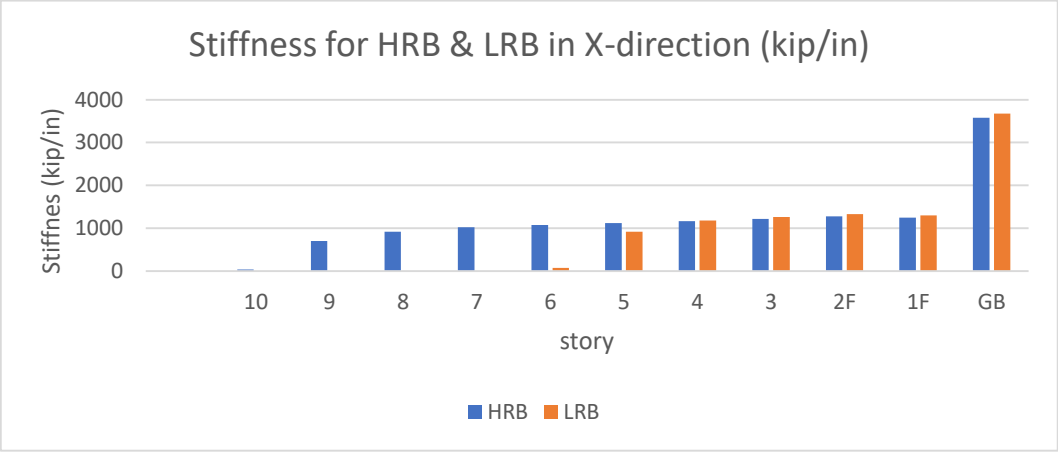


Fig 4.18: Stiffness of both HRB & LRB for Zone 2

Data table 4.15: Base reaction for HRB

Load Case/Combo	FX	FY	FZ	MX	MY	MZ	X	Y	Z
	kip	kip	kip	kip-ft	kip-ft	kip-ft	ft	ft	ft
p(D+L)	0	0	8305.584	175427.2328	-209112.5256	0	0	0	0

Data table 4.16: Base reaction for LRB

Load Case/Combo	FX	FY	FZ	MX	MY	MZ	X	Y	Z
	kip	kip	kip	kip-ft	kip-ft	kip-ft	ft	ft	ft
p(D+L)	0	0	4711.461	100081.9	-118616	0	0	0	0

4.5: ANALYZED DATA FOR ZONE 3

Data table 4.17: Displacement for HRB in X-direction

Story	Diaphragm	Load Case/Combo	UX	UY	RZ	Point	X	Y	Z
			in	in	rad		ft	ft	ft
9	D1	EQX 1	1.194347	0.00488	0.001216	504	24.9257	19.5381	97
8	D1	EQX 1	1.126508	0.009064	0.001237	506	25.195	19.5752	87
7	D1	EQX 1	1.033898	0.008427	0.001226	508	25.195	19.5753	77
6	D1	EQX 1	0.92168	0.00775	0.001172	510	25.195	19.5753	67
5	D1	EQX 1	0.793572	0.007056	0.001085	512	25.195	19.5753	57
4	D1	EQX 1	0.653713	0.006315	0.000968	514	25.195	19.5753	47
3	D1	EQX 1	0.506428	0.005513	0.000824	516	25.195	19.5753	37
2F	D1	EQX 1	0.355911	0.004607	0.000647	518	25.195	19.5753	27
1F	D1	EQX 1	0.205524	0.003607	0.000421	520	25.2097	19.6336	17

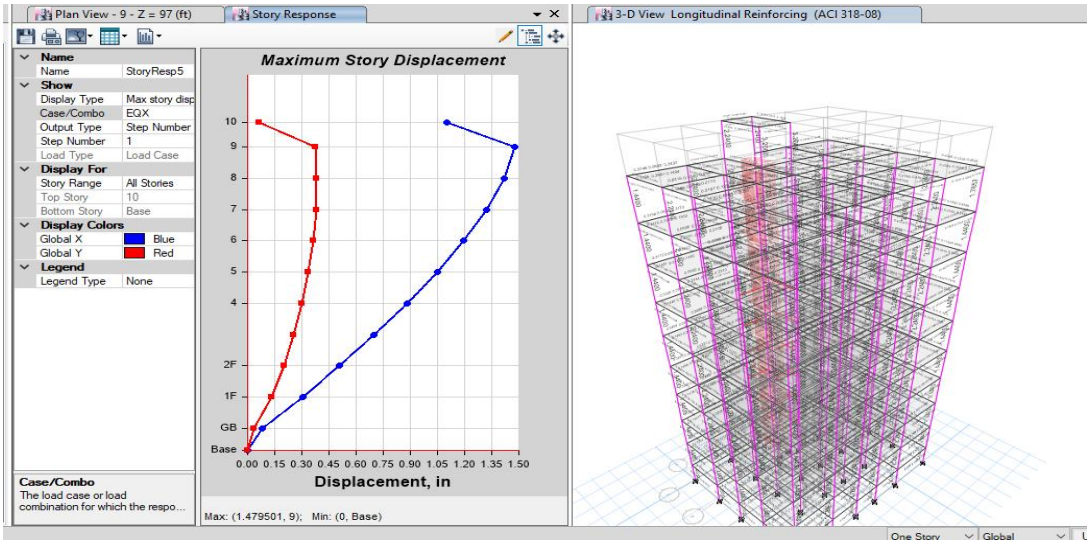


Fig 4.19: Max. Displacement for HRB

Data table 4.18: Max. Displacement for LRB in X-direction

Story	Diaphragm	Load Case/Combo	UX	UY	RZ	Point	X	Y	Z
			in	in	rad		ft	ft	ft
5	D1	EQX	0.610914	0.007238	0.00088	41	25.2004	19.5912	57
4	D1	EQX	0.54774	0.007062	0.000867	43	25.195	19.5753	47
3	D1	EQX	0.452196	0.006017	0.000792	45	25.195	19.5753	37
2F	D1	EQX	0.33302	0.004886	0.000645	47	25.195	19.5753	27
1F	D1	EQX	0.198413	0.003709	0.000424	49	25.2097	19.6336	17

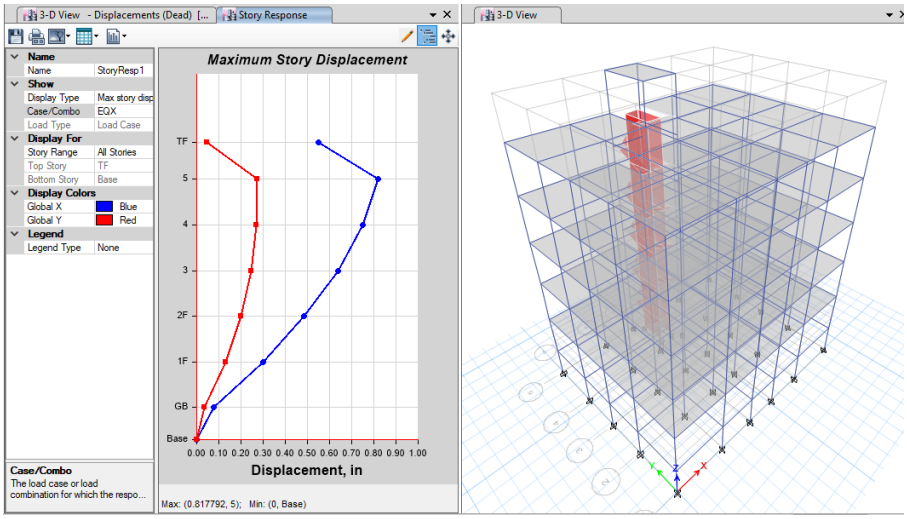


Fig 4.20: Max. Displacement for LRB

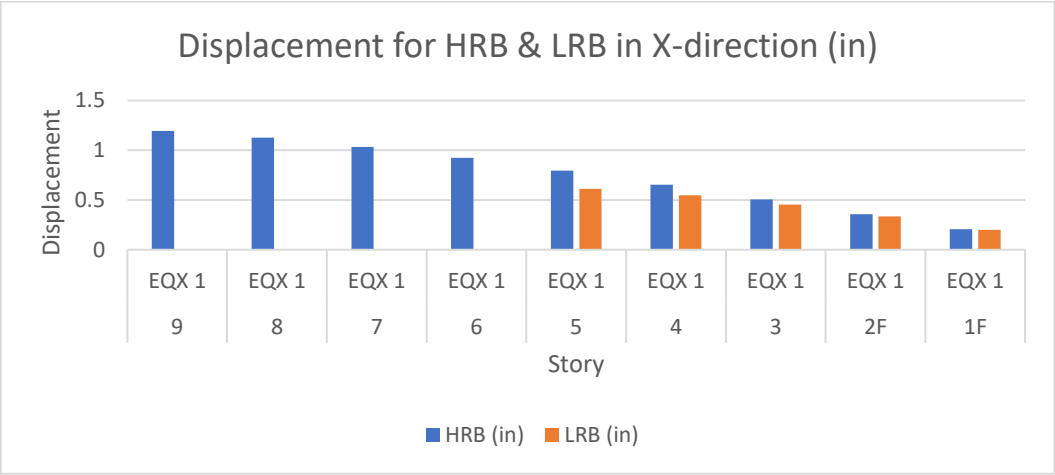


Fig 4.21: Max. Displacement of both HRB & LRB for Zone 3

Data Table 4.19: Max. Drift for HRB in X- direction

Story	Load Case/Combo	Direction	Drift	Label	X	Y	Z
					ft	ft	ft
10	EQX 1	X	0.000522	15	21.25	40	105
9	EQX 1	X	0.000682	46	23.3333	37.9167	97
8	EQX 1	X	0.000794	21	37.5833	0	87
7	EQX 1	X	0.001039	21	37.5833	0	77
6	EQX 1	X	0.001239	21	37.5833	0	67
5	EQX 1	X	0.001394	21	37.5833	0	57
4	EQX 1	X	0.00151	21	37.5833	0	47
3	EQX 1	X	0.0016	21	37.5833	0	37
2F	EQX 1	X	0.001695	21	37.5833	0	27
1F	EQX 1	X	0.001881	21	37.5833	0	17
GB	EQX 1	X	0.00094	1	0	0	7

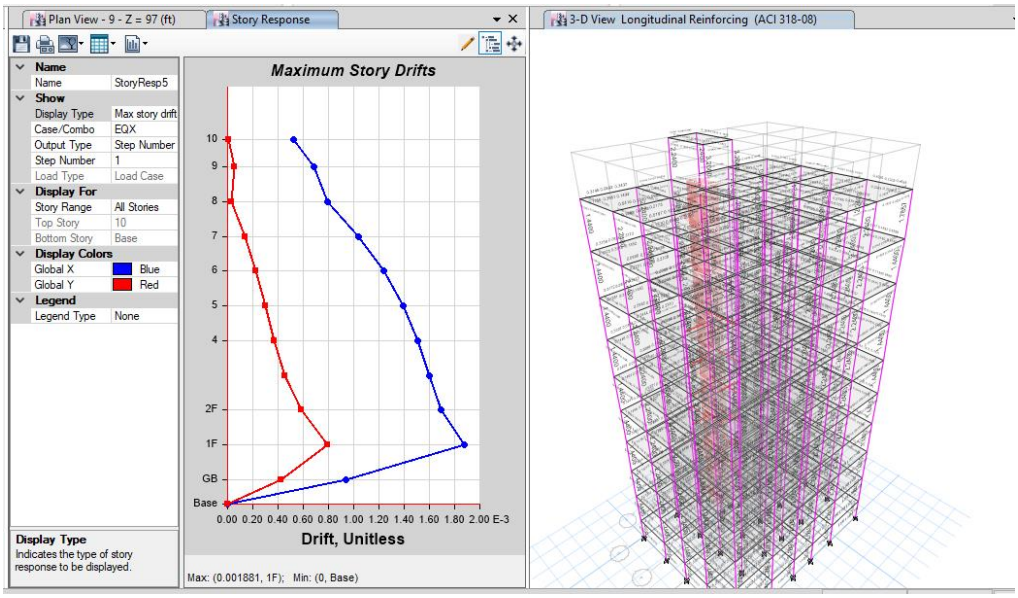


Fig 4.22: Max. Drifts for HRB

Data table 4.20: Max. Drift for LRB in X-direction

Story	Load Case/Combo	Direction	Drift	Label	X	Y	Z
					ft	ft	ft
TF	EQX	X	0.000461	20	28.75	40	65
5	EQX	X	0.000584	46	23.3333	37.9167	57
4	EQX	X	0.000943	21	37.5833	0	47
3	EQX	X	0.001281	21	37.5833	0	37
2F	EQX	X	0.001552	21	37.5833	0	27
1F	EQX	X	0.001835	21	37.5833	0	17
GB	EQX	X	0.00093	1	0	0	7

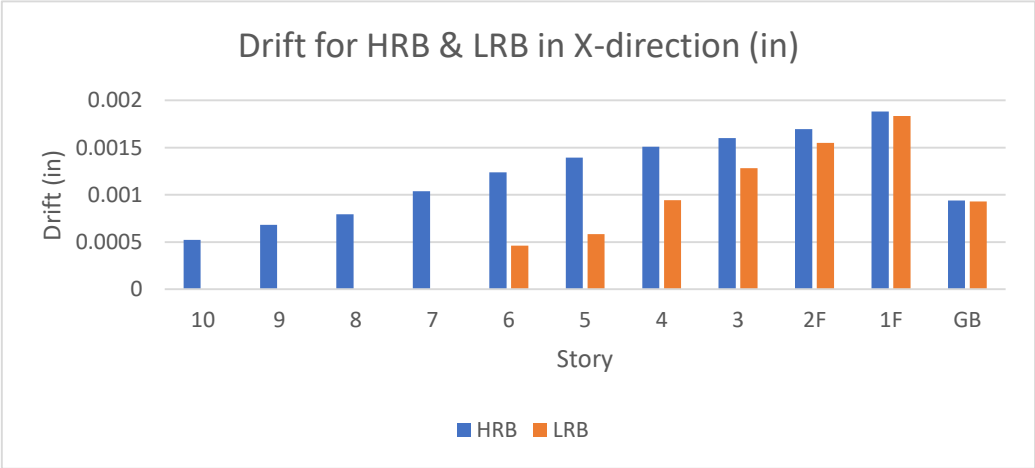


Fig 4.23: Drifts of both HRB & LRB for Zone 3

Data table 4.21: Max. Stiffness for HRB in X-direction

Story	Load Case	Shear X	Drift X	Stiffness X	Shear Y	Drift Y	Stiffness Y
		kip	in	kip/in	kip	in	kip/in
10	EQX 1	1.857	0.049278	37.6862	0	0.00053	0
9	EQX 1	53.463	0.074593	716.7236	0	0.003309	0
8	EQX 1	87.173	0.093345	933.8761	0	0.002108	0
7	EQX 1	115.24	0.111946	1029.424	0	0.0085	0
6	EQX 1	138.019	0.127662	1081.129	0	0.014054	0
5	EQX 1	155.893	0.139266	1119.393	0	0.018756	0
4	EQX 1	169.274	0.145291	1165.073	0	0.023288	0
3	EQX 1	178.62	0.14623	1221.501	0	0.028512	0
2F	EQX 1	184.445	0.144149	1279.545	0	0.037029	0
1F	EQX 1	187.362	0.150599	1244.107	0	0.050759	0
GB	EQX 1	187.543	0.052457	3575.137	0	0.018334	0

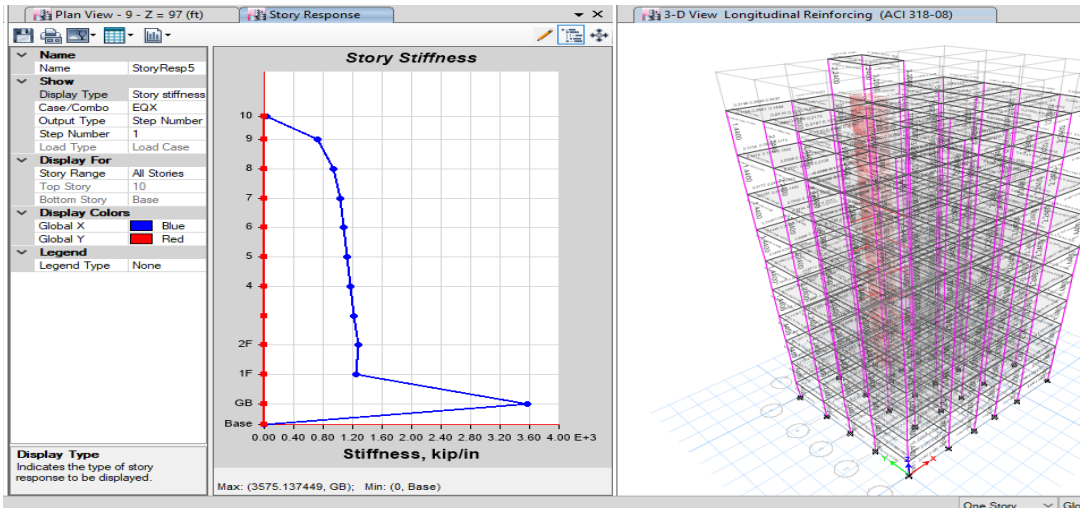


Fig 4.24: Max. Stiffness for HRB

Data table 4.22: Max. Stiffness for LRB in X-direction

Story	Load Case	Shear X	Drift X	Stiffness X	Shear Y	Drift Y	Stiffness Y
		kip	in	kip/in	kip	in	kip/in
TF	EQX	3.165	0.042136	75.1151	0	0.001378	0
5	EQX	62.097	0.067755	916.4892	0	0.002247	0
4	EQX	112.484	0.095161	1182.036	0	0.011941	0
3	EQX	149.625	0.118233	1265.511	0	0.023697	0
2F	EQX	174.478	0.130954	1332.36	0	0.036071	0
1F	EQX	188.29	0.144454	1303.466	0	0.051069	0
GB	EQX	189.336	0.0515	3676.429	0	0.018585	0

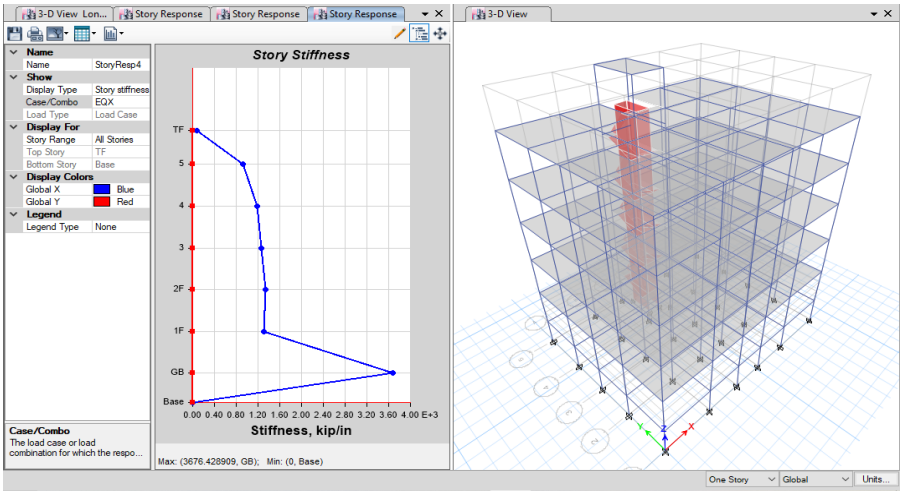


Fig 4.25: Max Stiffness for LRB

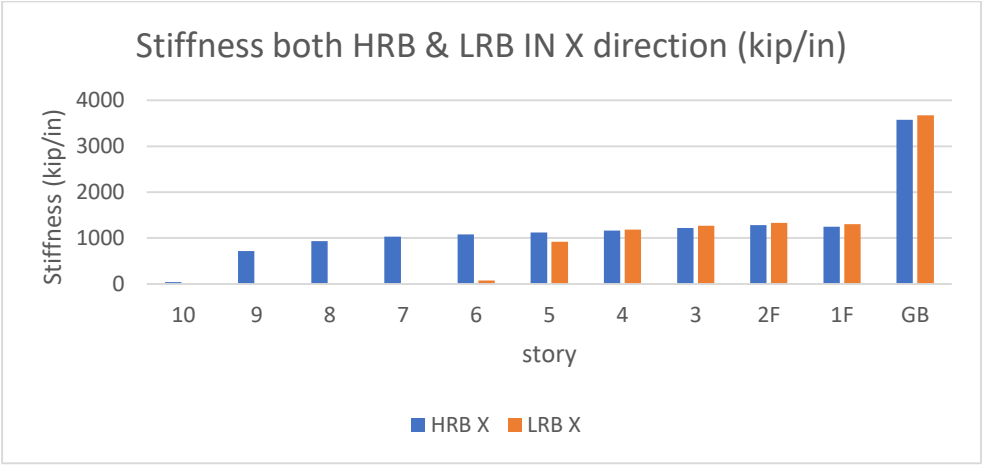


Fig 4.26: Stiffness for both HRB & LRB in Zone 3

Data table 4.23: Base shear for HRB

Load Case/Combo	FX	FY	FZ	MX	MY	MZ	X	Y	Z
	kip	kip	kip	kip-ft	kip-ft	kip-ft	ft	ft	ft
p(D+L)	0	0	8305.584	175476.2	-209113	0	0	0	0

Data table 4.24: base shear for LRB

Load Case/Combo	FX	FY	FZ	MX	MY	MZ	X	Y
	kip	kip	kip	kip-ft	kip-ft	kip-ft	ft	ft
p(D+L)	0	0	4711.461	100081.9	-118616	0	0	0

4.6 ANALYZED DATA FOR ZONE 4:

Data table 4.25: max. Displacement for HRB in X-direction

Story	Load Case/Combo	Direction	Maximum	Average	Ratio
			in	in	
9	EQX 1	X	4.205824	3.376042	1.246
8	EQX 1	X	4.028418	3.184435	1.265
7	EQX 1	X	3.75746	2.921336	1.286
6	EQX 1	X	3.402941	2.603103	1.307
5	EQX 1	X	2.980364	2.240194	1.33
4	EQX 1	X	2.504995	1.844299	1.358
3	EQX 1	X	1.989831	1.427701	1.394
2	EQX 1	X	1.444092	1.002379	1.441
1	EQX 1	X	0.865973	0.578991	1.496

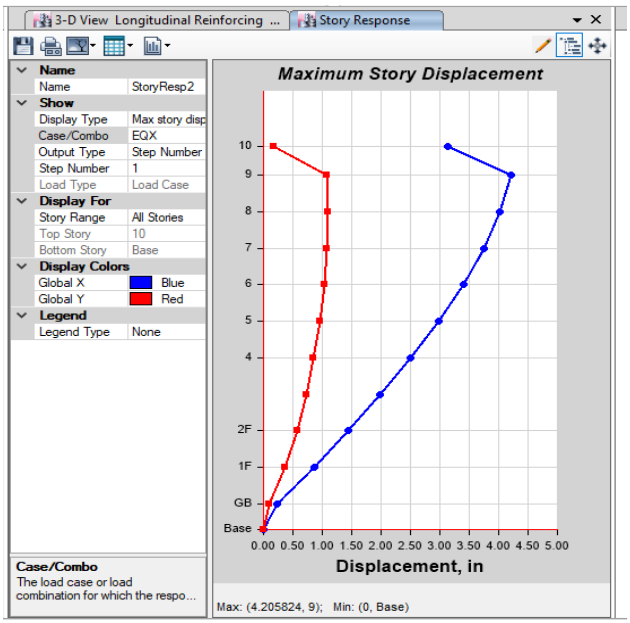


Fig 4.27: Max. Displacement for HRB

Data table 4.26: Max. Displacement for LRB in X-direction

Story	Load Case/Combo	Direction	Maximum	Average	Ratio
			in	in	
5	EQX 1	X	2.264885	1.677311	1.35
4	EQX 1	X	2.086016	1.506029	1.385
3	EQX 1	X	1.777994	1.24662	1.426
2F	EQX 1	X	1.355025	0.920818	1.472
1F	EQX 1	X	0.836955	0.550839	1.519

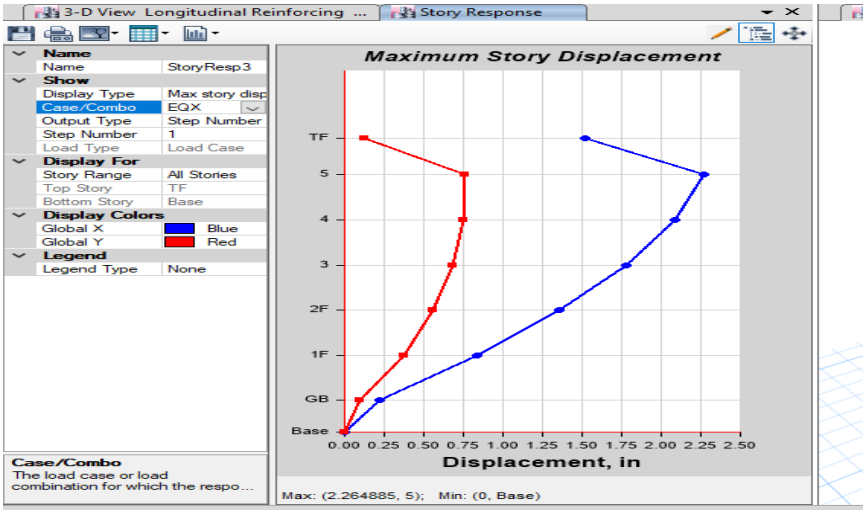


Fig 4.28: Max. Displacement for LRB

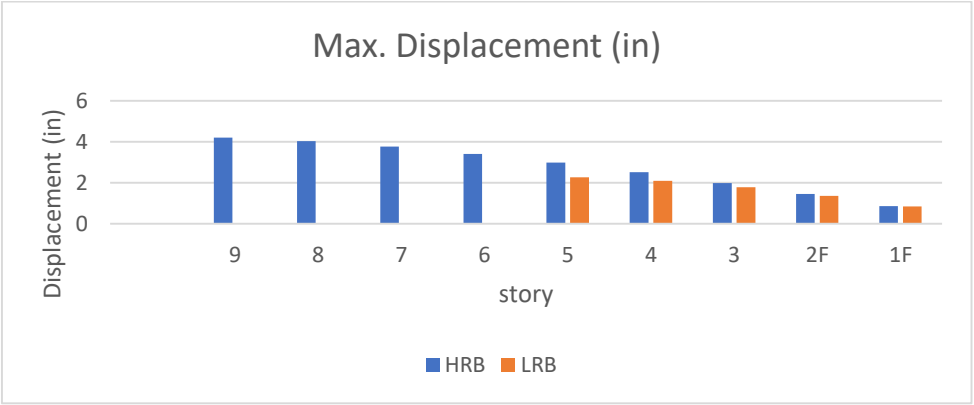


Fig 4.29: Max. Displacement both HRB & LRB in Zone 4

Data table 4.27: Max. Drift for HRB in X-direction

Story	Load Case/Combo	Direction	Drift	Label	X	Y	Z
					ft	ft	ft
10	EQX 1	X	0.001484	15	21.25	40	105
9	EQX 1	X	0.001938	46	23.3333	37.9167	97
8	EQX 1	X	0.002258	21	37.5833	0	87
7	EQX 1	X	0.002954	21	37.5833	0	77
6	EQX 1	X	0.003521	21	37.5833	0	67
5	EQX 1	X	0.003961	21	37.5833	0	57
4	EQX 1	X	0.004293	21	37.5833	0	47
3	EQX 1	X	0.004548	21	37.5833	0	37
2F	EQX 1	X	0.004818	21	37.5833	0	27
1F	EQX 1	X	0.005346	21	37.5833	0	17
GB	EQX 1	X	0.002672	1	0	0	7

Data table 4.28: Max. Drift for LRB in x-direction

Story	Load Case/Combo	Direction	Drift	Label	X	Y	Z
					ft	ft	ft
TF	EQX 1	X	0.001238	20	28.75	40	65
5	EQX 1	X	0.001593	46	23.3333	37.9167	57
4	EQX 1	X	0.002567	21	37.5833	0	47
3	EQX 1	X	0.003525	21	37.5833	0	37
2F	EQX 1	X	0.004317	21	37.5833	0	27
1F	EQX 1	X	0.005145	21	37.5833	0	17
GB	EQX 1	X	0.002614	1	0	0	7

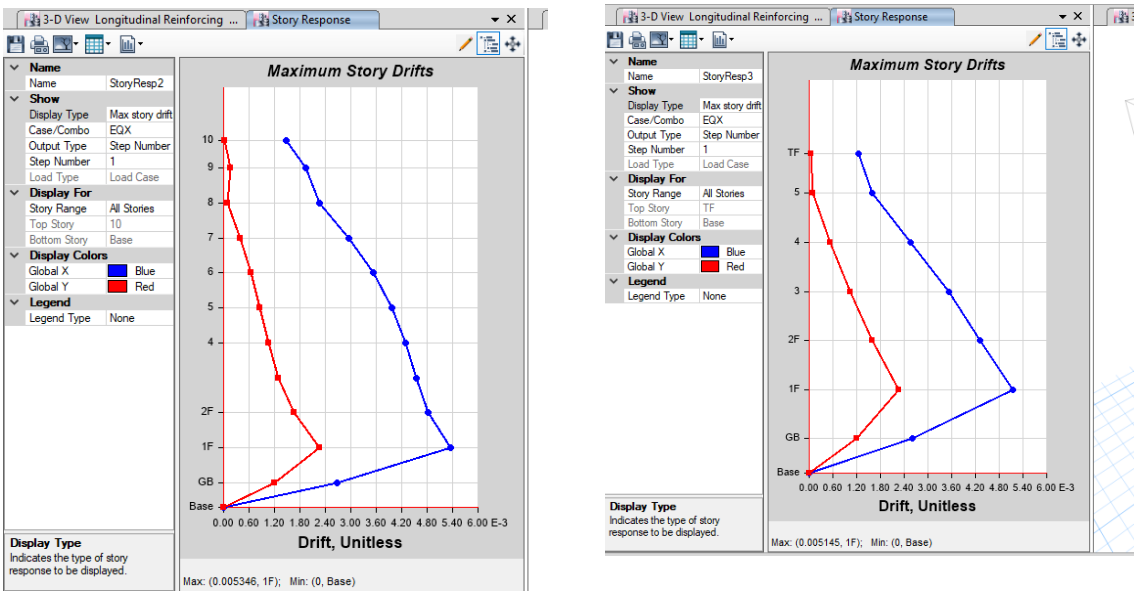


Fig 4.30: Drifts For HRB and LRB

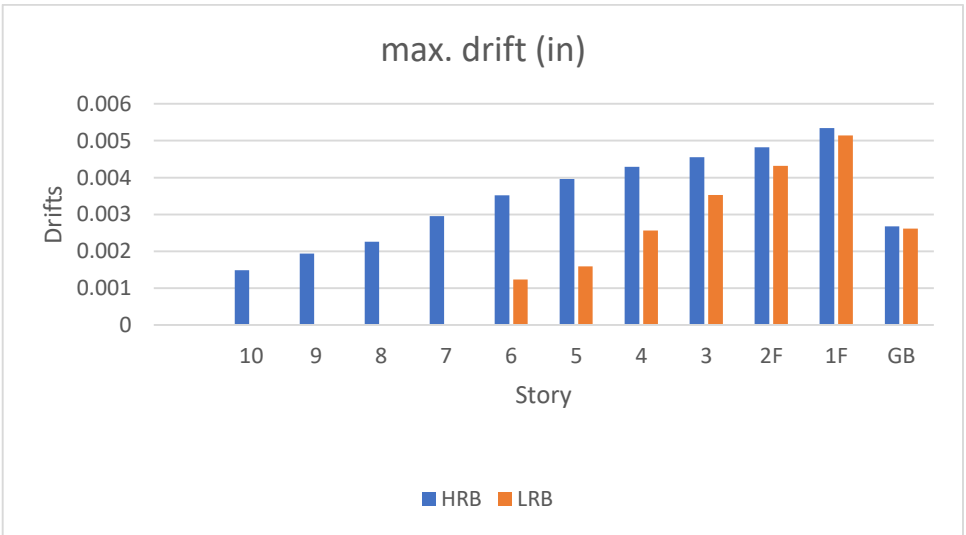


Fig 4.31: Max. Drifts for both HRB & LRB in Zone 4

Data table 4.9: Stiffness for HRB in X-direction

Story	Load Case	Shear X	Drift X	Stiffness X	Shear Y	Drift Y	Stiffness Y
		kip	in	kip/in	kip	in	kip/in
10	EQX 1	5.279	0.140083	37.6862	0	0.001507	0
9	EQX 1	151.981	0.212049	716.7236	0	0.009407	0
8	EQX 1	247.809	0.265356	933.8761	0	0.005991	0
7	EQX 1	327.596	0.318233	1029.424	0	0.024162	0
6	EQX 1	392.352	0.36291	1081.129	0	0.039951	0
5	EQX 1	443.162	0.395895	1119.393	0	0.053318	0
4	EQX 1	481.202	0.413023	1165.073	0	0.066202	0
3	EQX 1	507.769	0.415693	1221.501	0	0.081053	0
2F	EQX 1	524.328	0.409777	1279.545	0	0.105264	0
1F	EQX 1	532.619	0.428114	1244.107	0	0.144294	0
GB	EQX 1	533.133	0.149122	3575.137	0	0.052117	0

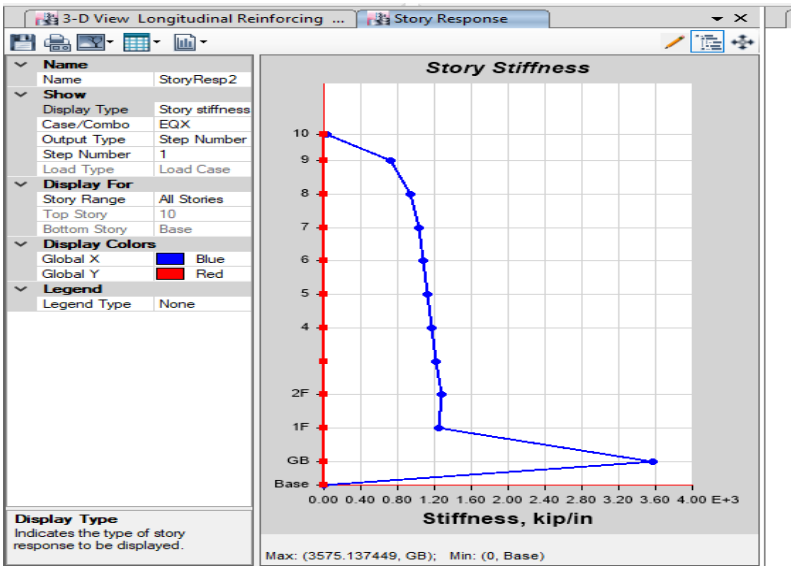


Fig 4.32: Stiffness for HRB

Data table 4.30: Stiffness for LRB in X- direction

Story	Load Case	Shear X	Drift X	Stiffness X	Shear Y	Drift Y	Stiffness Y
		kip	in	kip/in	kip	in	kip/in
TF	EQX 1	8.317	0.113493	73.2842	0	0.003572	0
5	EQX 1	166.153	0.184707	899.5504	0	0.005532	0
4	EQX 1	304.929	0.25941	1175.474	0	0.032262	0
3	EQX 1	410.831	0.325785	1261.047	0	0.065221	0
2F	EQX 1	485.007	0.364331	1331.224	0	0.100708	0
1F	EQX 1	529.088	0.404574	1307.765	0	0.143559	0
GB	EQX 1	532.884	0.144609	3685.006	0	0.052316	0

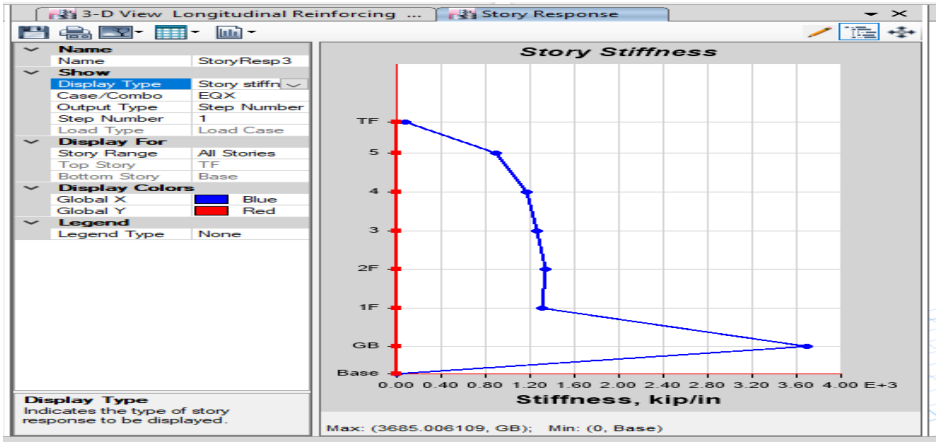


Fig 4.33: Stiffness for LRB

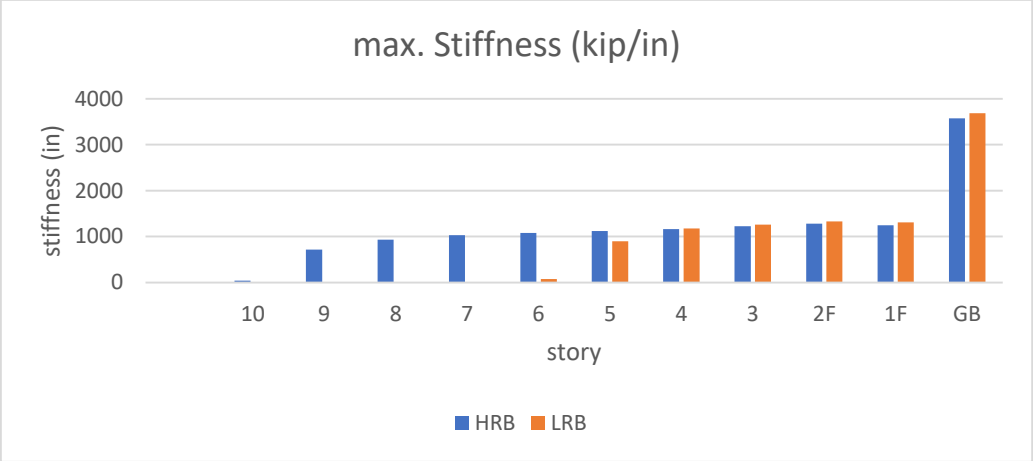


Fig 4.34: Max. Stiffness for both HRB & LRB in zone 4

Data table 4.31: Base shear for HRB

Load Case/Combo	FX	FY	FZ	MX	MY	MZ	X	Y	Z
	kip	kip	kip	kip-ft	kip-ft	kip-ft	ft	ft	ft
p(D+L)	0	0	8305.584	175476.2	-209113	0	0	0	0

Data table 4.32: Base shear for LRB

Load Case/Combo	FX	FY	FZ	MX	MY	MZ	X	Y
	kip	kip	kip	kip-ft	kip-ft	kip-ft	ft	ft
p(D+L)	0	0	4711.461	100081.9	-118616	0	0	0

4.7: Combined Graph

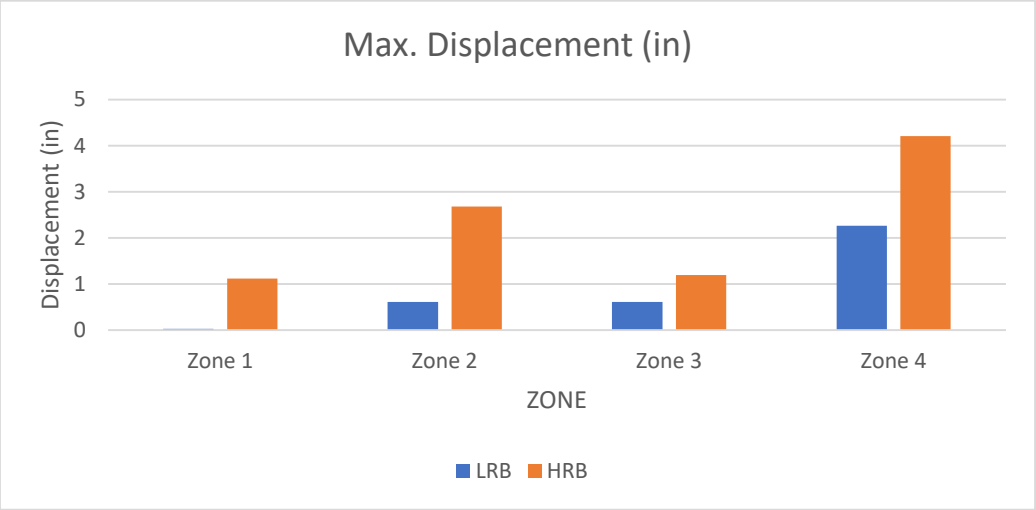


Fig 4.35: Combined Max. Displacement of LRB & HRB for all four zone

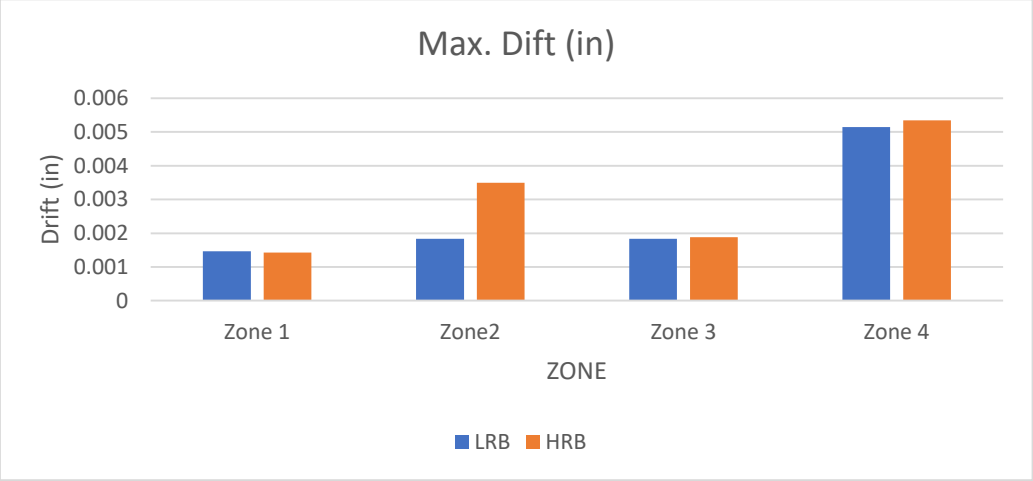


Fig 4.36: Combined max. Drift of LRB & HRB for all four zone

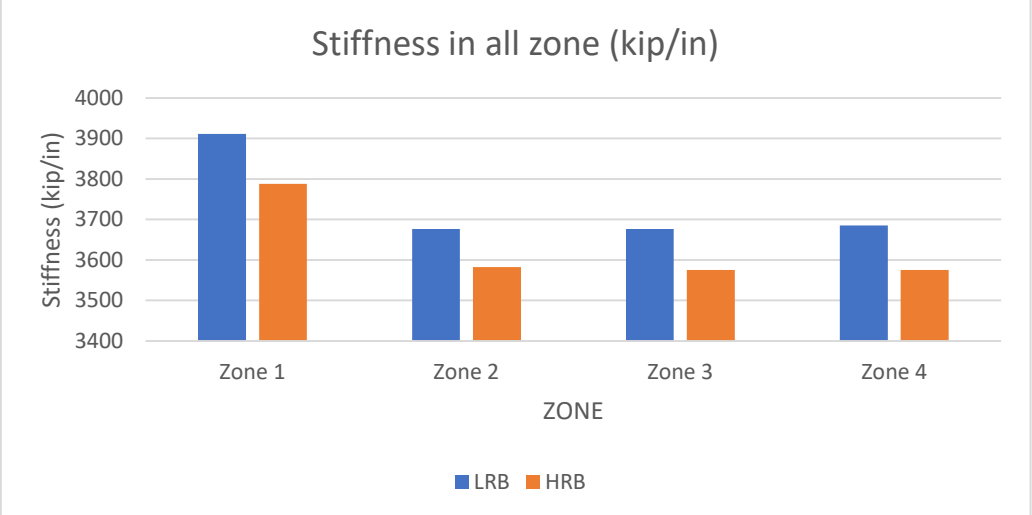


Fig 4.37: Combined Max. Stiffness of LRB & HRB for all four zone

According to this results we determine that the seismic zone 4 is far critical than the others. Only high rise buildings probably resist according to BNBC code that might use for safety and stability. Low raise building may consider as their behavior against Earthquake. High raise building changes its behavior graphically than low rise building. As wind loads are not consider so shear wall does not needed to be analyzed.

CAPTER 5

Conclusions and Future Works

4.1 Conclusion

From the study observed that,

1. The lateral displacement due to the earthquake of the structure analysis in case of high- rise buildings are more than the lateral displacement of the structure analysis in low-rise buildings by the BNBC-2020 code.
2. The lateral displacement due to the wind load of the structure analysis in high-rise buildings is more than the lateral displacement of the structure analysis in low-rise buildings by the BNBC-2020 code.
3. The building is analyzed linearly for seismic design.
4. All loads are taken according to BNBC code provided.

7. The building does not analyze non-linearly for seismic loads.

5.2 Limitations

1. The buildings are fully analyzed for seismic loads wind loads by preliminary and detailed design procedure.
2. In this study, only the ETABS software is used for the analysis.
3. If the analysis results compare with the actual hand calculation data, then more reliable results will be found. It should be done in the future work.
4. Wind loads does not consider for outcome result.
5. This analysis took only the value of seismic in X-direction.
6. Linear work.

5.3 Scope for Future Study

The analysis of wind load and seismic load on an 10-story residential building using ETABS provides valuable insights into the building's structural behavior and performance. However, there are several areas for future study that can further enhance our understanding of the building's response to different loads and improve its safety and stability. Some possible areas for future study include:

1. **Nonlinear Analysis:** Nonlinear analysis techniques can be used to model the building's response to extreme loading conditions, such as earthquakes, hurricanes, or tornadoes, which can cause significant damage to the building.

2. **Advanced Material Modeling:** Advanced material modeling techniques can be used to simulate the behavior of materials under different loading conditions and provide more accurate predictions of the building's performance.
3. **Dynamic Analysis:** Dynamic analysis techniques can be used to simulate the building's response to dynamic loads, such as wind and seismic loads, and provide a more detailed understanding of how the building responds to these loads.
4. **Retrofitting Strategies:** Retrofitting strategies can be developed and evaluated to improve the building's performance and safety under different load scenarios.

Overall, these areas of future study can further enhance our understanding of the structural behavior of buildings and provide valuable insights into how we can design and retrofit buildings to improve their safety and stability under different loading conditions.

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