SEISMIC PERFORMANCE OF STEEL BRACED FRAME STRUCTURES

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE AWARD OF DEGREE OF
MASTER OF TECHNOLOGY

IN

STRUCTURAL ENGINEERING

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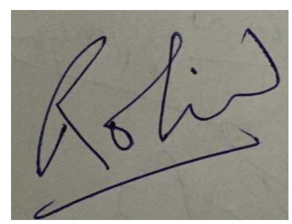
CANDIDATE'S DECLARATION

I, Rohit Singh (2K18/STE/20), student of M.Tech (Structural Engineering), hereby declare that the project Dissertation titled '**SEISMIC PERFORMANCE OF STEEL BRACES STRUCTURES'** which is submitted by me to the Department of Civil Engineering, Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of and Degree, Diploma Associate ship, Fellowship or other similar title or recognition.



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CERTIFICATE

I hereby certify that the Project Dissertation '**SEISMIC PERFORMANCE OF STEEL FRAMED STRUCTURE**' which is submitted by Rohit Singh (2K18/STE/20) to the Department of Civil Engineering, Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Technology, is a record of the project work carried out by the students under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

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ABSTRACT

The progress of steel usage has provided a significant growth in construction industry. It is well established that steel provides better ductility ,stability and strength to the structure. The structure should be good enough to withstand seismic loads as well as lateral loads. This study aims to determine that the steel braces is one of the best method to reduce seismic forces specifically knee bracing which gives most of the lateral stiffness and flexural yielding. In this context a 6 storey knee steel frame structure with a plan of 9 m *9 m is utilized. To test the results that the knee braced framed structure gives better results than the bared frame. A 6 storey knee braced steel structure has been analyzed using ETABS software based on IS 1893:2002 guidelines. Equivalent static analysis method used for calculating base shear and lateral force on each storey and compared with bare frame. ETABS software results are compared with manual results.

ACKNOWLEDGEMENT

The success of a Major project requires help and contribution from numerous individuals and the organization. Writing the report of this project work gives me an opportunity to express my gratitude to everyone who has helped in shaping up the outcome of the project.

I express my heartfelt gratitude to my project guide **Mr. Hrishikesh Dubey** for giving me an opportunity to do my Major project work under his guidance. His constant support and encouragement has made me realize that it is the process of learning which weighs more than the end result. I am highly indebted to the panel faculties during all the progress evaluations for their guidance, constant supervision and for motivating me to complete my work. They helped me throughout by giving new ideas, providing necessary information and pushing me forward to complete the work.

I also reveal my thanks to all my classmates and my family for constant support.

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CHAPTER 1

INTRODUCTION

Earthquakes are natural phenomenon which cause the ground to vibrate. It causes movement in both horizontal and vertical directions respectively. Earth interior is hot and lava comes out to the surface. As the lava comes out, it gets cooled and new land is moved which is continuously moving. Earthquake arise due to the constantly moving plates which either gets collide at their boundaries. The areas which are near the boundaries of the plates are more prone to earthquakes. The structure made should be able to withstand gravity forces as well as seismic forces and safety of structure. In addition, Structure are prone to lateral loads which exhibit more stresses causes bending and deflection of the structure. Structures are subjected to various loads wind load, earthquake load and gravity loads. The gravity load which are dead and live load acting on a given structure. Structure should be well enough to accept all type of loads. When structures are provided to horizontal loads mainly building structures, structures show greater deflection. Braces and shear walls are the most common lateral load resisting systems to reduce the displacement. The areas subjected to earthquakes, tall building structures cannot bear large deflections. Bracings are mostly used in structure subjected to wind and earthquake loads. It resist forces with the brace members both in compression or tension. This makes the bracing system highly efficient in resisting the horizontal loads. The braced frame make system efficient and structure laterally stiff. With the addition of the material to the bare frame and it forms efficient structure to a greater heights .

BRACINGS TYPES

Bracing systems are defined depending on the usage and the usage is based on the connection of beam and column. Braces are connected at two different joints i.e. column beam joint and away from column beam joint. Braces are classified into various types:

Material based :-

a) Reinforced Cement Concrete brace- The Cross section of this brace is of a beam or column. These braces are strong in compression as concrete is strong in compression also as their construction is hard they are not used. These braces can be used once due to seismic excitations and hence these are expensive.

b) Steel brace: These braces are made up of steel and types of steel sections are used such as angle sections, channel sections, tubular sections for steel braces. The steel braces mostly resist large tension force and fail in buckling. The benefit of steel braces is they can be used again and again after the damage and generally not expensive.

Based on the connection to the frames:-

a) Concentric: These are joined to beam or column connectivity. The examples of concentric braces on the basis of their configuration are as follows such as K type, V type and X type bracing.

b) Eccentric: These are connected to separate point of the given section. The section connected to members link aid in transfer energy from seismicity through plastic drift. These Bracings improve the lateral stiffness and increase the energy dissipation capacity. In eccentric braces, the lateral stiffness of the frame depends upon the bending deformation.

Design of steel buildings for seismic loads are based on below objectives:

a) Elastic response

b) Collapse prevention

To meet above objectives, structures are typically designed with greater lateral stiffness. Following above objectives to control large deflections during moderate earthquakes and with proper ductility to survive large inelastic deformations. The objectives can be achieved using ductility. Ductile braced frame structures have high lateral stiffness and ductility. The lateral stiffness is achieved by bracing element. The ductility is usually provided by an inelastic mechanism to overcome overloading in structures.

The mostly used ductile braced frame systems are

a) Eccentrically braced frames

b) Buckling restrained braced frames

Eccentric Braces Frames (EBFs): In this type of system, the bracing element is connected to beam as shown in figure. It consists of a small connecting link called ductile link. This link provides enough ductility and the energy dissipation to the structure. They are constructed by providing an eccentricity between the bracing tip and in between the brace and the column tip.

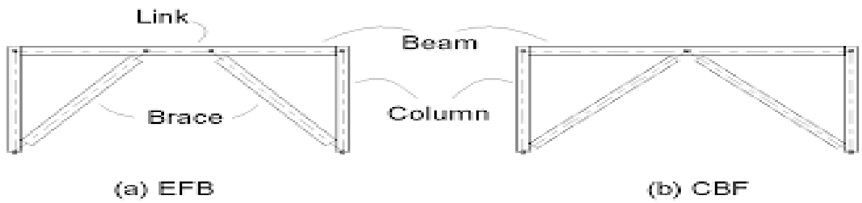


Figure 1: a) Eccentric brace frame

b) Concentric brace frame

Buckling Restrained Braces (BRBs): In this type of framework, they are utilized to decrease the buckling steel support during serious seismic loadings. It compromise of a steel centre encased with mortar secured with a steel packaging. Under seismic excitations the steel centre yields and the mortar covering forestalls further change in shape. The composite activity performs and forestalls shape under extreme conditions. The segment of BRB are as shown.

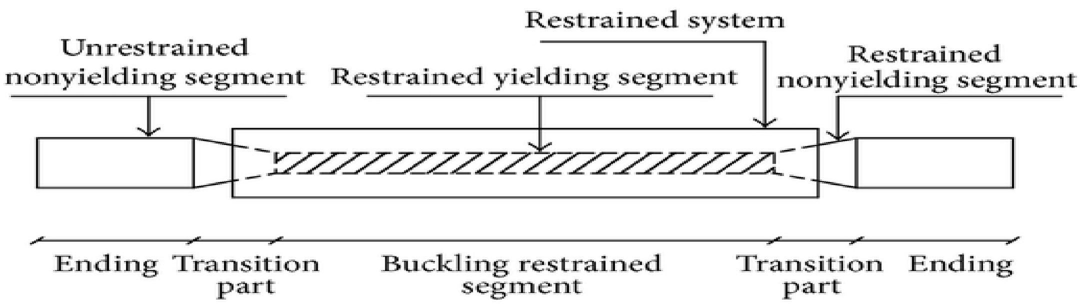


Figure 2: Components of BRB.

CHAPTER 2

Review of Literature

Christopoulus et al. (2008)

A Self centering energy dissipating frames is utilized in cross bracing framework. Buckling reinforced braced frames are additionally utilized and disperse vitality due to their self focusing capabilities which helps in reducing building deflection after prominent seismic excitations.

C.C. Jecob et.al (2009)

The earthquake behavior of less ductile steel framework intended for medium seismic regions have created enthusiasm with financially savvy structure of malleable framework for areas. anyway eccentrically braced frames (EBFs) which shows high ductility systems and can possibly offer practical arrangement in moderate seismic regions. Eccentrically Braced Frames (EBFs) offers a blend of high elastic stiffness and unrivaled inelastic execution qualities.

GhorahA. et al., (1997)

This paper shows that the inter story drift can moreover be considered as an approach to give uniform flexibility over the parts of the building. A story drift may achieve function of a slight story that may cause cataclysmic structure breakdown in an seismic function. Uniform story adaptability over all records is generally need in seismic arrangement.

K.G.Vishwath(2010)

A paper was introduced on seismic reaction of Steel supported fortified solid edges in International diary of common and auxiliary designing. A four story building was taken in zone four as shown to IS code 1893. The presentation of the structure is assessed by story float . X sort of steel propping is found to be beneficial.

K.K.Sgle V.Mhalngkr (2012)

An examination chip away at seismic analysis of skyscraper steel building with and without Bracing and study think about the after effects of seismic analysis of skyscraper steel building with various arrangements of bracing framework. The time history examination of the paper shows that bracing element will have exceptionally unmistakable impact on structural behavior under seismic burdens.

Tremblay et al. (2008)

An analytical study is evaluated to contrast the Buckling restrained braced casing having self focusing energy dissipation. This outcomes shows the remaining distortion of self focusing fatality disseminating support outline frame systems is unimportant under low and moderate danger level and is reduced up to enormous degree under greatest considered seismic tremor level.

Chudhari V., et. al (2015).

The journal explains the significant idea of earthquake opposing frames of X supported frame, V and Knee braced outlines in steel structures. In this journal Sap software has been utilized. The G+4 storey with steel uncovered was thought of and analyzed in various bases. As the plotted outcomes were taken from accompanying computer data. The pushover investigation showed distinguish the base shear and performance point.

Ratnsh Kumar, Prof. K. C. Bswal, et.al.

The investigation of braced steel frame structure data is generally concentrated in engineering. Numerous analyst profoundly reading these structures for their more noteworthy limit of conveying external factors. Model one was a Steel Moment Resisting Frame concentric supports in which they utilized Cross bracing and an un bracing frame is considered. Model two compromises two Steel Moment Resisting Frame with comparative V type and Inverted V bracing with different height.

Antha M, Diva K.K. et. al (2015)

A knee supporting ordered by Finite element method to decide specific assurance in specific methodology. In this the 2D outline thought about and most part consider a bit of data to record it a frame structure to figure external body. A single diagonal frame is thought of and the double knee bracing has taken. Because of solidarity to mass proportion the properties of material, ductility, nature of structure is taken. The fundamental point contrast Knee supporting frame with eccentric with Nonlinear static examination and non linear time history investigation dictated utilizing computer software. Analysis is identify the means of earthquake information. a definitive load were determined.

Arthi Thamrkshan, Arunema .S et. al

Steel bracing is efficient, simple to raise, consumes less space and has adaptability to structure for getting the ideal quality and solidness. There are various sorts of steel bracings accessible as indicated by wanted need. This paper contrasts steel frame outline consequences of the pushover method. The paper examining recommending the suitable setups. Steel braced frame is the auxiliary frameworks oppose earthquake loads in structures.

Sara Raphl, Prof. Soni Syed, et. al (2016)

In this exploration paper a relative investigation of various knee bracing system is introduced. Pushover analysis performed on steel frames outlines with double knee bracings. It demonstrated excellent conduct during a seismic activity with less directional disfigurement and stress. Four knee braced steel outlines with differing points are displayed and broke down for an edge investigation of knee part. From the nonlinear examination the total deformation for relating extreme burden load are obtained. This paper reasons that the steel frames with double knee bracings shows awesome conduct during a seismic movement and the degree of inclination of the knee member with more noteworthy than 350 shows maximum stiffness.

J. Sakar, E.V. Ragha Rao, N. Chamakesavulu. Et. al (2016)

A main role of the project being remarked upon is to discovers forces on components of a structure as required for configuration purposes. For buildings, Earthquake force is format with supporting elements from which the forces get moved to the system. This task provides values of bending moments, shear forces, storey drifts for an assortment of cases covered and shows storey drift increment from base to top. The examination showed that storey drift will be expanded from zone II to zone V in both the directions X and Z separately. The measure of storey drift relies up on the extent of earthquake tremor and furthermore on the displacement of the storey. Bending moment and shear force values shifts starting with one zone to another zone and hence subsequently will expanded from zone II to zone V.

Viswnath K.G, Prof. Praket. al (2016).

The idea utilizing steel bracing is one of the useful ideas can be utilized to fortify the current structures. Steel bracing utilized as a substitute to the next fortify or fitting procedures absolute load on the current structure won't change fundamentally. Steel bracings typically lessen shear requests on beam and columns and move horizontal loads through axial load component. The lateral displacement building contemplated are decreased by X bracing. This examination presume that the X bracing decrease the lateral deflection fundamentally.

Lugi DI Saro, Amr Elnshai. et. al (2004)

This investigation shows the seismic performance of steel moment resisting frames retrofitted with various braces system frameworks. A tall steel structure with steel border MRF was planned with horizontal stiffness in zones with high seismic perils. Most storey drifts of MBFs are 70% and about 50 % lower than SCBFs. The territory designs with buckling restrained braces have seismic execution barely better to MBF regardless of their mass. This measures steel for basic components and their associations in designs with mega braces is less than in uncommon concentrically braced frames. This decreases the expense of development and renders mega braces frames are appropriate for seismic retrofitting applications.

Mahnud Mri, Abas Zdeh. et. al

Frames comparable measurements however different heights in systems are structured predictable with Iranian code of practice for seismic resistant design of building and afterward dependent on nonlinear push over static analysis. A seismic factors like factor behavior and execution level are looked at. Considering tables related with seismic data it demonstrated regardless of stages expanded the strength factor diminished and furthermore the ductility expanded. A amount of dispersing and energy absorbed in chevron knee brace framework is very customary knee braces system framework which shows high ductility of chevron knee braces system against of solidness knee braces system.

Jinko Kim, Junhe Paret. al (2009)

The seismic conduct of framed structure with chevron buckling restrained braces was examined and conduct factors like over strength, ductility, and response modification factor were assessed. The kind of structures for example building frame system and dual system framework with 4, 8, 12, and 16 stories were planned. Nonlinear static pushover analyses utilizing the distinctive loading designs and gradual powerful analysis using twenty earthquake records were administrated to figure conduct factors. Time history analyses were likewise led with 20 earthquake tremors getting dynamic reactions. The dual systems structured with the little seismic load indicated prevalent static and dynamic performances.

Lelataviwat.S, Dung.P, Prof. Jenda. E, Chanan.W. et. al (2017).

This paper shows the behavior and style idea of a proficient basic structural steel systems based on creative uses of knee brace support. knee braced frames incorporate moderately straight forward associations of basic development after an earthquakes and less block when contrasted with standard bracing systems. Different arrangement of KBFs are frequently planned and definite for different degrees of strength, stiffness, and ductility. They all are designed all together that all inelastic exercises are limited to the knee braces and assigned yielding components. A plan ideas to assure sure ductile behavior of knee frame are first summed up.The outcomes show that KBFs can give practical options in contrast to standard structural systems.

CHAPTER 3

MATERIAL AND SPECIFICATIONS

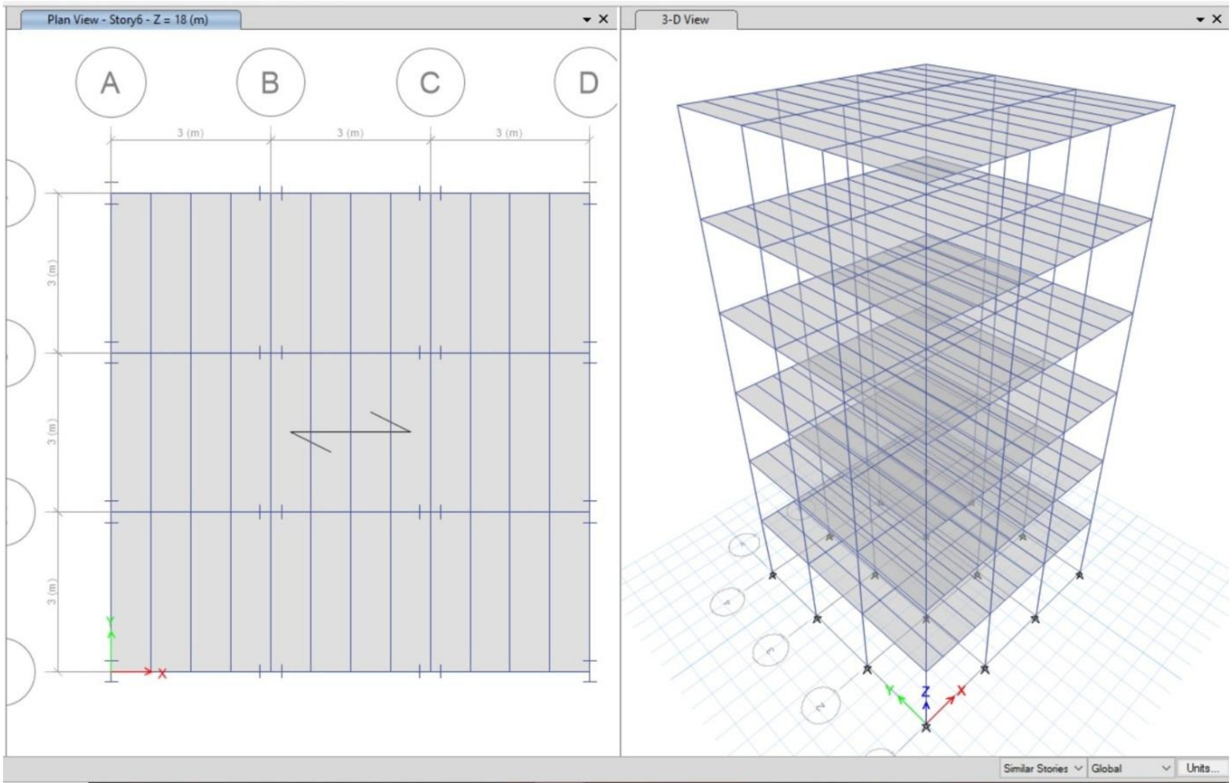
3.1 INTRODUCTION OF MODELED STRUCTURES

A Model structure of 6 storey steel frame structure with X bracing system with floor plan of 9m x 9 m is taken.

The various analysis i.e. Response Spectrum , Time history is performed in ETABS software based on IS 1893:2002 guidelines.

Depending on the complexity in the problem for bracing models had utilized ETABS software so as to find lateral and base shear.

The outcomes were plotted as even structures of tabular forms and chart for different storey drift and displacement.



3.2 Code, Standards and Specifications

The specifications and software used are listed below:

- The Loading i.e. Dead, Live and Earthquake were received utilizing IS codes.
- Spectral analysis and seismic loading were surveyed by IS 1893:2002.
- The structure were planned according to IS 800:2007 & IS 456:2000.
- ETABS 2018 was used for the investigate and plan of basic components.

3.2 Properties of Material

3.3.1 Steel

Steel properties in this thesis depend on data recorded in Table 3.1

Density	780 kg/m^3
Specific Weight	7800 kg/m^3
Poisson's ratio	.3
Yield stress,(fy)	2400 kg/cm^2
Ultimate strength, (fu)	4000 kg/cm^2
Elasticity modules	$2.01*10^6$ kg/cm^2

3.3.2 Concrete Values

Concrete data are shown in Table 3.2

Density	240	kg/m^3
Specific Weight	2400	kg/m^3
Elasticity module	21882	kg/m^2

3.3.3 Non-Linear Properties

The non-linear material properties are utilized as per compression strain and tension strain that are recorded in table. Stress strain curve of steel is as shown in given figure.

Table 3.3: Nonlinear properties (ASCE 7-10)

	Tension strain	Compression strain
IO	0.01	0.005
LS	0.02	0.01
CP	0.05	0.02

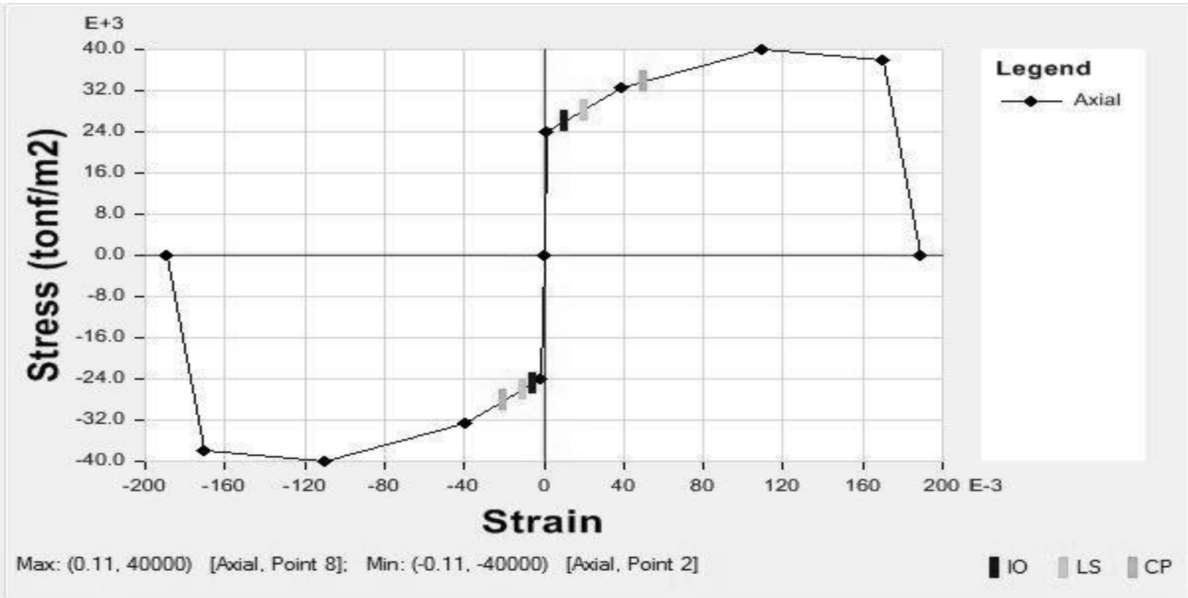


Figure 3.3: Stress -strain property of steel

3.4 Model Structures Loading parameters

3.4.1 Assessment of Floor Dead Load

a) Dead Load Calculation

For assessment of loads- unit tables from IS code are utilized in the software so that the density can be determined by the program.

b)Live Load Calculation

Live load calculation is done using IS code 1893:2002 and IS 456:2000 and IS code 800:2007. Half of the moving load is burdened at the floors.

c)Design Load Criteria

Various load combinations are as follows

1.5 (DL+LL)

1.2 (DL+LL+ELY)

1.2 (DL+LL+ELY)

1.5 (DL+ELX)

1.5 (DL+ELY)

0.9DL+1.5ELX

0.9DL+1.5ELY

DL:-Dead Loads,

LL:-Live Loads

EL:- Earthquake Loads In X And Y Direction.

3.5 Earthquake Load

IS 1893 is used to calculate the earthquake loads. Earthquake acts in two directions x and y directions.

In the solving of seismic loads on the structure can be linked with number of methods. In that following methods we had two simple methods in which one is solved manually and another to use by computer calculations.

Equivalent static method is the method to identify the load carrimg capacity for the structure. As it is a fundamental concept involve in it by using IS code 1893:2002. Initially, the base shear is find out and afterward the load has been uniformly distributed over the entire structure.

The base shear and lateral shear were plotted by code provided in distribution of mass means seismic weight of structure body. Zones of the location of each area is provided in code by explaining the terms importance factor, zone factor, response reduction factor.

Base shear is calculated using the IS code guidelines

As we know from IS code.

VB = Ah*W

A = Seismic coefficient for a structural building.

W = Seismic weight of structure considered.

The design horizontal seismic coefficient for a given structure A and various parameters are given as

A = Z*I*Sa / 2*R*G

A = Z = zone factor.

I- importance factor.

R -response reduction factor.

Sa / g -coefficient of response acceleration for rock and soil sites

T - he fundamental natural period for buildings obtained

Ta = 0.075*h *0.75 for RC frame resisting structures.

Ta = 0.09 * h/√d for building of moment resisting frames and structures.

h = The height of the building from the base foundation to top roof (m).

3.6. Lateral Distribution of the base shear

The base shear is formulated along the height of steel structure. The base shear at given storey is dependent along the height of the storey and the mass at which it is concentrated, and the shape of building. Seismic loads are tend to move and displace the foundation with extreme levels. The degree of freedom which was denoted by nodal points on which the load due to deflection is zero. As a result the number of stories is equal to number floors.

The lateral force magnitude at floor node is determined by:

1) Distribution of stiffness over the height of given structure

2) Nodal displacement in any given mode

3) Mass of floor

3.7 ETABS SOFTWARES

ETABS is a designing programming bundle that takes into account multi-story building investigation and plan arrangements. Displaying instruments and formats, code-based burden remedies, investigation strategies and arrangement methods, all organize with the network like math one of a kind to the current class of structure. Fundamental or progressed frameworks under static or dynamic conditions could likewise be assessed utilizing ETABS. For a tasteful evaluation of seismic execution, modular and direct-joining time-history investigations may couple with P-Delta and enormous Displacement impacts. Nonlinear connections and concentrated or fiber pivots may catch material nonlinearity under monotonic or hysteretic conduct. Instinctive highlights make utilizations of any intricacy handy to actualize. Interoperability with a progression of plan and documentation stages makes ETABS an organized and gainful instrument for plans which range from straightforward 2D edges to expand present high tall structures.

3.8 WHY ETABS IS USED ?

ETABS is employed for the analysis of concrete shear walls and concrete moment frames. Once we are ready to limit the drift, we will output the forces from ETABS into a spreadsheet for design.

3.9 Features and Benefits of ETABS

- The info, yield and numerical arrangement strategies of ETABS are solely intended to exploit the novel physical and mathematical qualities related with building type structures. Accordingly, this examination and style device assists information readiness, yield understanding and execution all through.

- The requirement for specific reason programming has never been more apparent as Structural Engineers set up non-direct unique examination as a regular occurrence and utilize the more noteworthy PC power accessible today to make bigger expository frameworks.

CHAPTER 4

METHODOLOGY

To work out the forces evoked seismically within the structures, there comes a wide range of examinations which offer various degrees of exactness depending upon several factors. The strategy for examination might be ordered on the possibility of three factors that the sort of the remotely applied burdens, the conduct of materials or state structure, overall, and furthermore the sort of model picked.

METHOD OF ANALYSIS

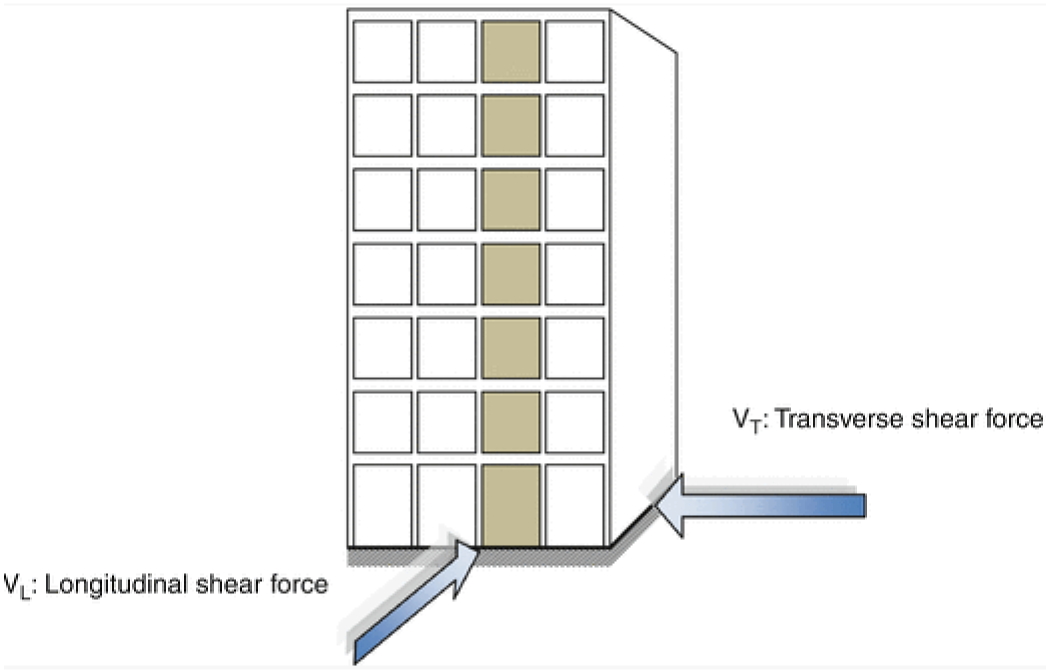
There are four methods of analysis, namely:

- Linear Static Analysis
- Linear Dynamic Analysis
- Non-linear Static Analysis
- Non-linear Dynamic Analysis

Linear Static Analysis is used for regular structures with restricted height. Linear Dynamic Analysis may be evaluated by superposition method or response spectrum method. This procedures may make the effect of the higher modes of vibration in the building and also the distribution of forces within the elastic range. It represent an improvement over linear static analysis.

The noteworthy contrast difference between the linear static and dynamic analysis is the degree of force and their distribution along the height of the structure. Non-linear static analysis is an enhancement over the linear static or dynamic analysis with this logic that it permits the inelastic behavior of the given structure. The methods still assumes monotonically increasing lateral loads along the height of structure. The technique is relatively elementary to be actualized and informed data on the deformation, strength, and ductility . The method is comparatively elementary to be implemented, and provides data on the deformation, strength, and ductility of the structure. A non-linear dynamic analysis or inelastic time history analysis is the only methodology to explain the actual behavior of the structure throughout an seismic ground motions. The methodology depends on the direct integration of the movement differential equations by taking the elastic plastic deformation of the structure components. This system captures the effect of amplification due to resonance, the variety of deflection at different degrees of a structure.

Equivalent Static Method



Equivalent static force method is a simple technique to substitute the impact of dynamic loading of an normal earthquake by a static force distributed horizontally on a structure for configuration purposes.

The total applied seismic force V is assessed in two level directions parallel to the principal axes of the building. It guarantees that the building reacts in crucial horizontal mode.

For this to be right, the building must be low ascent and must be symmetric to stay away from twist movements underground motions. The structure must be prepared to oppose impacts caused by seismic forces in either direction, however not in the two ways at the same time.

Linear dynamic analysis

In this method, the response of the structure to ground motion is calculated in the time domain, and all phase information is therefore maintained. Only linear properties are assumed. The analytical method can use modal decomposition is used to an extent of reducing the degrees of freedom in the given model or structures

This method explains that sum of vectors of inertia forces and sum of vector of viscous damping forces and sum of vector of internal forces is equal to the sum of vector of external forces.

Non Linear Static Analysis

It is commonly referred as Push Over Analysis. It is method for determining the extreme load and deflection ability of a structure.

It is an analysis which holds non linear relationship between forces and displacements. Stiffness matrix does not remain constant. The different solving method is required for the nonlinear analysis.

Pushover analysis is a static methodology that utilizes nonlinear technique to assess seismic deformations. Structures. As individual segment of a structure yield or fail, the dynamic forces on the structure are moved to other components. A pushover analysis simulates this phenomenon by applying loads until the feeble connection in the structure is found and afterward reexamining the model to incorporate the adjustments in the structure caused by feeble connection. A subsequent emphasis demonstrated how the loads are reallocated. The structure is squeezed again until the second feeble link connection is found. This cycle continues until a yield design for the entire structure under seismic loading is distinguished.

Pushover analysis is used to assess the seismic limit of existing structures and for retrofit seismic plan. It can likewise be valuable for performance based design of new building that depend on ductility or redundancies to oppose seismic forces.

Non linear Dynamic Analysis

Nonlinear time-history analysis comprises the detailed way for simulating response of structures exposed to extreme degrees of seismic excitation. The analytical method depend on principles and highlight the ability to locate the inelastic dynamic behavior of structures. The examination precision and model straightforwardness permits to defeat the unpredictability related to nonlinear dynamic analysis. The model methodology is utilized in the system of a limited program for seismic response analysis of structures. The consistency and the precision of the program are checked by mathematically reproducing pseudo dynamic tests on full-scale structures.

CHAPTER 5

CALCULATIONS

In this chapter, the various manual calculations used in this study are calculated with all the required formulae.

5.1. Equivalent Static Analysis for Calculating the Base Shear and Lateral Shear

Specification of a 6-storey steel residential building

Given data,

Stories = 6

Live load = 3kN/m2

Columns = ISHB250-2

Beams = ISLB200

Bracing = ISMB175

Thickness of Deck = 110mm

Thickness of wall = 120mm

Importance factor = 1.0

Zone=3

5.2. Seismic Weights Computations

Unit weight of concrete as 25kN/m3 and 20 kN/m3 for masonry

1) Slab: Dead load of Deck = Volume of Deck * unit weight of concrete

= (9*9*0.11) * 25 = 222.75kN

2) Coloumn: from steel table

ISHB250-2 = 54.7kg/m = 547N/m

Dead load due to self-weight (16 no's) = No. of columns * self-weight * length of column. = 16 * 0.547 * 3 = 26.26kN

3) BEAMS

ISLB200 = 19.8kg/m = 198N/m

Dead load to self-weight (18 no's) = 0.198 * 18 * 3 = 10.7kN

4) WALL

Weight of wall per unit length = 0.12 * 3 * 20

Dead load due to weight = (9+9+9+9) * 7.2 = 259.2kN. 5)

Live Load (25%) = unit weight * area of deck = (0.25*3) * (9*9) = 60.75kN.

Load on all Floors

W1 = W2 = W3 = W4 = W5 = DECK + COLUMNS + BEAMS + WALLS + LIVE LOAD

= 222.75 + 26.26 + 10.7 + 259.2 + 60.75 = 579.66kN

5) Fundamental Time Period

Ta = 0.09 * √h/d

= 0.09 * √18/9 = 0.54 s

6) Moment Frame with in Fill Walls

Medium soil taken

Ta = 0.54 s

Sa/g = 2.5

Zone factor- Zone 3, Z = 0.16

Importance factor (I) = 1.0

Response Reduction factor(R) = 3.0

Horizontal acceleration coefficient (A_h)

$$A_h = \frac{Z}{2} * \frac{Sa}{g} * \frac{I}{R}$$

$$= \frac{0.16}{2} * 2.5 * \frac{1.0}{2.0}$$

$$= 0.0667$$

Shear at base (V_B)

$V_B = A_h*W = 0.0667 * 3860$

$V_B = 257.47kN$

Storey shear forces are calculated as follows (last column of the table),

V6 = Q6 = 77.27kN

V5 = V6 + Q5 = 77.27 + 81.90 = 159.17kN

V4 = V5 + Q4 = 159.17 + 52.42 = 211.59kN

V3 = V4 + Q3 = 211.59 + 29.49 = 241.08kN

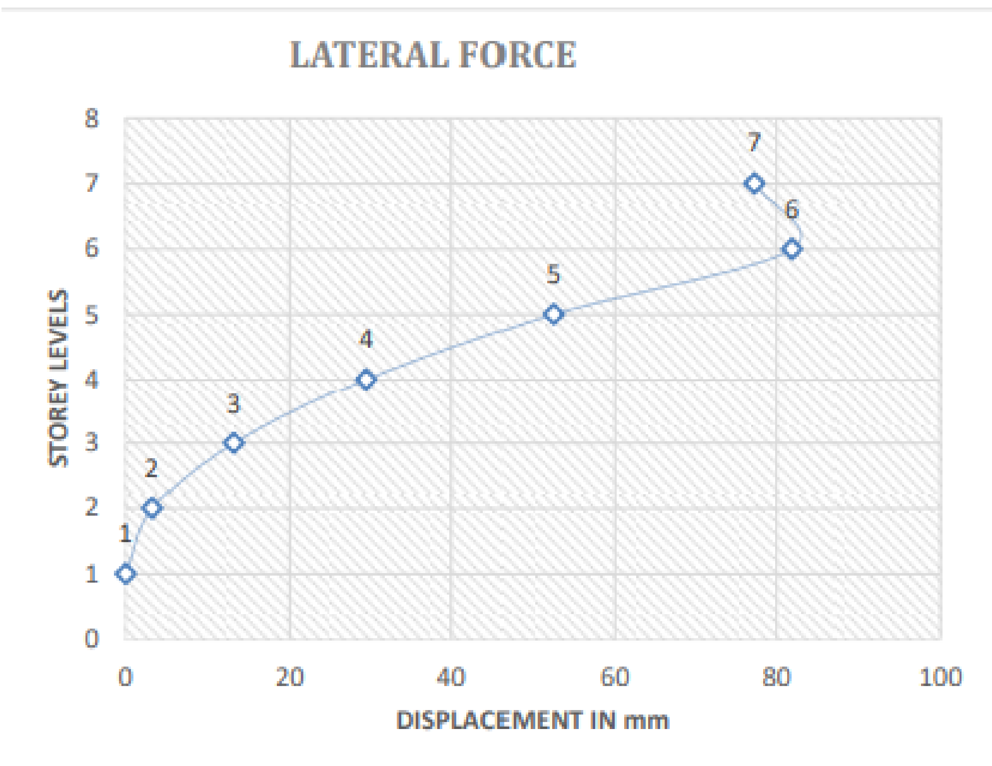
V2 = V3 + Q2 = 241.08 + 13.11 = 254.19kN

V1 = V2 + Q1 = 254.19 + 3.28 = 257.47kN

Lateral Force and Shear Force Distribution

FLOOR LEVEL	W_I(KN)	hi (m)	$W_i h_i^2$ (kN-m^2)	Storey forces $Q_i = V_B \frac{W_i h_i^2}{\sum_{t=1}^{n} W_i h_i^2}$	Storey shear force (v_i) (kN)
6	380	18	123,120	77.25	77.25
5	580	15	130,500	81.88	159.13
4	580	12	83,520	52.46	211.56
3	580	9	46,980	29.43	241.02
2	580	6	20,880	12.11	253.13
1	580	3	5,220	3.26	256.39
			$\sum_{t=1}^{n} W_i h_i^2$ = 410,220		

Lateral Force and shear Force Distribution in Fig



CHAPTER 5

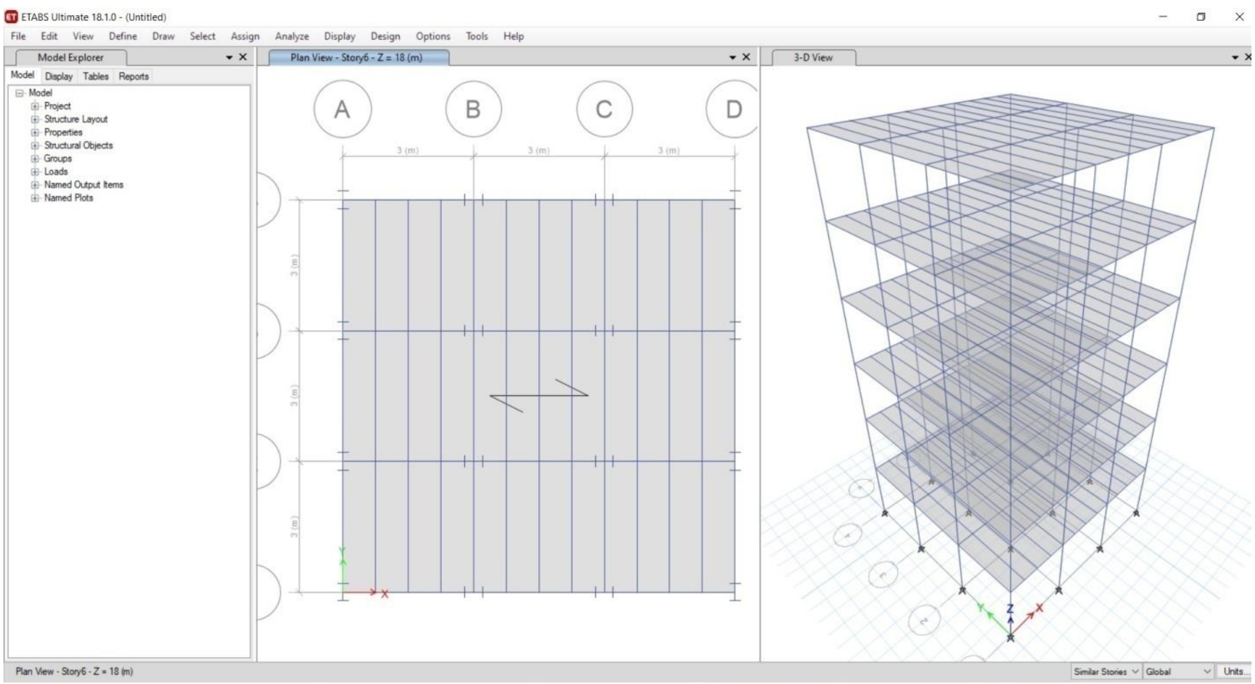
RESULTS

Storey Drifts in X-Direction

The values shows the storey level, storey displacement and inter storey drift for steel bare frame and types of bracing patterns which are bare frame, knee bracing in X- direction by response spectrum analysis

Storey Drifts in Y-Direction

The values shows the storey level, storey displacement and inter storey drift for steel bare frame types of bracing patterns which are bare frame, knee bracing in Y-direction by response spectrum analysis



5.1 X-Direction Inter storey Drifts

Storey level	Bare Frame	Frame with Knee bracing
6	0.014	0.0010
5	0.022	0.0010
4	0.029	0.0016
3	0.034	0.0016
2	0.029	0.0012
1	0.050	0.0020
0	0	0

5.2 Y-Direction Inter storey Drifts

Storey level	Bare Frame	Frame with Knee bracing
6	0.0163	0.0001
5	0.0296	0.0013
4	0.0416	0.0016
3	0.0506	0.0016
2	0.0051	0.0002
1	0.0086	0.0005
0	0	0

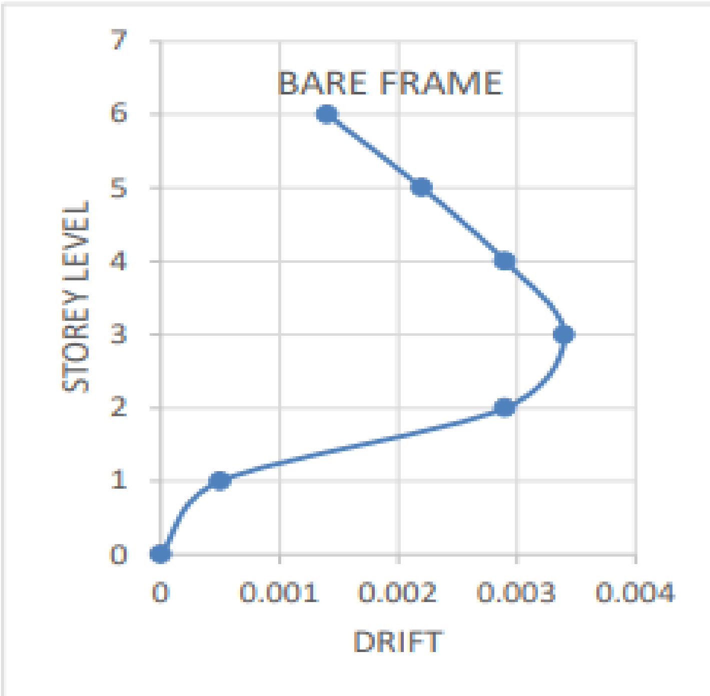
5.3 X-Direction Inter storey Displacement

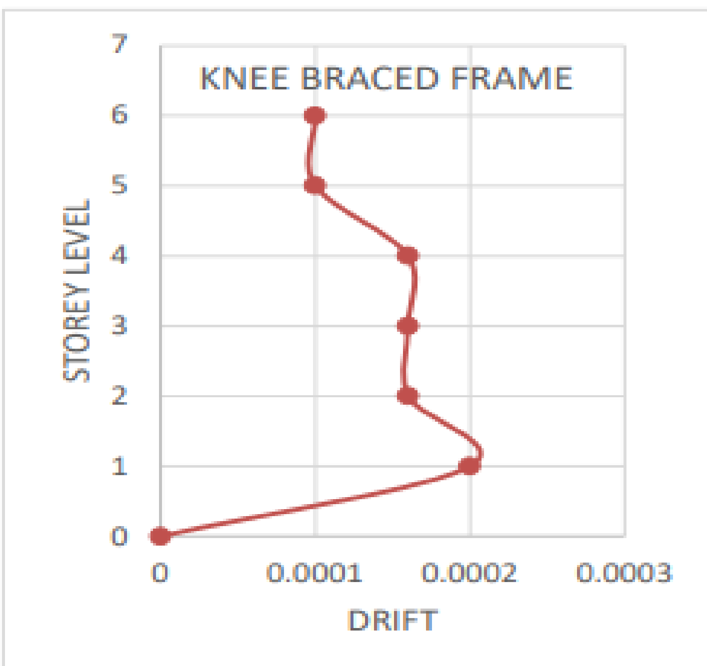
Storey level	Bare Frame	Knee with Knee bracing
6	0.127	0.0090
5	0.113	0.0080
4	0.093	0.0070
3	0.064	0.0054
2	0.034	0.0036
1	0.005	0.0020
0	0	0

5.4 Y-Direction Inter Storey Displacement

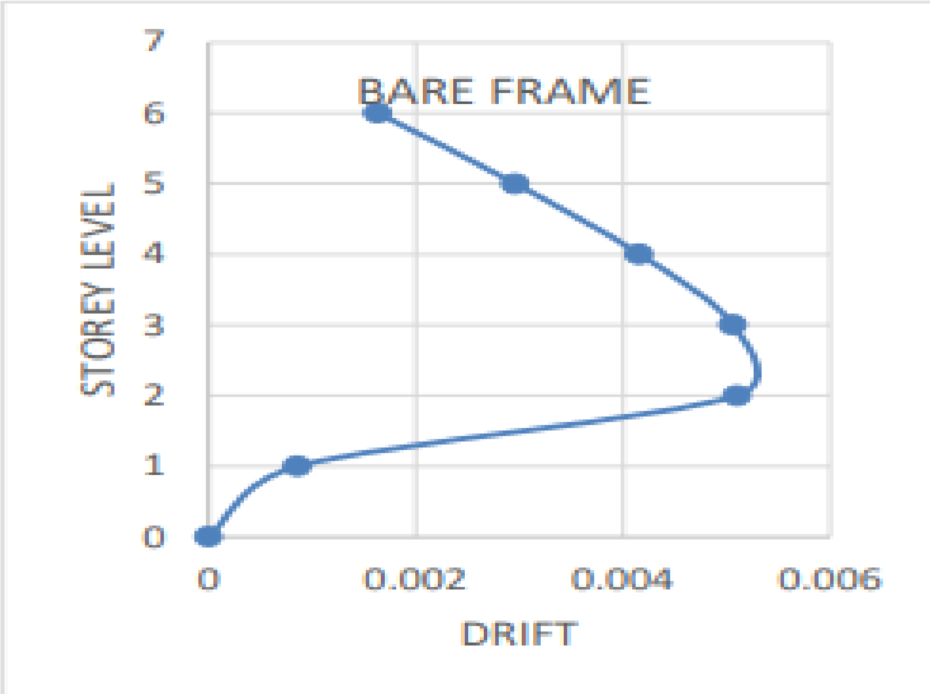
Storey Level	Bare Frame	Knee with knee bracings
6	0.0273	0.0125
5	0.0260	0.0115
4	0.0230	0.0102
3	0.0188	0.0086
2	0.0137	0.0070
1	0.0086	0.0030
0	0	0

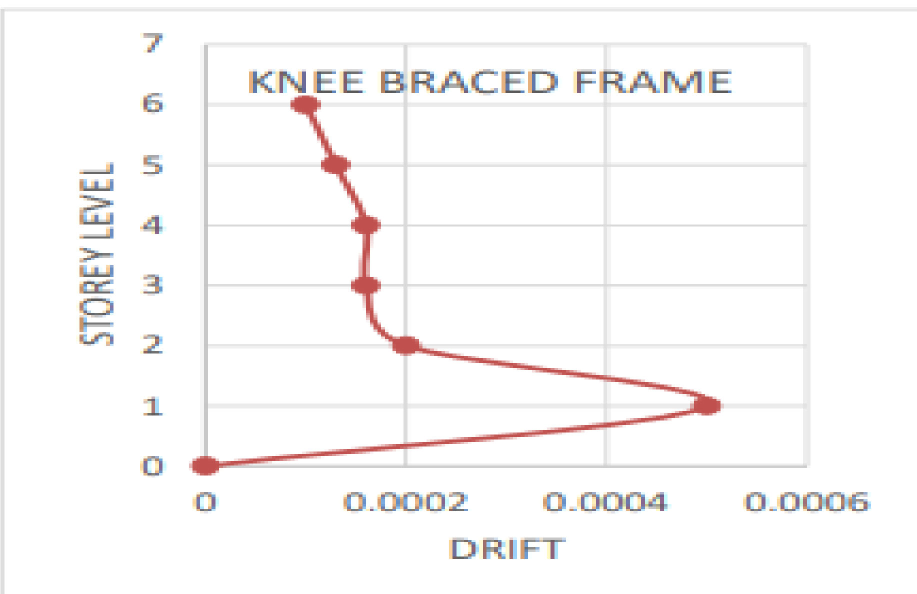
5.6 X-Direction Inter Storey Drifts Graphs



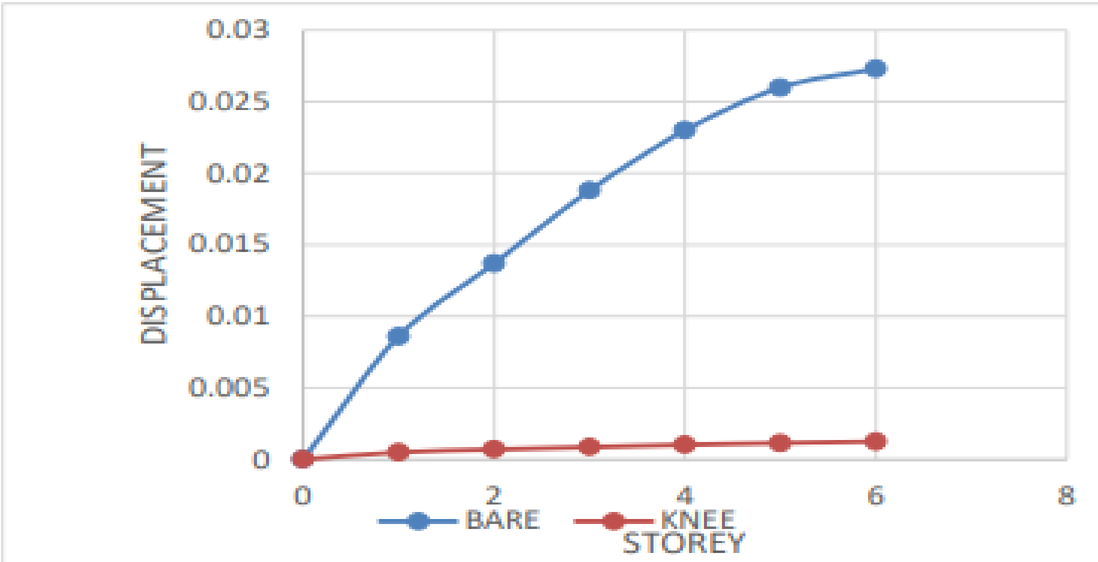


5.7 Y-Direction Inter Storey Drifts

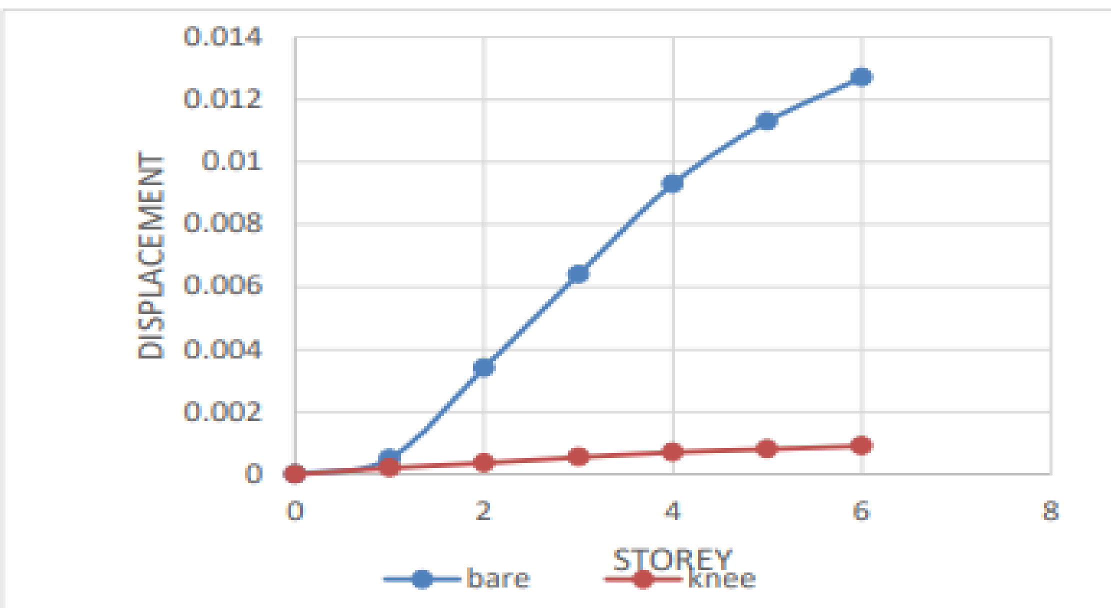


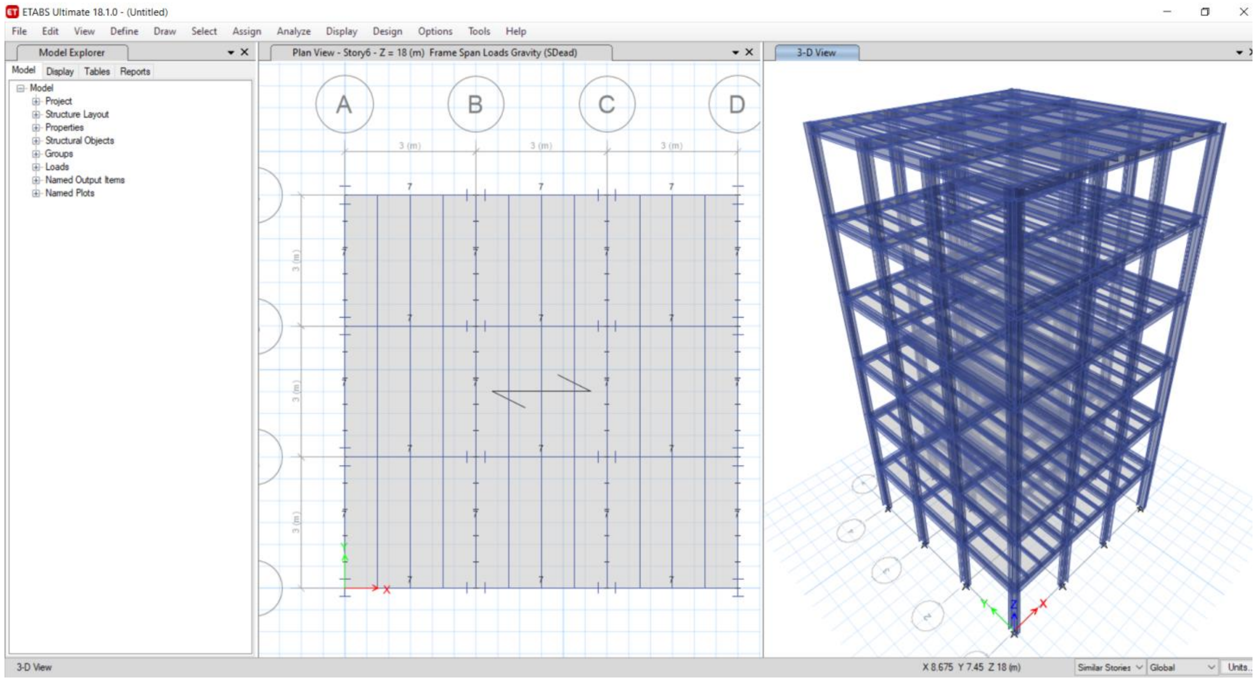


5.8 X-Direction Inter Storey Displacement



5.9 Y-Direction Inter storey Displacement





The below table gives the base reactions provided by the software. The values of FX,FY,FZ and MX,MY,MZ are given respectively.

Output Case	Case Type	Step Type	Step Number	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m
Modal	LinModEigen	Mode	10	0	12.5776	0	22.2468	0	56.5992
Modal	LinModEigen	Mode	11	-12.6468	0	0	0	25.7145	56.9105
Modal	LinModEigen	Mode	12	0	0	0	0	0	-95.1407
Dead	LinStatic			0	0	3328.5763	14978.5933	-14978.5933	0
Live	LinStatic			0	0	972	4374	-4374	0
SDead	LinStatic			0	0	3024	13608	-13608	0
EQ X	LinStatic			-95.2737	0	0	0	-1376.0983	428.7316
EQ Y	LinStatic			0	-89.4395	0	1291.8319	0	-402.4779
RS-X	LinRespSpec	Max		78.1927	73.8337	0	887.4533	938.3688	448.4192
RS-Y	LinRespSpec	Max		76.4279	72.1673	0	867.4233	917.1896	438.2983
Comb1	Combination			0	0	7324.5763	32960.5933	-32960.5933	0
Comb1.5	Combination			0	0	10986.8644	49440.8899	-49440.8899	0

5.10 <u>Base reactions</u>

Response Spectrum Analysis

This section has the various table showing different values like modal load participation ratios, time periods of different modes, their frequencies, modal participating mass ratios.

Modal Mass Participation Rations

Table 5.11 below gives values of model mass participation rations

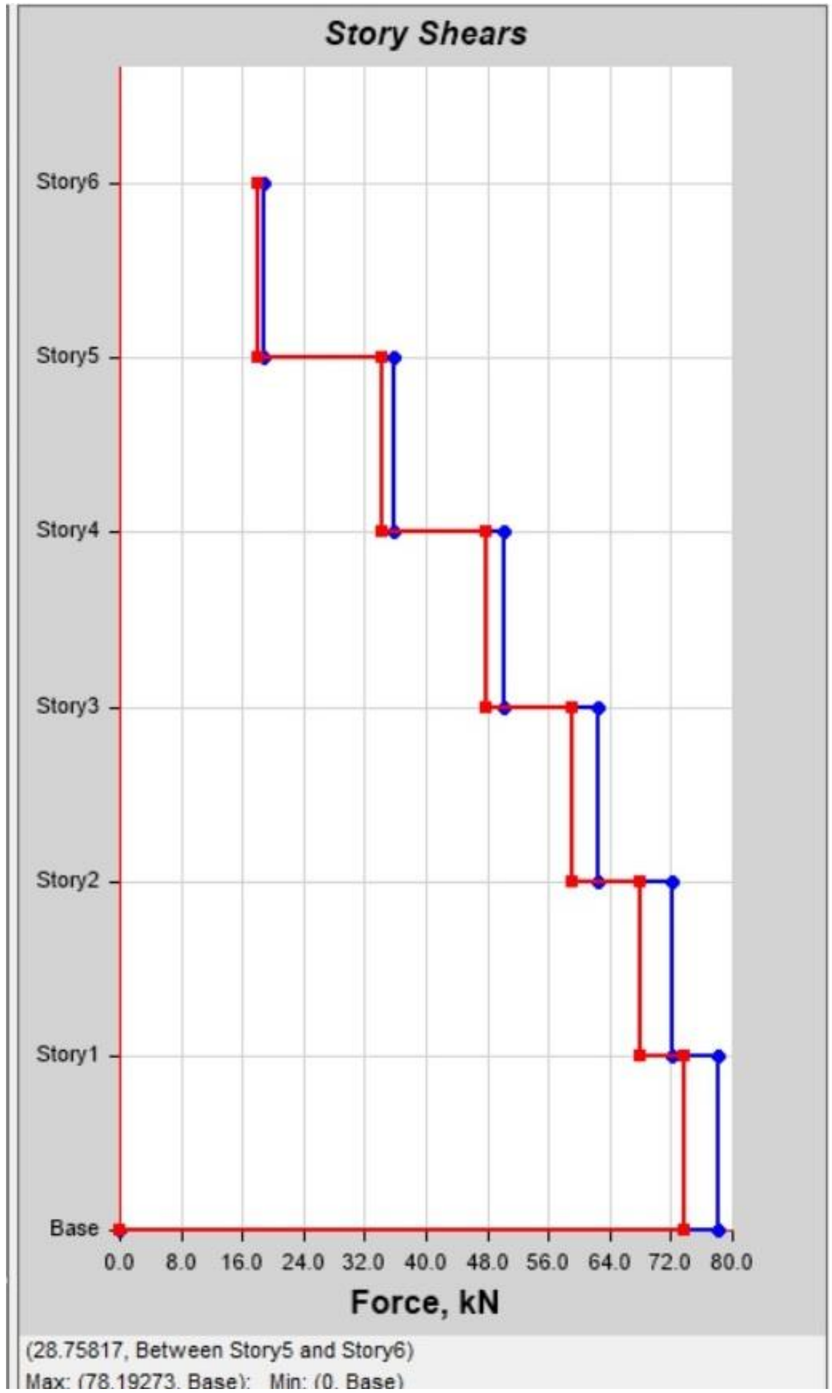
Case	Mode	Period sec	UX	UY	UZ	SumUX	SumUY	SumUZ	RX	RY	RZ	SumRX	SumRY	SumRZ
Modal	1	0.85	0	0.8971	0	0	0.8971	0	0.113	0	0	0.113	0	0
Modal	2	0.798	0.9005	0	0	0.9005	0.8971	0	0	0.1092	0	0.113	0.1092	0
Modal	3	0.639	0	0	0	0.9005	0.8971	0	0	0	0.8964	0.113	0.1092	0.8964
Modal	4	0.236	0	0.0713	0	0.9005	0.9684	0	0.7628	0	0	0.8757	0.1092	0.8964
Modal	5	0.225	0.0695	0	0	0.97	0.9684	0	0	0.7731	0	0.8757	0.8823	0.8964
Modal	6	0.175	0	0	0	0.97	0.9684	0	0	0	0.0708	0.8757	0.8823	0.9672
Modal	7	0.112	0	0.0202	0	0.97	0.9886	0	0.0656	0	0	0.9413	0.8823	0.9672
Modal	8	0.109	0.0192	0	0	0.9893	0.9886	0	0	0.0607	0	0.9413	0.943	0.9672
Modal	9	0.083	0	0	0	0.9893	0.9886	0	0	0	0.021	0.9413	0.943	0.9882
Modal	10	0.066	0	0.0079	0	0.9893	0.9965	0	0.0443	0	0	0.9856	0.943	0.9882
Modal	11	0.064	0.0074	0	0	0.9967	0.9965	0	0	0.0436	0	0.9856	0.9865	0.9882

Time Period and Frequencies

Case	Mode	Period sec	Frequency cyc/sec	CircFreq rad/sec	Eigenvalue rad^2/sec^2
Modal	1	0.85	1.176	7.389	54.5969
Modal	2	0.798	1.253	7.871	61.9519
Modal	3	0.639	1.565	9.8322	96.6728
Modal	4	0.236	4.239	26.6358	709.4673
Modal	5	0.225	4.453	27.9782	782.7784
Modal	6	0.175	5.703	35.8353	1284.1671
Modal	7	0.112	8.9	55.9207	3127.13
Modal	8	0.109	9.188	57.7299	3332.738
Modal	9	0.083	12.01	75.4618	5694.4773
Modal	10	0.066	15.256	95.8561	9188.391
Modal	11	0.064	15.53	97.5781	9521.4833
Modal	12	0.048	20.705	130.0908	16923.6263

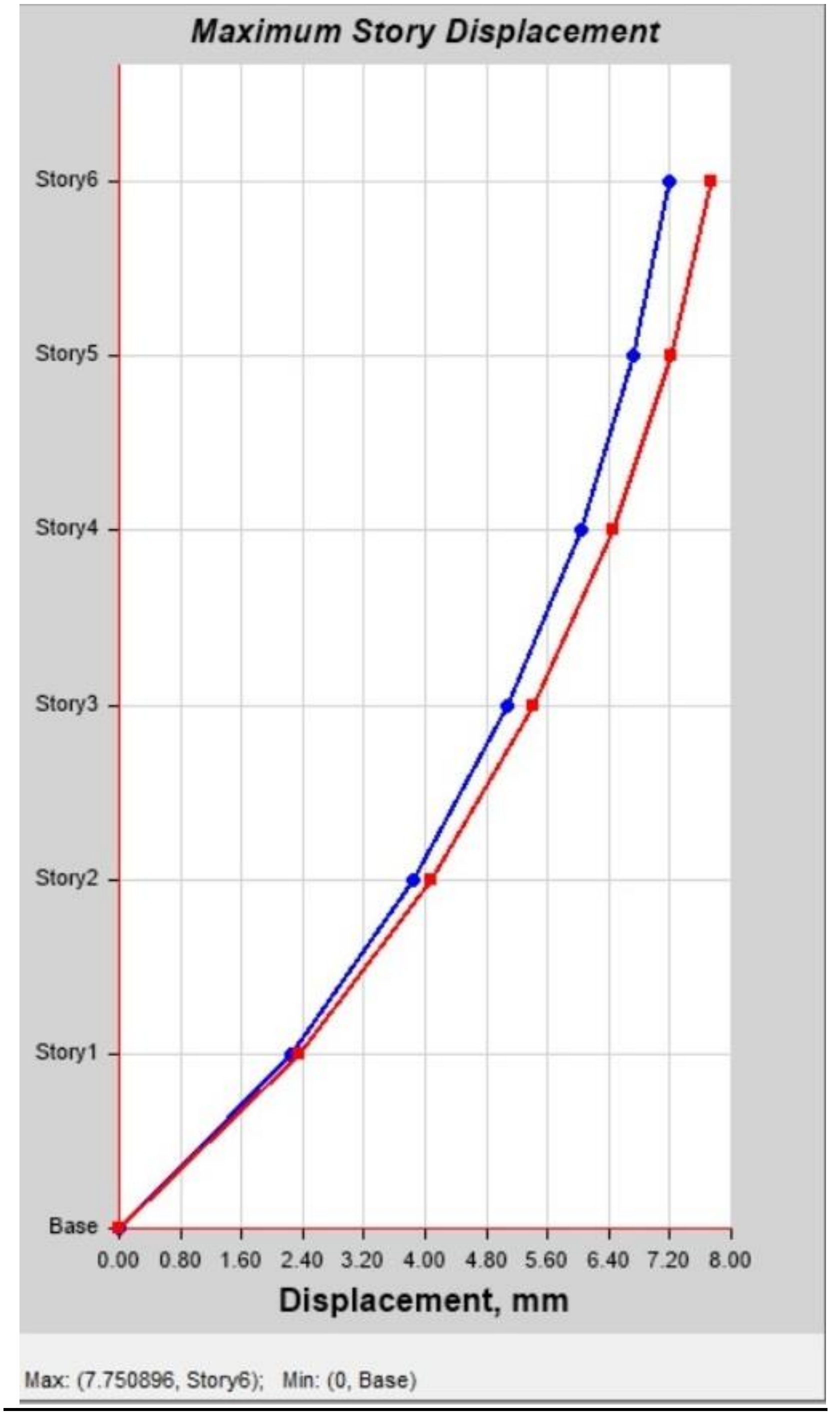
Table 5.11 gives time period and frequencies

Storey Shear



This gives the maximum force at storey height which is max value of (78.19273 KN)

<u>Storey Displacement</u>



The maximum value of displacement is on Storey 6 with value (7.750896).

Time History Values

The values of model mass participation rations and model period and frequencies are given below.

5.12 Model Mass Participation Rations

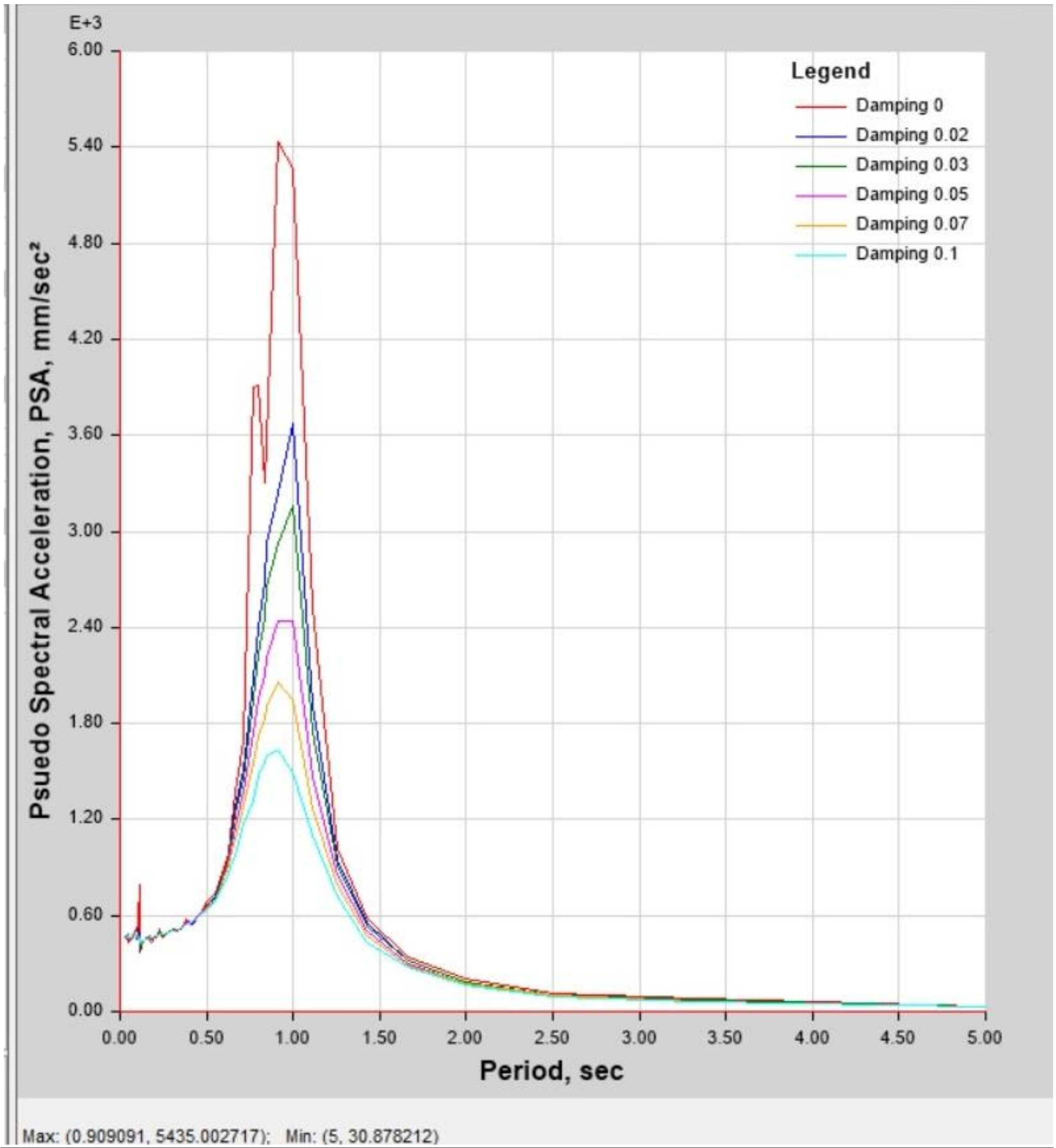
Case	Mode	Period sec	UX	UY	UZ	SumUX	SumUY	SumUZ	RX	RY	RZ	SumRX	SumRY	SumRZ
Modal	1	0.85	0	0.8971	0	0	0.8971	0	0.113	0	0	0.113	0	0
Modal	2	0.798	0.9005	0	0	0.9005	0.8971	0	0	0.1092	0	0.113	0.1092	0
Modal	3	0.639	0	0	0	0.9005	0.8971	0	0	0	0.8964	0.113	0.1092	0.8964
Modal	4	0.236	0	0.0713	0	0.9005	0.9684	0	0.7628	0	0	0.8757	0.1092	0.8964
Modal	5	0.225	0.0695	0	0	0.97	0.9684	0	0	0.7731	0	0.8757	0.8823	0.8964
Modal	6	0.175	0	0	0	0.97	0.9684	0	0	0	0.0708	0.8757	0.8823	0.9672
Modal	7	0.112	0	0.0202	0	0.97	0.9886	0	0.0656	0	0	0.9413	0.8823	0.9672
Modal	8	0.109	0.0192	0	0	0.9893	0.9886	0	0	0.0607	0	0.9413	0.943	0.9672
Modal	9	0.083	0	0	0	0.9893	0.9886	0	0	0	0.021	0.9413	0.943	0.9882
Modal	10	0.066	0	0.0079	0	0.9893	0.9965	0	0.0443	0	0	0.9856	0.943	0.9882
Modal	11	0.064	0.0074	0	0	0.9967	0.9965	0	0	0.0436	0	0.9856	0.9865	0.9882
Modal	12	0.048	0	0	0	0.9967	0.9965	0	0	0	0.0082	0.9856	0.9865	0.9964

5.13 Model Period and Frequencies

Case	Mode	Period sec	Frequency cyc/sec	CircFreq rad/sec	Eigenvalue rad^2/sec^2
Modal	1	0.85	1.176	7.389	54.5969
Modal	2	0.798	1.253	7.871	61.9519
Modal	3	0.639	1.565	9.8322	96.6728
Modal	4	0.236	4.239	26.6358	709.4673
Modal	5	0.225	4.453	27.9782	782.7784
Modal	6	0.175	5.703	35.8353	1284.1671
Modal	7	0.112	8.9	55.9207	3127.13
Modal	8	0.109	9.188	57.7299	3332.738
Modal	9	0.083	12.01	75.4618	5694.4773
Modal	10	0.066	15.256	95.8561	9188.391
Modal	11	0.064	15.53	97.5781	9521.4833
Modal	12	0.048	20.705	130.0908	16923.6263

Time history Curves

This is the plot of spectral acceleration and time period in X and Y direction respectively. various damping values are considered.



CHAPTER 6

SUMMARY

In this thesis ,a structure of G+5 storey building was analyzed by equivalent static analysis and Response Spectrum analysis. The bare frame and knee braced frame are analyzed in order to check out the storey drift as per IS 1893:2002. The model of base length 9m and width 9m for a typical storey height of 3m of each storey in building. The joints between beams and columns are fixed. The column at ground level is fixed support with zero displacement. The Beam ISLB200, Column ISHB 250 and Bracings ISMB175. Equivalent static analysis is done by manually for base shear and lateral displacement. The software used in this project was ETABS, the pushover analysis and response spectrum analysis has done. The result of their storey drift, and storey displacement are plotted both of bare frame and knee braced frame.

CONCLUSIONS

From the above study, the following conclusions were made:

- The seismic behavior on G+5 structural model with bare frame and knee frame bracing arrangements for analysis.
- The inter storey drift in X-direction is more compared to permissible drift ratio as per IS code 1893:2002.
- The knee braced frame system is significant to reduce the effect on lateral displacement by spectral acceleration (Sa).
- The inter storey drift in Y-direction is far compared to permissible drift.
- The knee bracing frame structural inter storey drift is acceptable as per IS code 1893:2002.

FUTURE SCOPE OF WORK

- This analysis was conducted to find out comparison between seismic parameters such as base shear, roof displacement, time period, storey drift, storey displacement for steel bare frame with knee braced patterns are studied
- A comparative study can also be carried out by altering the structural member sizes, and comparing its performance.
- In this moment resisting steel bare frame with knee bracing patterns are analyzed using pushover analysis, equivalent static analysis, response spectrum analysis.

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