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"A COMPARISION OF EARTHQUAKE RESISTANT BUILDINGS IN ZONE IV & ZONE V USING ETAB"

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ABSTRACT

Reinforced concrete (RC) buildings are routinely designed and detailed to have somewhat higher strengths than those required for actual service load conditions. Analysis of several past numerous seismic tremors have demonstrated that building structures have the capacity to manage without any harm the seismic constraints bigger than those, they were intended for during design. Generally, the members are provided with larger sizes and greater material strengths than the minimum design requirements a stipulated in the building design codes. The present design procedures for seismic design also results in greater strengths. Moreover, the redundancy in the structure on account of in redistribution of stresses will also lead to increased overall strength. This study deals with the comparison of design base shear of three RC framed buildings with varying storey heights and STOREY drifts in different Indian seismic zones.

Comparison of G+8 earthquake resistant building in two zone-iv and zone-v using Etabs. IS code for dead load IS 875 (part-1), for live load IS 875 (part-2), for concrete design IS 456-2000 and for earthquake IS-1893-2002 (part-1).

CHAPTER 1
INTRODUCTION

INTRODUCTION

1.1 GENERAL

Earthquake is any sudden shaking of the ground caused by the passage of seismic waves through Earth's rocks. Seismic waves are produced when some form of energy stored in Earth's crust is suddenly released, usually when masses of rock straining against one another suddenly fracture and "slip." Earthquakes occur most often along geologic faults, narrow zones where rock masses move in relation to one another. The major fault lines of the world are located at the fringes of the huge tectonic plates that make up Earth's crust.

Little was understood about earthquakes until the emergence of seismology at the beginning of the 20th century. Seismology, which involves the scientific study of all aspects of earthquakes, has yielded answers to such long-standing questions as why and how earthquakes occur.

About 50,000 earthquakes large enough to be noticed without the aid of instruments occur annually over the entire Earth. Of these, approximately 100 are of sufficient size to produce substantial damage if their centers are near areas of habitation. Very great earthquakes occur on average about once per year. Over the centuries they have been responsible for millions of deaths and an incalculable amount of damage to property.

1.2 SEISMIC DESIGN PHILOSOPHY

A severe earthquake is one of the most destructive phenomena of nature. It is quite impossible to precisely predict and prevent an earthquake, but the damage to a structure can be reduced by its proper design. Hence it is prudent to do the seismic analysis and design to prevent structures against any catastrophe. The severity of the damage depends on the combination of several factors such as- earthquake magnitude, proximity to epicenter, and the local geological conditions, which affect the seismic wave propagation. The lateral forces due to earthquake cause the maximum problem for structures.

Earthquake resistant design is thereby primarily concerned with limiting the seismic risk associated with man-made structures to socio-economically acceptable levels. It aims to foresee the potential consequences of an earthquake on civil infrastructure and to ensure the design & construction of buildings complies with design codes in order to maintain a reasonable level of performance with some accepted level of damage during an earthquake exposure, The ductility of a structure acts like a shock absorber and helps in dissipating a certain amount of seismic energy.

1.3 BACKGROUND AND MOTIVATION OF THE PRESENT STUDY

The present work in its utmost sense, tries to delineate that what will be the changes in the structural design of buildings with variation in the seismic zones. It helps in giving a generalized sense of design and detailing differences that will be taking place with the increment in probable severity of ground motions. Thereby, aiding in developing a general perception about the design of regular RC buildings particularly in India. Jain et al. (2008), has done the detailing comparison for some selected members of a six-storey building. The similar idea has been used in this work as well, the buildings in various zone have been considered as per IS 456. This study moreover, attempts to do a comparison of the base shear, STOREY drifts of the buildings for all the various zones.so as to give further insights into the design aspects. Kumar et al. (2013) has carried out such comparison for all components of a G+8 building.

For determination of seismic forces, the country is classified in four seismic zones

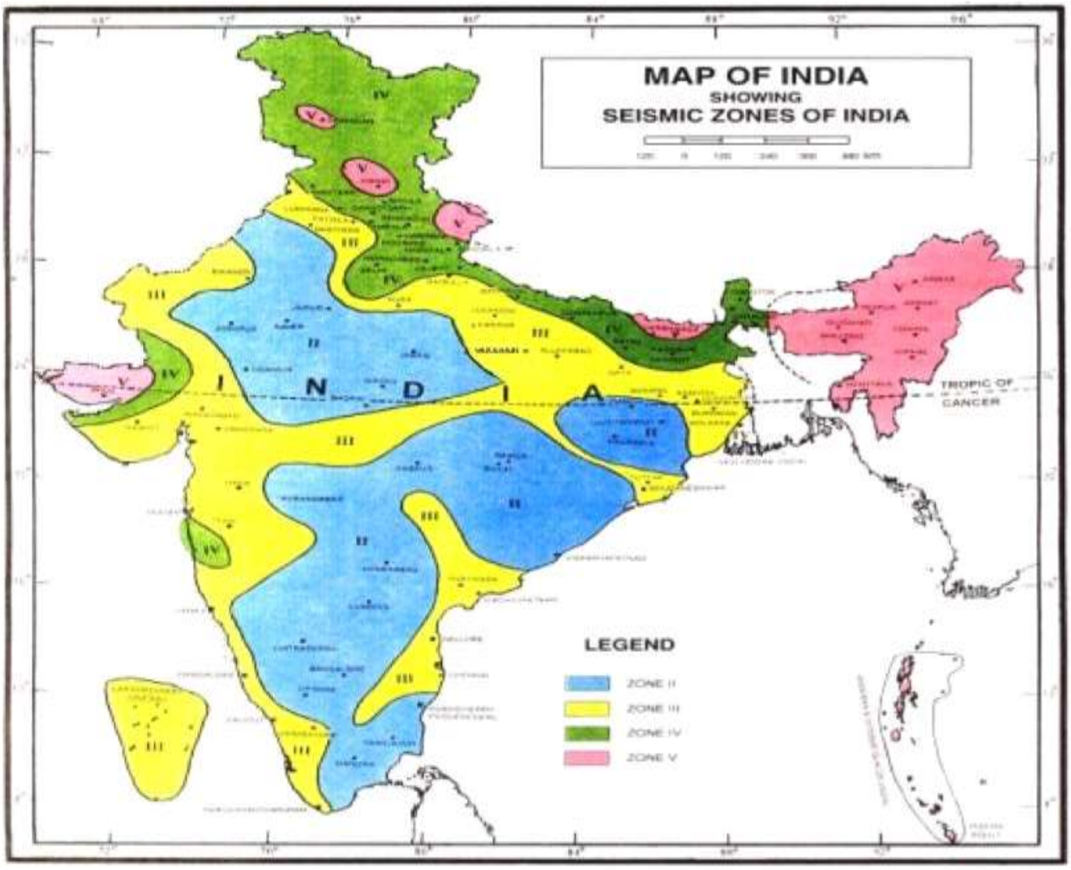


Fig 1.1 shows seismic zones of India *(ref., IS 1893:2002)*

1.4 OBJECTIVES OF THE STUDY

This work attempts to evaluate effect of change of seismic zones on the design and performance of the building. Modelling and Analysis of G+8 storey earthquake resistant building. The work includes comparison of Base Shear, Storey Drifts, Storey Shears, Maximum Storey Displacement, Storey Stiffness, Storey Overturning Moment for different models.

1.5 ORGANISATION OF THE THESIS

The organization of forthcoming chapters is done as explained below-

i. Literature review on Seismic design of buildings.

ii. Methodology of the Study

iii. Modeling of the Plan

iv. consists of discussion of results and comparison of this study is dealt with.

v. It consists conclusion and future of the work of this study.

CHAPTER -2
LITERATURE REVIEW

LITERATURE REVIEW

• Harshitha M N, Binod Kumar, Rajiv Kumar Chaudray, Saurabh Singh, Shivam Shivhar "Study on Analysis and Design of a Commercial Building".

This paper investigates about the Analysis and Design of a Commercial Building by using ETABS software and also gain sufficient knowledge in complete Analysis and Design Procedure. In this research they checked on G+4 Commercial Building frame made up of Reinforced Concrete. Providing with all necessary specifications. This project mostly stressed on Indian Standard Code Books and National Building Code (NBC) because planning and design of any building will be recognized as per the standards by these design aids. This paper provides information about the design procedure Analysis Results i.e. Shear Force, Bending Moment, Deflections etc. and various IS Code books.

• Rohith kumar, B.R. Sachin, P.Dyavappanavar, Sushmita N.J, Sunitha, Vinayak.Yadavad " Analysis and design of Multi Storey Structure using Etabs"

This project investigates that most buildings are of straight forward geometry with horizontal beams and vertical columns. Although any building configuration is possible with ETABS in most cases, a simple rigid system defined by horizontal floors and vertical columns lines can establish building geometry with minimum effort, most of the floors level in buildings are similar. This can reduce the modeling and design time. The main aim of this project is to complete a multi storey building and to ensure that the structure is safe against gravity loading conditions and to fulfill the function for which the structures have been built for the design of structure dead loads and live loads have been considered. The analysis and design of the structure is done by using Etabs Software and also with the confirmation of IS 456-2000.

• Prof.Dr.H.J.Shah, Prof.Dr.Sudhir K Jain "Seismic Analysis and Design of a Six Storey Building"

This Project has been developed by using Building Codes. In this paper the structure designed is used for exhibition an art gallery. It is the expanded with the existing building site therefore analysis and design is for this building is performed. Based on the span of structural member in each floor Dimension are found. Also they used M25, M30 Grade concrete, Fe-415steel, L.L. and D.L. Seismic Load as per the IS:1893-2016.Analysis and complete Design of structure is completed in step-by-step procedure

• Varikuppala Krishna, Chandrashekhar, Rajashekhar "Analysis and design of Multistoried Building by using Etabs".

This research paper explains about how structural engineers are facing the challenge of striving for the most efficient and economical design with accuracy in solution ensuring that the final design of a building must be serviceable for its intended function over its designed life span. In this project they assumed parking+5 stories RCC framed building analyzed and designed under the Lateral load effect of wind and earthquake using ETABS. Etabs is incorporated with all major analysis engine that is static, dynamic, Linear, Nonlinear etc. are used to analyze and design especially in case of buildings. Because of facilities provided in software at the modeling stage the building can be modeled as per the arrangement of members of the project in practical considerations. They also considered various seismic and gravity forces during calculations as per IS code.

• Dhinakaran P, Logesh K, Srinivasan .V, Vineeth B, "Planning Analysis and Design of Shopping Mall"

This paper investigates about the engineered designed process. The buildings which are being constructed are gaining significance, in general, those with the best possible outcomes which are referred to members. This paper aims to analyze a high rise building of 30 floors by considering seismic, dead loads and live loads. The design criteria for high rise building strength, serviceability and stability. The version of the software used is etabs-16 In the present study they determined the effects of lateral loads on moments, shear force, axial force, base shear maximum displacement and tensile forces on structural system are subjected and also comparing of seismic of zones 2 3 4.

• P. Jayachandran, "Design of tall Buildings Preliminary Design and Optimization",

The Design of Tall Buildings essentially involves a conceptual design, approximate analysis, preliminary design and optimization, to safely carry gravity and lateral loads. The design criteria are, strength, serviceability, stability and human comfort. The strength is satisfied by limit stresses, while serviceability is satisfied by drift limits in the range of H/500 to H/1000. Stability is satisfied by sufficient factor of safety against buckling and P-Delta effects. The factor of safety is around 1.67 to 1.92. The human comfort aspects are satisfied by accelerations in the range of 10 to 25 milli-g. The aim of the Structural Engineer is to arrive at suitable structural schemes, to satisfy these criteria, and assess their structural weights in weight/unit area in square feet or square meters. This initiates structural drawings and specifications to enable Construction Engineers to proceed with fabrication and erection operations. The weight of steel in lbs/sqft or in kg/sqm is often a parameter the Architects and Construction Managers are looking for from the Structural Engineer. This includes the weights of floor system, girders, braces and columns. The premium for wind, is optimized to yield drifts in the range of H/500, where H is the height of the tall building. Here in, some aspects of the design of gravity system, and the lateral system, are explored.

The design issues for preliminary design and optimization have been briefly summarized, and a rational methodology of Design was shown. This enables optimization of initial structural systems for drift and stresses, based on gravity and lateral loads. Some insight into the design of many types of Tall Building Structural Systems and their subsystems was provided based on past experience in Tall Building Design.

• Minisik Bang and Jaehong Lee "An Analytical Model For High-Rise Wall-Frame Building Structures"

In this project, the governing equations of a wall-frame building are formulated through the continuum approach and the whole structure is idealized as a shear–flexural cantilever. The effect of shear deformation of the wall and flexural deformation of the frame are considered and incorporated in the formulation of the governing equations. A displacement-based one-dimensional finite element model is developed to predict lateral drift of wall-frame structures under horizontal loads. Numerical results are obtained and compared with previously available results and the values obtained from the finite element package MIDAS. The study indicates that the effect of shear deformation of the wall as well as the flexural deformation of the frame should be considered especially for tall and/or slender buildings. The proposed method is found to be simple and efficient provides reasonably accurate results in early design stage of tall building structures.

An analytical model was developed to study the deflection of wall-frame structures. The model is capable of predicting accurate deflection for various configuration including core types and aspect ratios of the structures. To formulate the problem, a one-dimensional displacement-based finite element method is employed. Based on the theoretical developments and numerical results, the following concluding remarks can be made:

(i). The previous conventional model, which neglects the shear deformation of the wall and the flexural deformation of the frame, overestimates the shear rigidity of the wall and the flexural rigidity of the frame. Accordingly, the model significantly underestimates the lateral deflection of the wall frame structures.

(ii). The analytical model, which considers the shear deformation of the wall and neglects the flexural deformation of the frame, gives the better results than the conventional model, yet yields remarkable discrepancy in lateral deflection with MIDAS model.

(iii). The analytical model, which considers both the shear deformation of the wall and the flexural deformation of the frame, shows excellent agreement with MIDAS solution for all the types of wall-frame structures considered. That is, the model can give sufficiently accurate results with considerably less efforts and time.

(iv). As the aspect ratio of the building structure gets higher, the upper part of the structure is rather not governed by shear mode, but by flexural and shear mode equally. Accordingly, neglecting the flexural deformation of the frame can yield significant error in computing the lateral deflection, and the proposed analytical model should be employed. The approximate method of analysis is valuable in providing a fundamental understanding of the behavior of a tall building structure and in allowing the initial sizing of primary members as part of the preliminary design process. The proposed analytical model is found to be very accurate and efficient for the analysis of the behavior of a wall-frame structure. As a natural extension of this research, a model which incorporates the twisting deformation or P-delta effect awaits further attention.

CHAPTER 3
METHODOLOGY

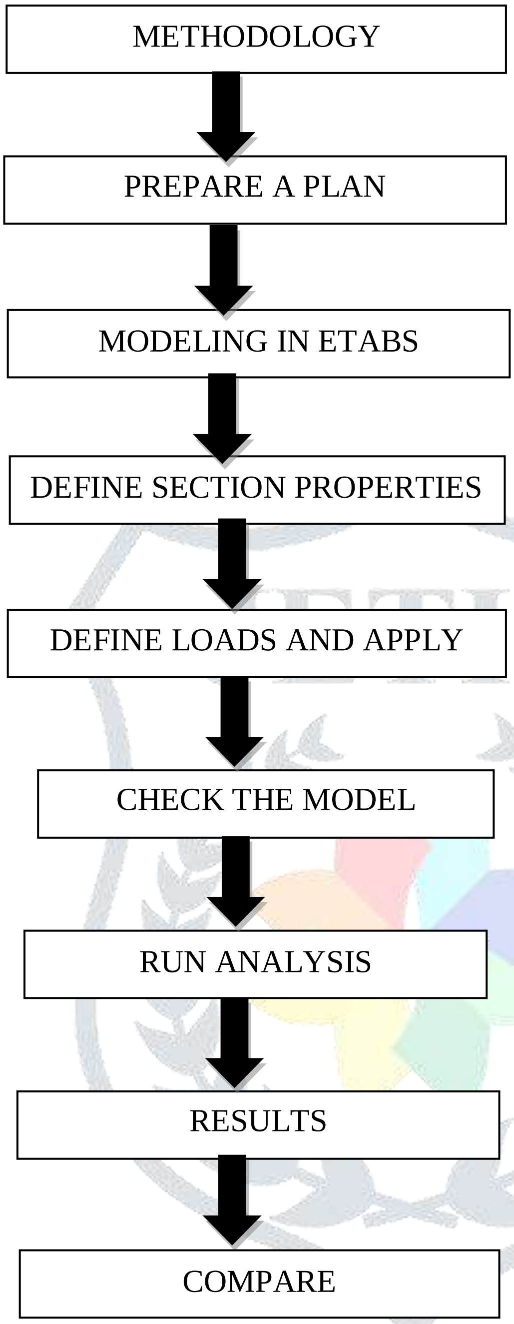
METHODOLOGY

3.1 General

The current study involves analyzing of the parametric study which were done for specific high me building without floating column and with floating column at different location of building and constant shear walls at specific location, special moment resisting frame multistorey building is situated at zone 4 and 5 of seismic zone.

The building is modelled using the software ETABS. floating column is very essential in multistorey building but providing them at seismic zone the structure may collapse so shear wall is also used to provide stiffness. The building selected is G+8 in seismic zone 4 and 5, the parameter such as base shear, maximum moment, storey shear, Storey Drift, Overturning Moment, Storey Stiffness, Maximum Storey Displacement.

The modelling of the buildings is done using AutoCAD and ETABS software, the codes used for the design are the IS 456-2000 and IS 1893-2016(part1), IS 875(Part-1 and Part-2)



METHODOLOGY OF THE STUDY

3.2 AutoCAD

AutoCAD is powerful software licensed by auto desk. The word auto came from auto desk company and cad stands for computer aided design. AutoCAD is used for drawing different layouts, details, plans, elevations, sections and different sections can be shown in AutoCAD.

It is very useful software for civil, mechanical and also electrical engineer. The importance of this software makes every engineer a compulsion to learn this software's. We used AutoCAD for drawing the plan, elevation of a residential building. We also used AutoCAD to show the reinforcement details and design details of a stair case. 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.

AutoCAD allows the designer to use and manage it on multiple machines using network licensing. Being an easily available program, AutoCAD is used globally by students, teachers, architects, freelancers, engineers, fashion designers. Like other CAD programs, AutoCAD also works on a database of geometric systems, including points, lines, arcs, etc. The user works on the application through the commands; editing or drawing is done from the inbuilt command line. AutoCAD is issued free of cost to students, educators, and institutions.

AutoCAD is globally used by surveyors, designers, engineers, drafters. Globally, AutoCAD has proven as an efficient and user-friendly program. Commercial drafting and computer-aided design (CAD) software applications are AutoCAD. AutoCAD software is recognized internationally for its remarkable editing capabilities, which make it likely to digitally draw building plans or recreate 3D images. This software was developed in the year 1982 by Autodesk.

Highlights of AutoCAD

Before the invention of AutoCAD, all designing and modeling were done manually. This was a time-consuming task and resulted in a lot of costly errors. But, with the invention of AutoCAD, the process of modeling and designing got digitalized and simplified. A technology that has emerged as a solution to most of the designers, engineers, and architects.

Some of the most powerful components of AutoCAD are-

- The designers and architects can create accurate models, sketches, and drawings with AutoCAD. This is next to impossible when done manually.
- With the introduction to AutoCAD, the user can even model 3D objects with colors & materials that can be applied to various surfaces, making it simpler for the user to anticipate the outcome, which cannot be fulfilled in manual 3D sketches.
- Creating drawings manually is a time-consuming task. When designers create drawings on a digital platform with computer software, they get the benefit of the application interface. Editing is also easy with AutoCAD as it has many editing commands.
- AutoCAD is an advanced program that has default commands incorporated in the application. With these commands, the users can edit and change their files without any limitations.

3.3 ETABS (Extended Three Dimensional Analysis of building System)

ETABS is an engineering software product that caters to multi-story building analysis and design. Modeling tools and templates, code-based load prescriptions, analysis methods and solution techniques, all coordinate with the grid-like geometry unique to this class of structure. Basic or advanced systems under static or dynamic conditions may be evaluated using ETABS. For a sophisticated assessment of seismic performance, modal and direct-integration time-history analyses may couple with P-Delta and Large Displacement effects. Nonlinear links and concentrated PMM or fiber hinges may capture material nonlinearity under monotonic or hysteretic behavior. Intuitive and integrated features make applications of any complexity practical to implement. Interoperability with a series of design and documentation platforms makes ETABS a coordinated and productive tool for designs which range from simple 2D frames to elaborate modern high-rises.

Modeling of Structural Systems

Fundamental to ETABS modeling is the generalization that multi-story buildings typically consist of identical or similar floor plans that repeat in the vertical direction. Modeling features that streamline analytical-model generation, and simulate advanced seismic systems, are listed as follows:

- Templates for global-system and local-element modeling
- Customized section geometry and constitutive behavior
- Grouping of frame and shell objects
- Link assignment for modeling isolators, dampers, and other advanced seismic systems
- Nonlinear hinge specification
- Automatic meshing with manual options
- Editing and assignment features for plan, elevation, and 3D views

Loading, Analysis, and Design

Once modeling is complete, ETABS automatically generates and assigns code-based loading conditions for gravity, seismic, wind, and thermal forces. Users may specify an unlimited number of load cases and combinations.
Analysis capabilities then offer advanced nonlinear methods for characterization of static-pushover and dynamic response. Dynamic considerations may include modal, response-spectrum, or time-history analysis. P-delta effect account for geometric nonlinearity.
Given enveloping specification, design features will automatically size elements and systems, design reinforcing schemes, and otherwise optimize the structure according to desired performance measures.

Output, Interoperability, and Versatility

Output and display formats are also practical and intuitive. Moment, shear, and axial force diagrams, presented in 2D and 3D views with corresponding data sets, may be organized into customizable reports. Also available are detailed section cuts depicting various local response measures. Global perspectives depicting static displaced configurations or video animations of time-history response are available as well.

ETABS also features interoperability with related software products, providing for the import of architectural models from various technical drawing software, or export to various platforms and file formats. SAFE, the floor and foundation slab design software with post-tensioning (PT) capability, is one such option for export. CSI coordinated SAFE to be used in conjunction with ETABS such that engineers could more thoroughly detail, analyze, and design the individual levels of an ETABS model.

3.4 LOAD COMBINATIONS

A load combination results when more than one load type act on the structure. Building codes usually specify a variety of load combinations together with load factors for each load type in order to ensure the safety of the structure under different maximum expected loadings scenarios. For example, in design of staircase, a dead load factor be 1.2 times the weight of the structure. And live load factor may be 1.5 times the maximum expected live load. These two factored loads are combined to determine the required strength of the staircase. It is less likely that the structure will experience much change in its permanent load.

1. 1.5 (DL + LL)
2. 1.5 (DL+ EQ X)
3. 1.5 (DL – EQ X)
4. 1.5 (DL + EQ Y)
5. 1.5 (DL - EQ Y)
6. 1.2 (DL + LL + EQ X)
7. 1.2 (DL + LL – EQ X)
8. 1.2 (DL + LL + EQ Y)
9. 1.2 (DL + LL – EQ Y)
10. 0.9 DL + 1.5 EQ X
11. 0.9 DL - 1.5 EQ X
12. 0.9 DL + 1.5 EQ Y
13. 0.9 DL - 1.5 EQ Y

UN-FACTORED LOAD & SERVICE LOAD COMBINATIONS

3.6.1 GRAVITY LOAD COMBINATIONS

14. 1.0 (DL + LL)

3.6.2 SEISMIC LOAD COMBINATIONS

15. 1.0 (DL + EQ X)
16. 1.0 (DL – EQ X)
17. 1.0 (DL + EQ Y)
18. 1.0 (DL – EQ Y)
19. 1.0 DL + 0.8 (LL + EQ X)
20. 1.0 DL + 0.8 (LL – EQ X)
21. 1.0 DL + 0.8 (LL + EQ Y)
22. 1.0 DL + 0.8 (LL – EQ Y)

FOLLOWING COMBINATIONS ARE TO BE CONSIDERED AS PER CLAUSE 6.3.2.2 OF IS 1893 (PART 1):2002

3.6.3 GRAVITY LOAD COMBINATIONS

23. 1.2(DL+LL) +EQ X +0.36 EQY
24. 1.2(DL+LL)–EQ X + 0.36 EQY
25. 1.2 (DL+LL) + EQX - 0.36 EQY
26. 1.2 (DL + LL)–EQ X - 0.36 EQY
27. 1.5 (DL + EQ X) + 0.45 EQ Y
28. 1.5 (DL – EQ X) + 0.45 EQ Y
29. 1.5 (DL – EQ X) - 0.45 EQ Y
30. 1.5 (DL + EQ Y) + 0.45 EQ X
31. 1.5 (DL – EQ Y) + 0.45 EQ X
32. 1.5 (DL – EQ Y) - 0.45 EQ X
33. 1.0 DL+0.8 (LL+EQ X) +0.3EQY
34. 1.0(DL+0.8(LL+EQX)-0.3 EQY
35. 1.0 DL+0.8(LL+EQ Y) +0.3EQX
36. 1.0 DL+0.8(LL+EQY) - 0.3EQX
37. 1.0 (DL + EQ X) + 0.3 EQ Y
38. 1.0 (DL – EQ X) + 0.3 EQ Y
39. 1.0 (DL+ EQ X) - 0.3 EQ Y
40. 1.0(DL – EQ X - 0.3 EQ Y
41. 1.0 (DL + EQ Y) + 0.3 EQ X
42. 1.0 (DL + EQ Y) - 0.3 EQ X
43. 1.0 (DL – EQ Y) + 0.3 EQ X
44. 1.0 (DL – EQ Y) - 0.3 EQ X

CHAPTER-4
MODELING

MODELING

4.1 DATA FOR THE ANANLYSIS

Following data used in the analysis of the RC frame building model

TABLE 1 SUMMARIZED OF SPECIFICATIONS

Description	Information
Plan size	36.1m x 26.8m
Number of Basements below Ground	0
Number of Stories above Ground	G+8
Building Heights	24 m
Type of Structure	RC Framed Structure
Grade of Concrete	M25
Grade of Steel	Fe500
Software Used	AutoCAD and ETABS
Beam Dimensions	600mm x 300mm 500mm x 300mm
Column Dimensions	600mm x 400mm
Slab Thickness	150mm
Stair Dimensions Width Tread Riser	 1500mm 300mm 150mm

TABLE 2 (BUILDING DATA)

Specifications	8 storey
Unit Weight of Concrete	25 kN/m^3
Unit Weight of Steel	78.5 kN $/m^3$
Live Load	4 kN $/m^3$ and 5 kN $/m^3$
Dead Load of 300mm Walls	2.4x0.3x20= 14.4 kN $/m^3$
Floor Finish Load	1.5 kN $/m^3$
Importance Factor	1.0
Seismic zone Factor For zone IV For Zone V	 0.24 0.36
Response Reduction Factor	1.0
Soil Type	II (Medium)

4.2 Dynamic Study

Dynamic of structural building means when the dynamic loading is applied to the structure and the behavior of the structure is studied. In dynamic load analysis which act on structure is the load which is in moving nature or it is the load which changes with respect time Dynamic load includes people, wind, traffic, earthquake, and blast. Any structure can selected to dynamic loading

Static analysis is the method of analysis in which the load changes gradually with respect to time and in which inertia force can be neglected. Dynamic analysis is the method of analysis in which loading changes rapidly with respect to the time and in this analysis inertia force cannot be neglected.

In dynamic loading the natural frequency of the load changes rapidly when compared to the natural frequency of the structure and static loading changes slowly. In the time of earthquake. The natural frequency generated are very rapid and along with that their nature of occurrence is undetermined and cannot be calculated.

The time period in dynamic loading is uncertain and the time period for which earthquake may occurred in nature cannot be determined so to overcome this the structure should be such design that it can easily absorb all the lateral louds that they may affect the structure at the time of earthquake.

Computer model should be made for the structural analysis as it is the most critical part in the design of the real physical structure. There is various software through which analysis can be performed and accurate result can be obtained. In present study software used is ETABS for modelling and analyzing the building through various parameter, by using software finding of result become easy and with all the parameter such as base shear, displacement, maximum moment, peak storey shear. Area of steel reinforcement can be included. There is various dynamic analysis method, in this project response spectrum method is used

4.3 Parameters Consider

Dead Load:-

Dead lead of the structure is the overall weight of the structure itself. All the weight of the beam, slabs, column are considered inside the dead load. As the dead load of the structure is very heavy and the materials used under structure are very heavy which as a whole makes the structure mass. Calculation of dead load is very essential and almost care should be taken in consideration of dead load.

The dead load comprises of all the loads of the structure which is permanent in nature such as the weights of the partition wall, floor finish load,

For floors:

unit weight of reinforces cement concrete-25 kN/m^3

Unit weight of the steel is-78.5 kN/m^3

Imposed load:

Imposed load is the load that is movable load. It is temporary load that can change the one, location i.e. live load is the load which is produce due to the personal use of some occupant living the building, live load can be produced due to any furniture, any machine any kind of vibration, people moving from one place to another place etc,

Earthquake load:

Earthquake loads (E) should be calculated in accordance with the relevant code of the country which the plant is located in; but in general, UBC is the most popular code for earthquake load for the building, and ASCE07 is preferred for industrial structures as this code focuses on industrial structures.

The engineer is responsible for determining the earthquake loads used for the foundation design. Earthquake loads from vendors or other engineering disciplines should not be accepted without verification.

For low-friction slide plates ($\mu \leq 0.2$), all the longitudinal earthquake loads should be applied at the fixed pier. In case of higher friction slide plates ($\mu > 0.2$), 70% of the earthquake loads should be applied at the fixed pier. The earthquake loads in transverse and vertical should be distributed in proportion to the vertical load applied to both piers.

The piers are normally designed for the fixed end, and then the pier for the sliding end is made identically in order to avoid potential errors in construction and to reduce engineering time. If this proves to be uneconomical, the sliding end should be designed for 30% of the longitudinal earthquake load if using low-friction slide plates, and for 50% of the longitudinal earthquake load if using higher friction slide plates.

AUTOCAD PLAN

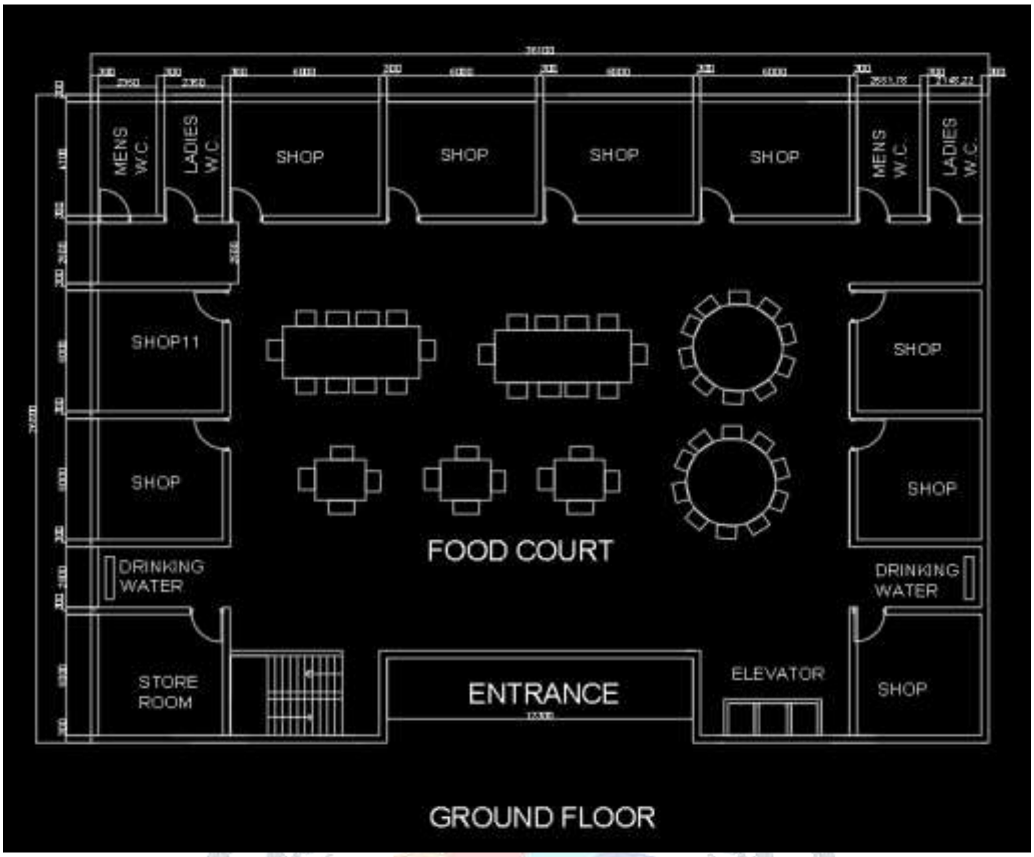


FIG-4.1 Plan of Ground Floor Building (all dimensions in mm)

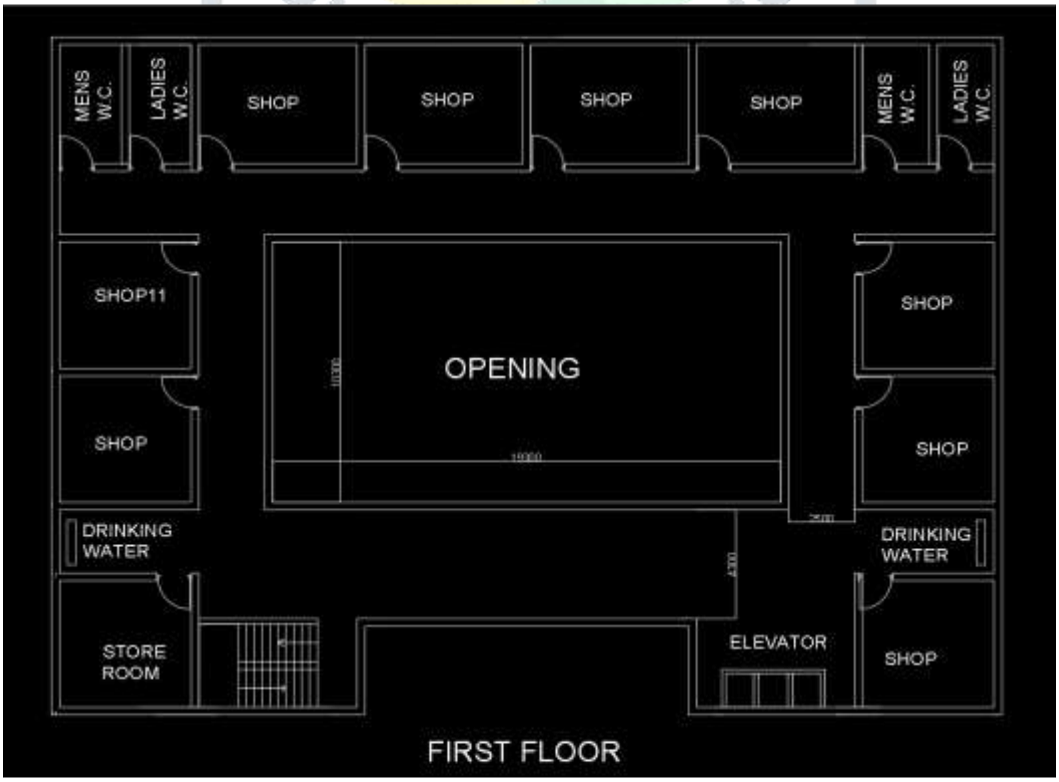


FIG-4.2Plan of 1st 2nd 3rd 4th 5th 6th 7th 8th floor Building (all dimensions in mm)

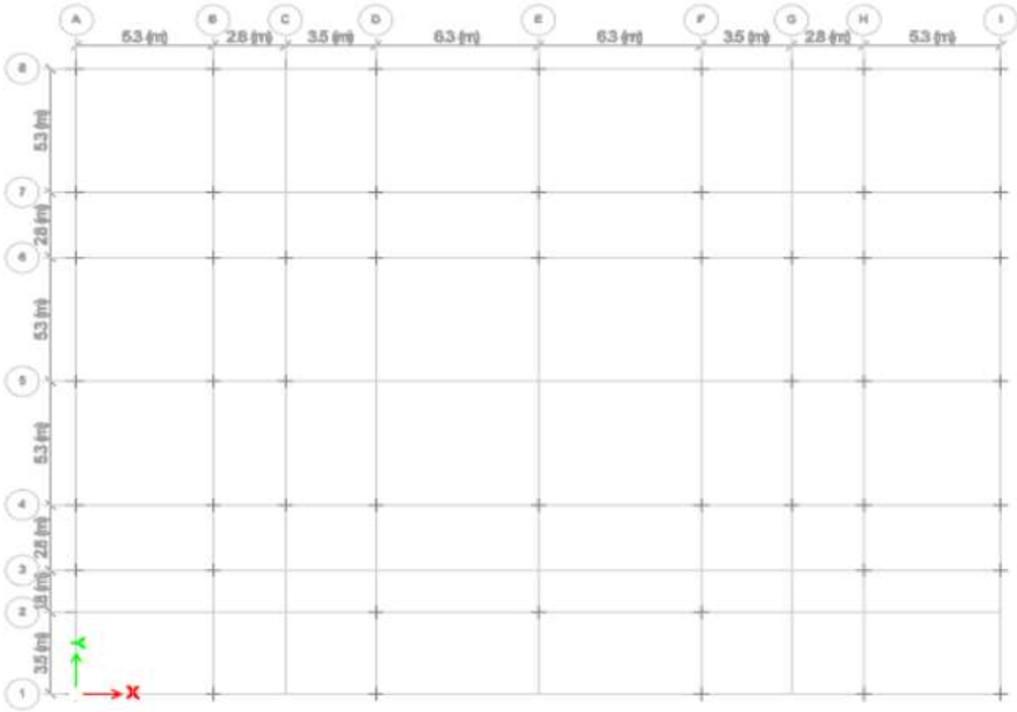


Fig-4.3 Centre Line Plan of Building from ETABS (all dimensions in m)

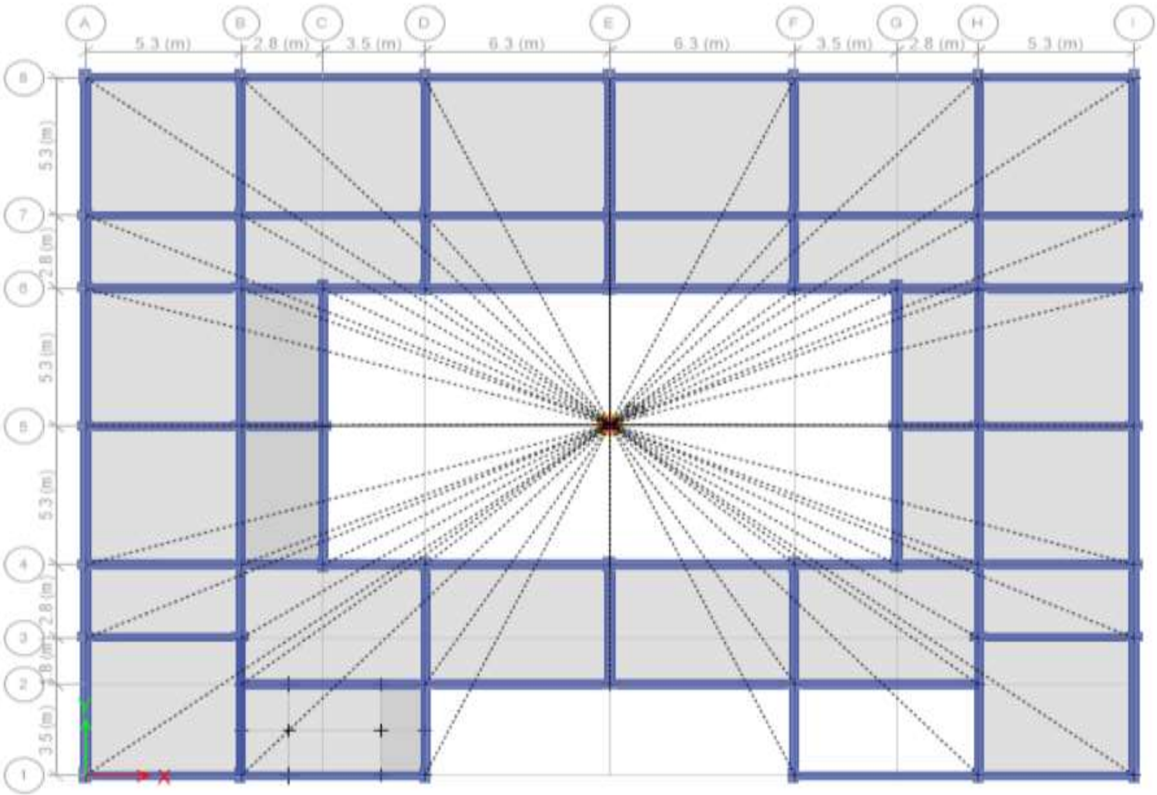


Fig 4.4 Plan of Building from ETABS

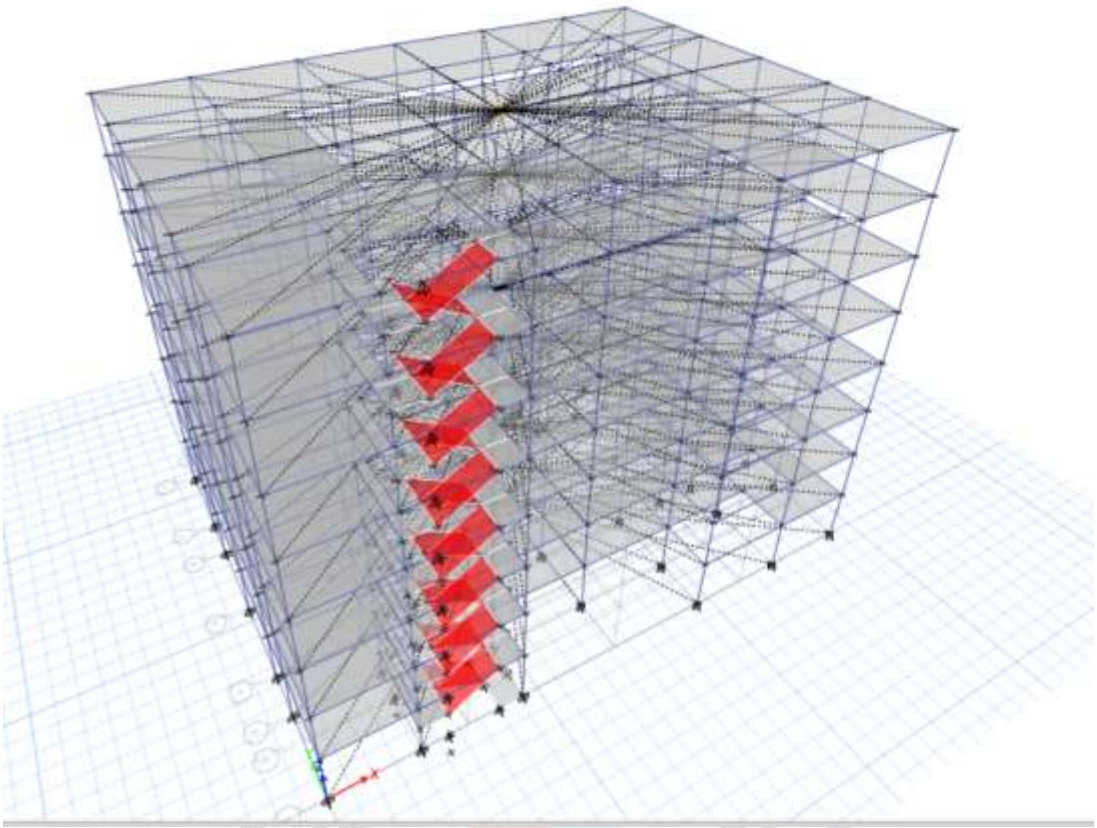


Fig 4.5 Diaphragm of Building

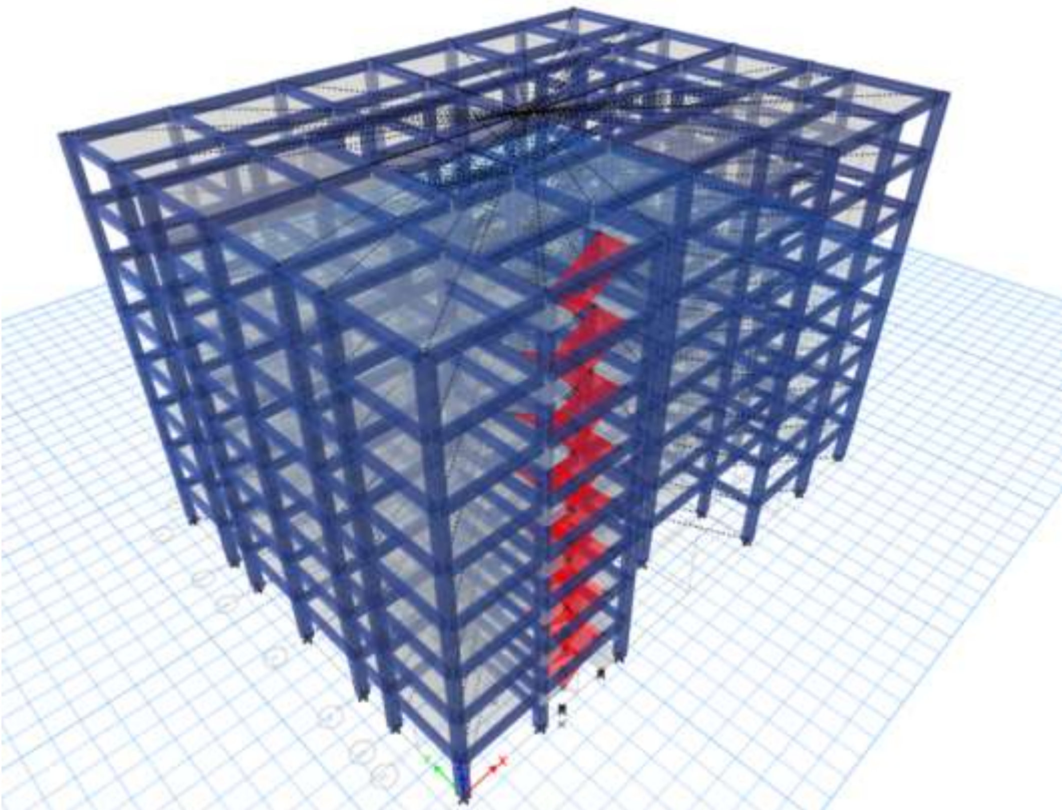


Fig 4.6-3-D views of (G+8) Building

CHAPTER-5
RESULTS
&
COMPARISION

RESULTS & COMPARISION

5.1 General

In order to fulfil the objectives, a building geometry with eight stories is chosen and designed as per different Indian seismic zones followed by a comparison of the design is presented in the Chapter.

5.2 Building Geometry and Design Considerations

The plan of the building frame considered the present study is shown in Fig 4.1. The building with the plan shown in this figure is considered for Eight storeys Building. Each of the building with their specific height are designed for all the seismic zones. The building designations with the seismic zone.

All the buildings are designed as per IS 1893 (2002) considering medium soil conditions.. The buildings in this study have column 3.5m, slab thickness 150mm as observed from the study of typical existing residential buildings. Considering unit weight of concrete as 25 kN /m^3 a weight of floor finishes to be 1.5kN/m^2, the slab dead load comes out to be 4.125kN/m^2. Taking the Live Load intensity as 4kN/m^2 for floor slabs and 1.5kN/m^2 for roof slabs into account, and the earthquake loads as per IS 1893(part-1); all the load combinations have been considered for analysis as in the code IS 1893(part-1). Buildings in various zones (IV, V) are designed considering them as OMRF and detailed according to IS: 456, the characteristic strength of concrete and steel are taken as 25MPa and 500MPa respectively.

In order to study the design and detailing of the buildings selected, structural analysis is carried out for vertical and lateral loads. The comparison of design base shear, STOREY drifts have been done. For all the three RC buildings, the following assumptions are made in this work-

•There is a common plan for all the buildings of dimensions 36.1 m x 26.8 m located on medium soil.

•The floor diaphragms are assumed to be rigid.

•For analysis and design centre line dimensions are considered.

- **Frame Geometry:-**

Buildings G+8 with heights are taken into consideration for the study and for each seismic zone separate modals were created in E-Tabs software.

- **EQUIVALENT STATIC ANALYSIS – AN OVERVIEW**

The equivalent static method is the simplest method of analysis. Here, force depend upon the fundamental period of structures defined by IS Code 1893:2002 with some changes. First, design base shear of complete building is calculated, and then distributed along the height of the building, based on formula provided in code. Also, it is suitable to apply only on buildings with regular distribution of mass and stiffness.

5.3 BASE SHEAR

Base shear is an estimate of the maximum expected lateral force on the base of the structure due to seismic activity.

- **Determination of Base shear**

The total design lateral force or design base shear along any principal direction is determined by the expression:

$$V = A_h W$$

Where

A_h = design horizontal seismic coefficient for a structure

W = seismic weight of building

The design horizontal seismic coefficient for a structure A is given by : Comparision Of Maximum Overturning Moment

$$A_h = (ZIS_a)/ 2Rg$$

Z is the zone factor in Table 2 of IS 1893:2002 (part 1). I is the importance factor,

R is the response reduction factor, S_a/g is the average response acceleration coefficient for rock and soil sites as given in figure 2 of IS 1893:2002 (part 1). The values are given for 5% damping of the structure.

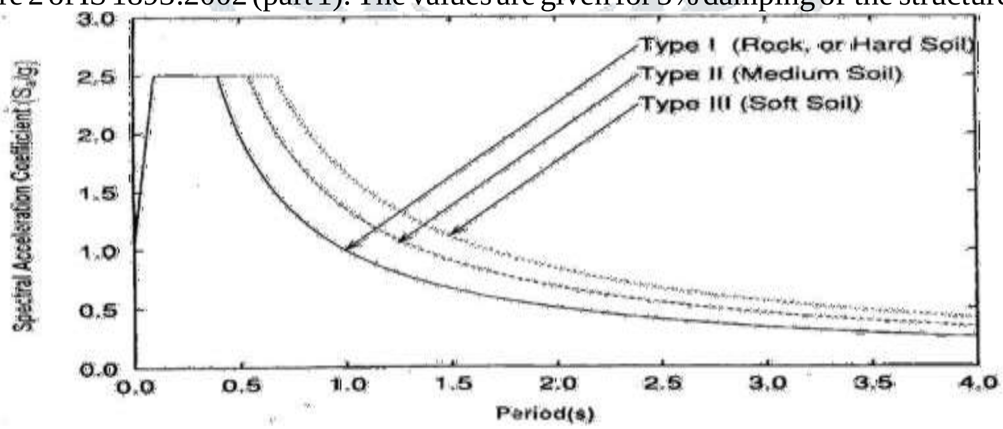


FIG- 5.1 Acceleration Coefficient

T is the fundamental natural period for buildings calculated as per clause 7.6 of IS 1893:2002 (part1).
Ta = 0.085h0.75 for Ta = 0.075h0.75 for moment resisting frame without brick infill walls
Ta = 0.085h0.75 for resisting steel frame building without brick infill walls Ta = 0.09h/√d for all other buildings including moment resisting RC frames
h is the height of the building in m and d is the base dimension of building at plinth level in m.
From the design base shear results, it can be clearly observed that there is a significant increase in Base shear as we move from zone IV to zone V, indicating the increase in severity of earthquakes occurring in these regions. Moreover, from the Fig it is evident that magnitude of design Base Shear increases with the increase in height of a building.

- **COMPARISON OF DESIGN BASESHEAR**

Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure. Calculations of base shear depend on:

- soil conditions
- proximity to sources of seismic activity (such as geological faults)
- probability of significant seismic ground motion
- the level of ductility and over-strength associated with various structural configurations and the total weight of the structure
- The fundamental (natural) period of vibration of the structure. The design base shear is calculated for all the different cases of varying storey heights and seismic zones as per equivalent static method (IS 1893, 2002).

5.4 STOREY SHEARS

Story shear is the graph showing how much lateral (read: horizontal) load, be it wind or seismic, is acting per story. The lower you go, the greater the shear becomes (see figure under story shear below).

Storey shear factor is the ratio of the story shear force when story collapse occurs to the story shear force when total collapse occurs. Through a series of dynamic analyses, simple equations are provisionally proposed to calculate the necessary story shear safety factor that can be used to prevent story collapse. When analyzing the effect of lateral loading on a multi-storey building due to seismic or wind loads, the storey shear and storey drift graphs tell a useful story. The storey shear graph shows the height-wise distribution of storey shears and lateral forces. A normalized storey shear graph has its shear values divided by the shear that occurs at ground level so that the normalized shear at that level is 1.0. It is therefore important to specify the ground level accurately in the form so that the graph is normalized to the correct shear.

5.4.1 IN ZONE IV

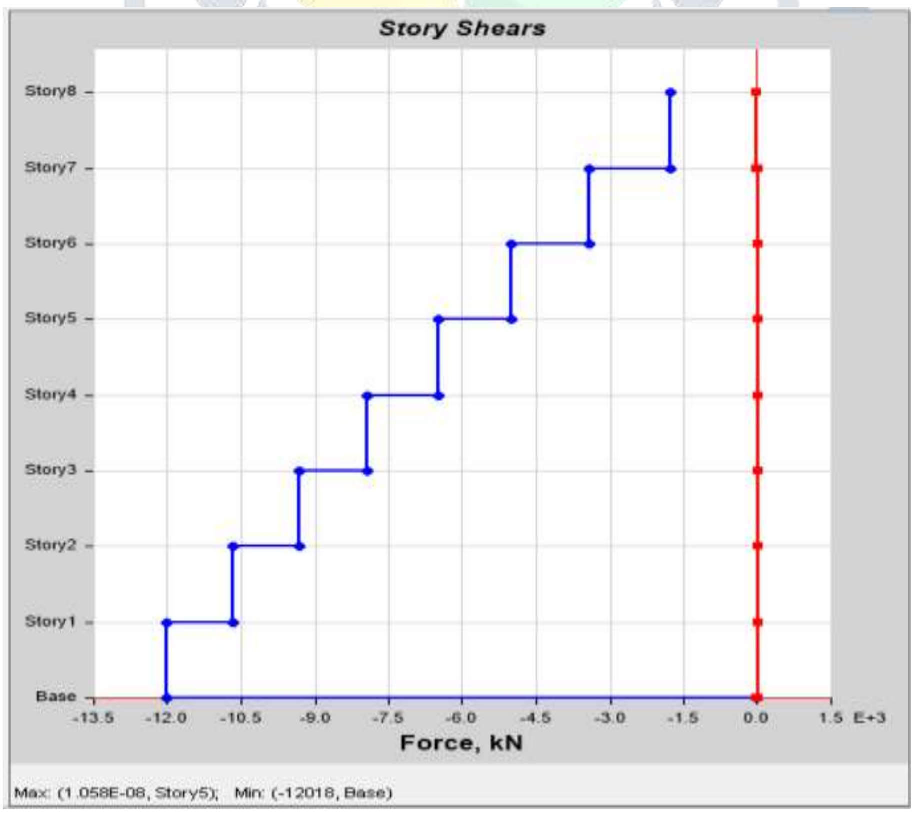


FIG-5.4.1a STOREY SHEARS IN ZONE-IV IN X-DIRECTION

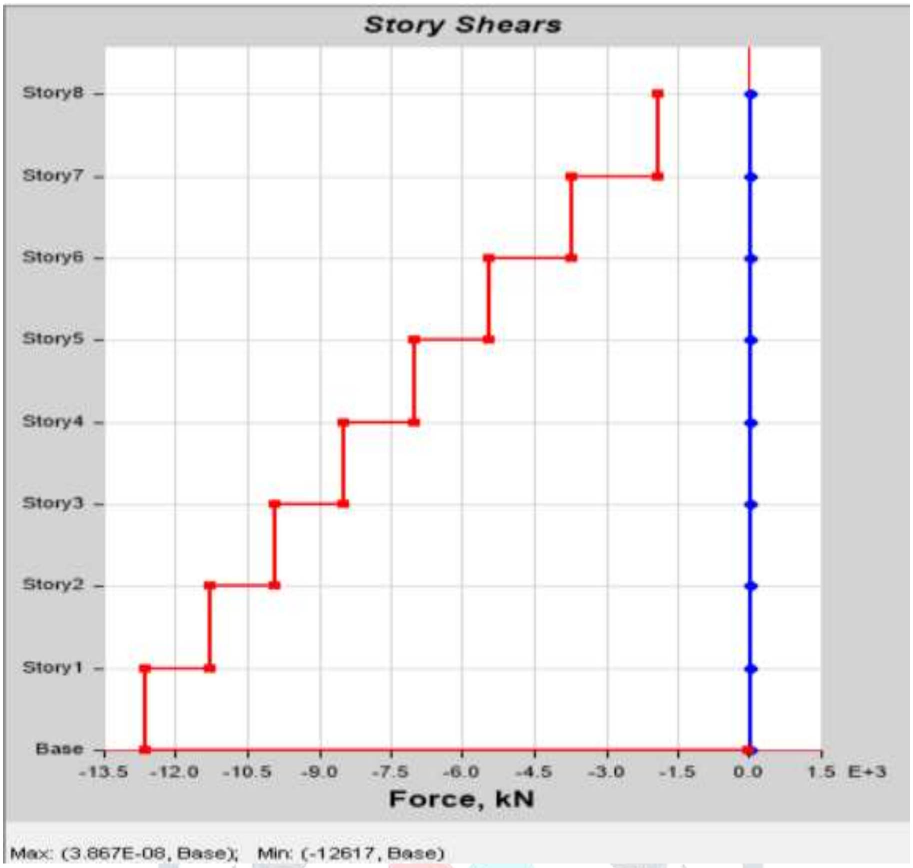


FIG-5.4.1b STOREY SHEARS IN ZONE-IV IN Y-DIRECTION

5.4.2 IN ZONE V

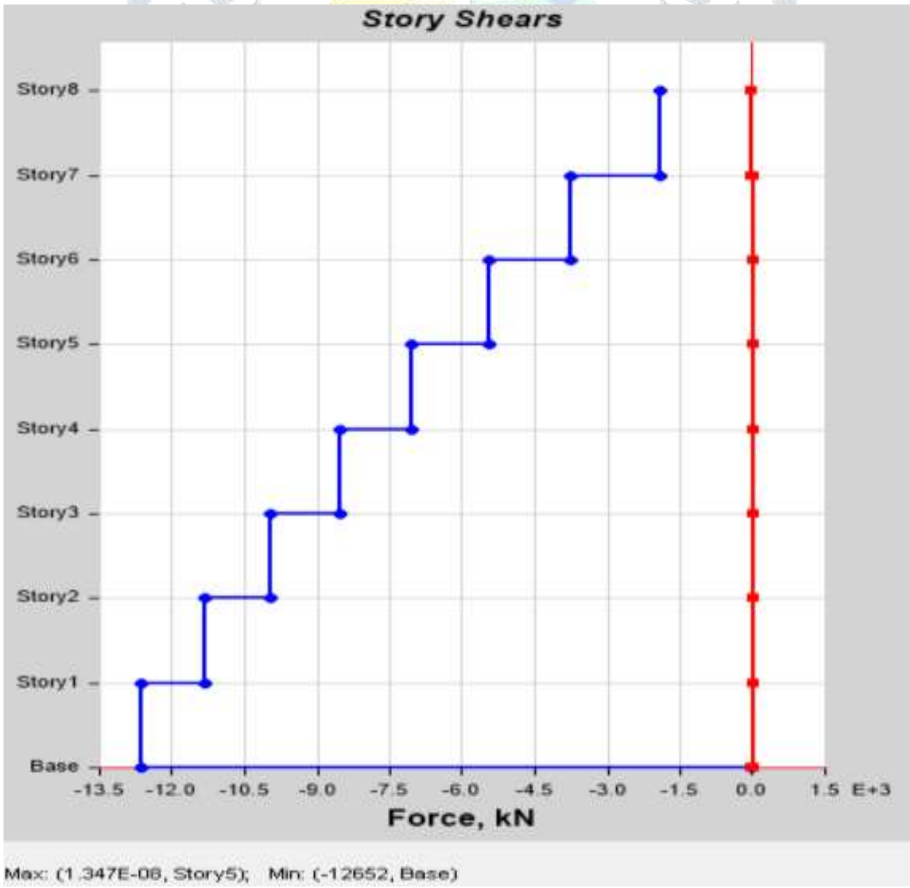


FIG-5.4.2a STOREY SHEARS IN ZONE-V IN X-DIRECTION

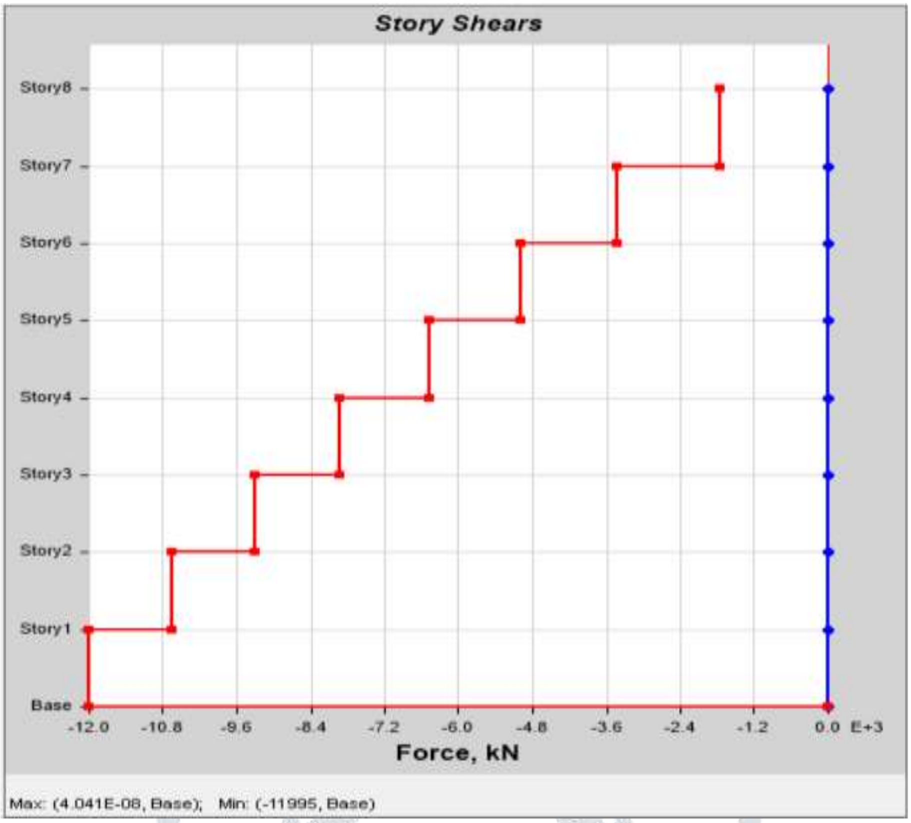


FIG-5.4.2b STOREY SHEARS IN ZONE-V IN Y-DIRECTION

5.5 STOREY DRIFT

When analyzing the effect of lateral loading on a multi-storey building due to seismic or wind loads, the storey shear and storey drift graphs tell a useful story. Storey drift is the lateral displacement of a floor relative to the floor below, and the storey drift ratio is the storey drift divided by the storey height. Seismic loading codes typically impose limits on storey drift as a percentage of the storey height and so the storey drift ratio is a useful quantity that can be directly compared with the code requirements. A storey drift ratio graph will show if particular floors are drifting more than others and highlight the fact that they may need stiffening.

Story drift is the difference of displacements between two consecutive stories divided by the height of that story. Story displacement is the absolute value of displacement of the storey under action of the lateral forces.

The importance of story drift is in design of partitions/ curtain walls. They must be so designed as to accommodate the storey drift, else they will crack. For structural glazing/ brick walls on external surfaces.

Drift is a very complex topic in structural engineering. It involves too many factors to arrive at a suitable decision. It involves engineering judgment, the phenomenon fresh engineers might not feel. In this article, I have tried to explain what is building drift, allowable limits, ways and means to check in ETABS models and to control the excessive drift. Please keep in mind, this article is not about the building drift as far as structural science is concerned, rather this topic of drift is related to ETABS software. I am quoting here the definitions from UBC-97 code:-

STORY DRIFT is the lateral displacement of one level relative to the level above or below.

STORY DRIFT RATIO is the story drift divided by the story height.

5.5.1 IN ZONE IV

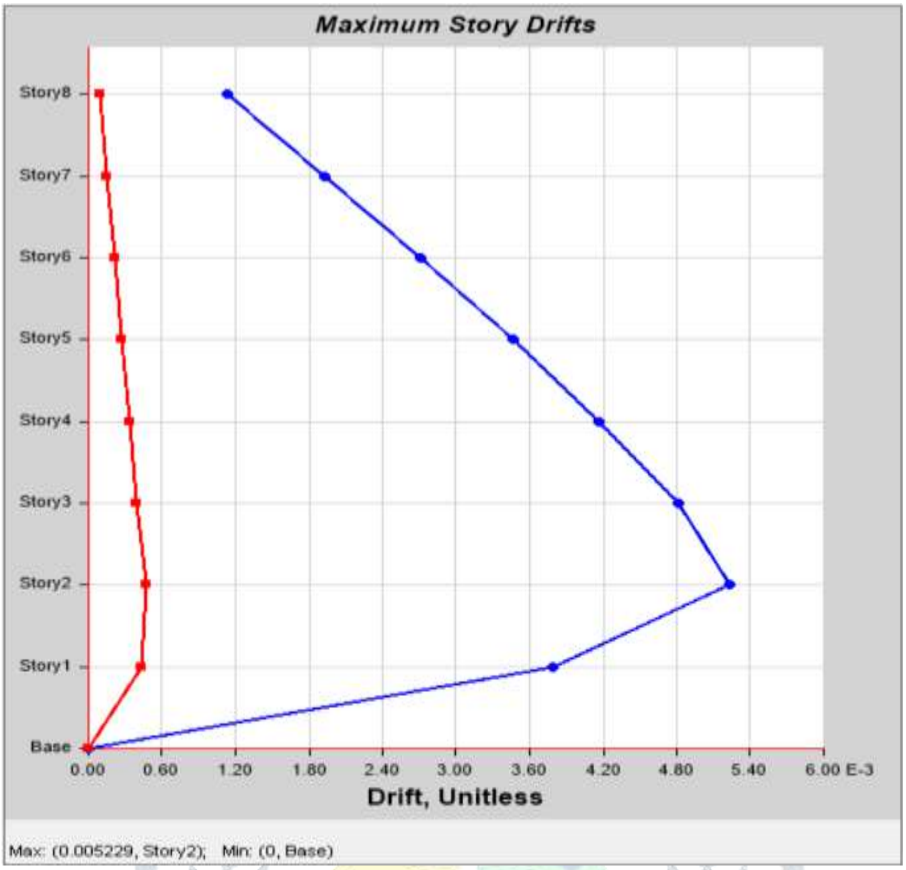


FIG-5.5.1a STOREY DRIFT IN ZONE- IV IN X-DIRECTION

FIG-5.5.1b STOREY DRIFT IN ZONE- IV IN Y-DIRECTION

5.5.2 IN ZONE V

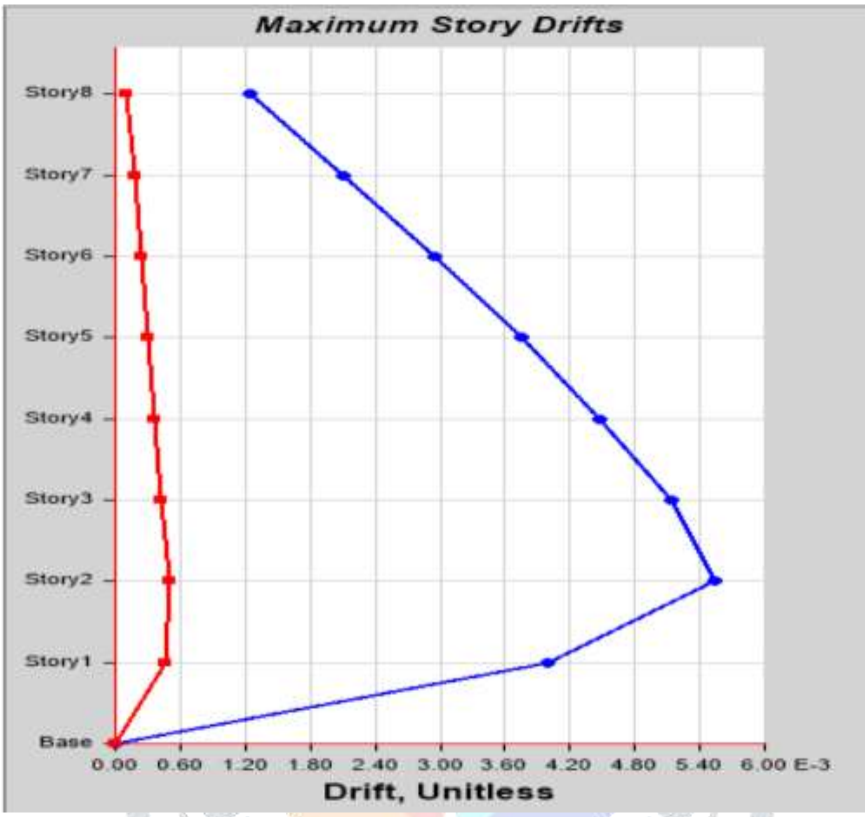


FIG-5.5.2aSTOREY DRIFT IN ZONE- V X-DIRECTION

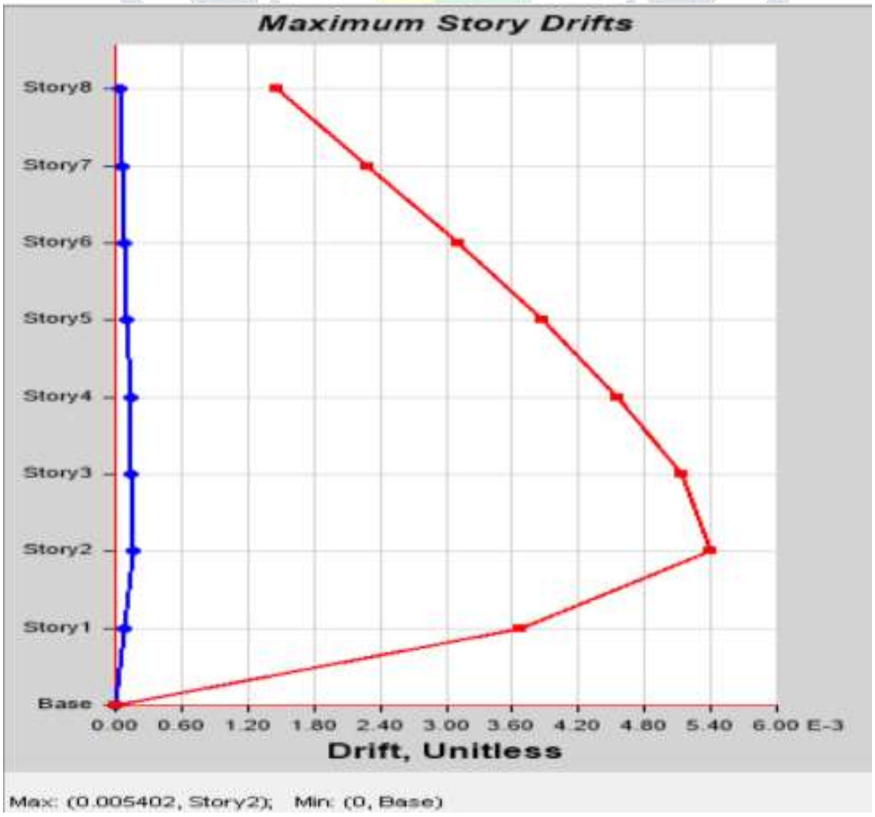


FIG-5.5.2b STOREY DRIFT IN ZONE- V IN Y-DIRECTION

5.6 MAXIMUM STOREY DISPLACEMENT

To understand story drift, also known as inter-story drift, we first need to understand story displacement. Story displacement is the deflection of a single story relative to the base or ground level of the structure. Intuitively, we can expect higher total displacement values as we move up the structure. So, a graph showing the story displacement vs. the height of the structure looks exactly like the deflected shape.

5.6.1 IN ZONE IV

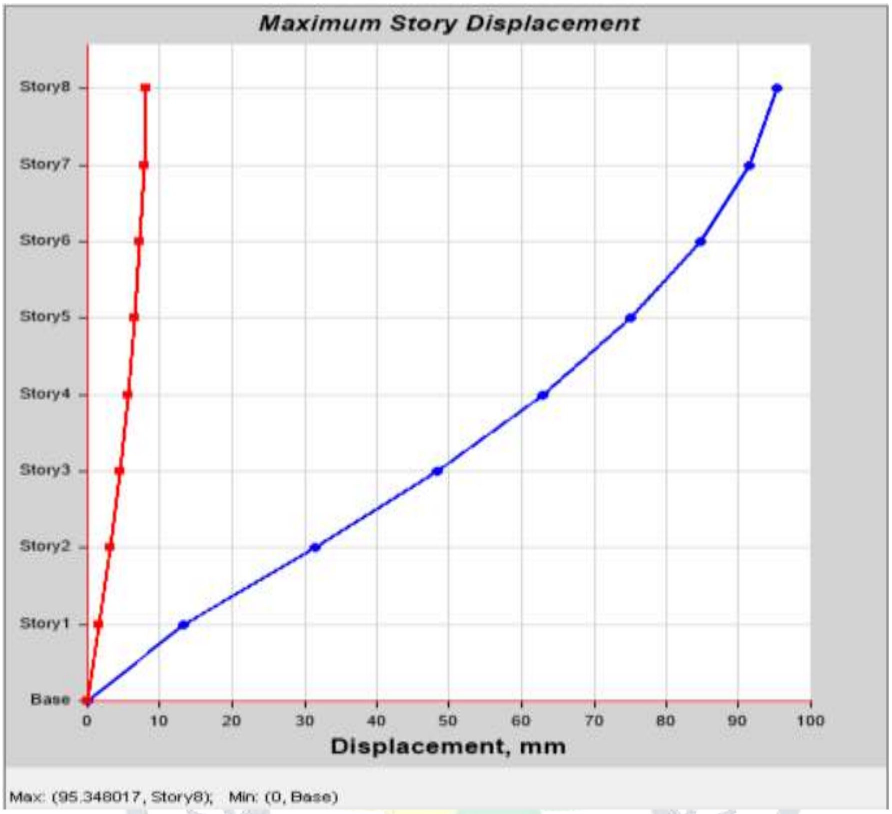


FIG-5.6.1a MAXIMUM STOREY DISPLACEMENT IN X- DIRECTION

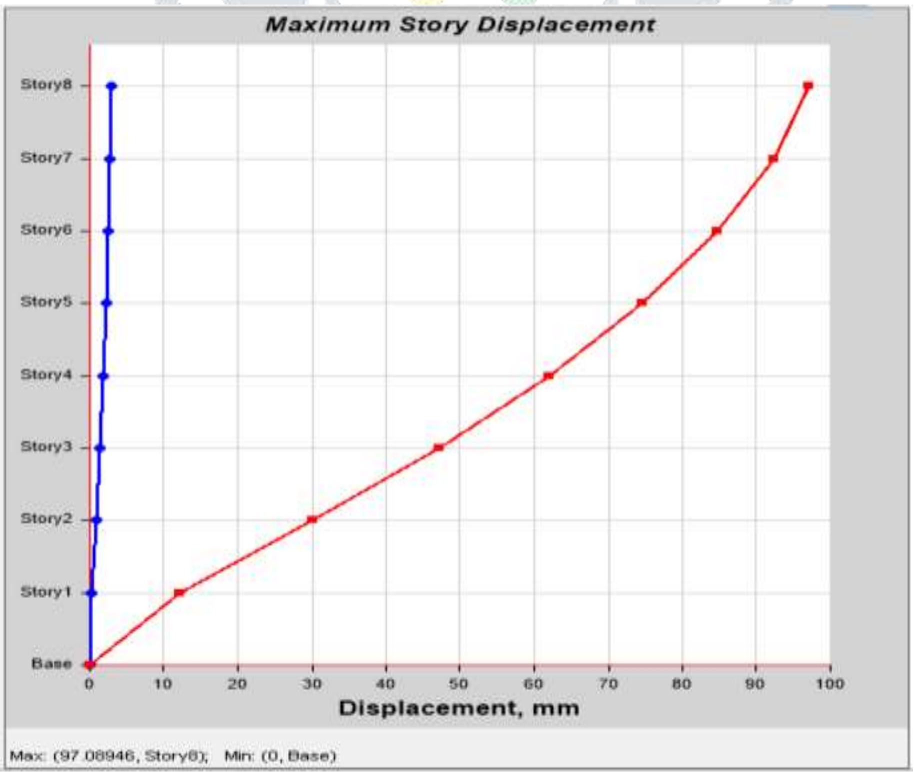


FIG-5.6.1b MAXIMUM STOREY DISPLACEMENT IN Y- DIRECTION

5.6.2 IN ZONE V

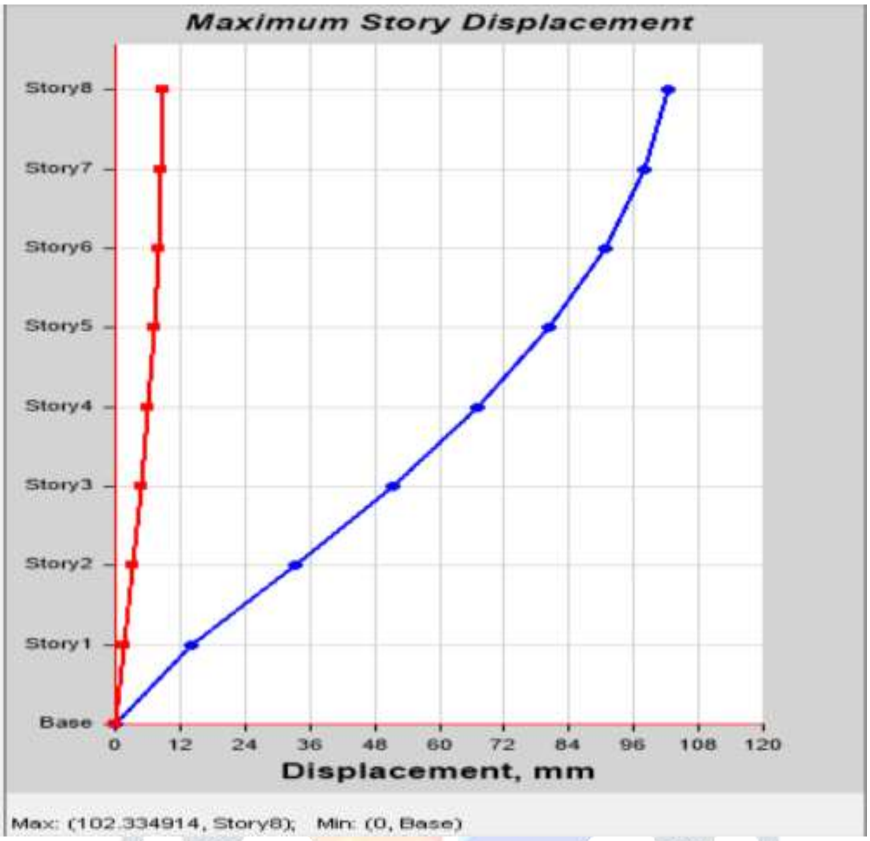


FIG-5.6.2a MAXIMUM STOREY DISPLACEMENT IN X- DIRECTION

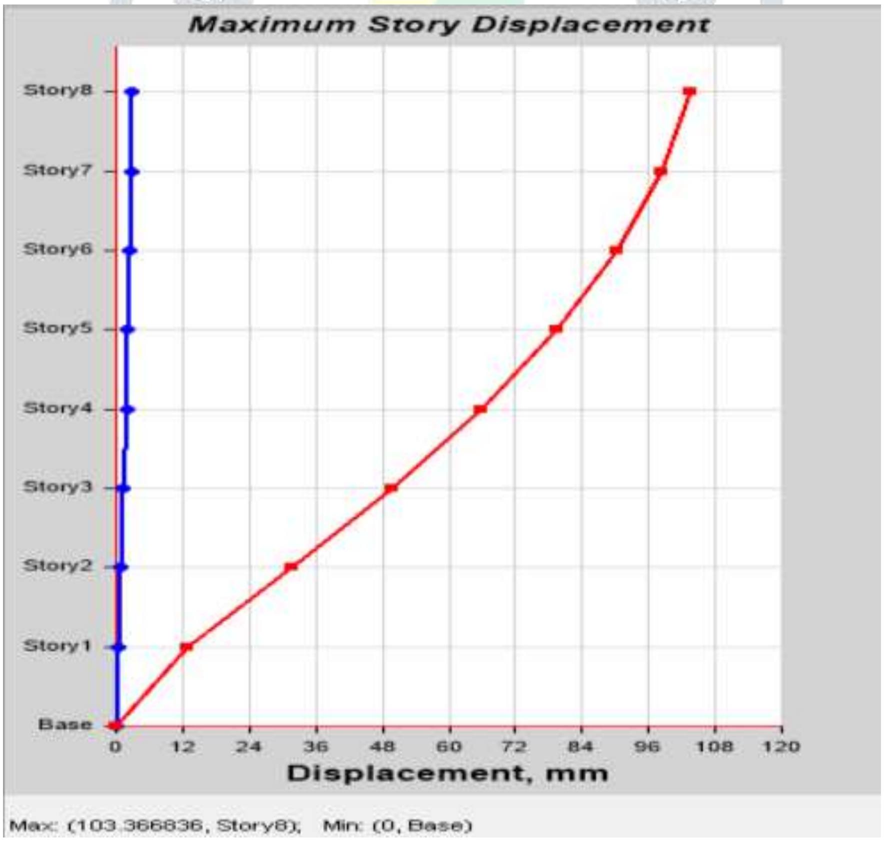


FIG-5.6.2b MAXIMUM STOREY DISPLACEMENT IN Y- DIRECTION

5.7 STOREY STIFFNESS

In structural engineering, the term 'stiffness' refers to the rigidity of a structural element. In general terms, this means the extent to which the element is able to resist deformation or deflection under the action of an applied force. In contrast, flexibility or pliability is a measure of how flexible a component is, i.e. the less stiff it is, the more flexible it is.

5.7.1 IN ZONE IV

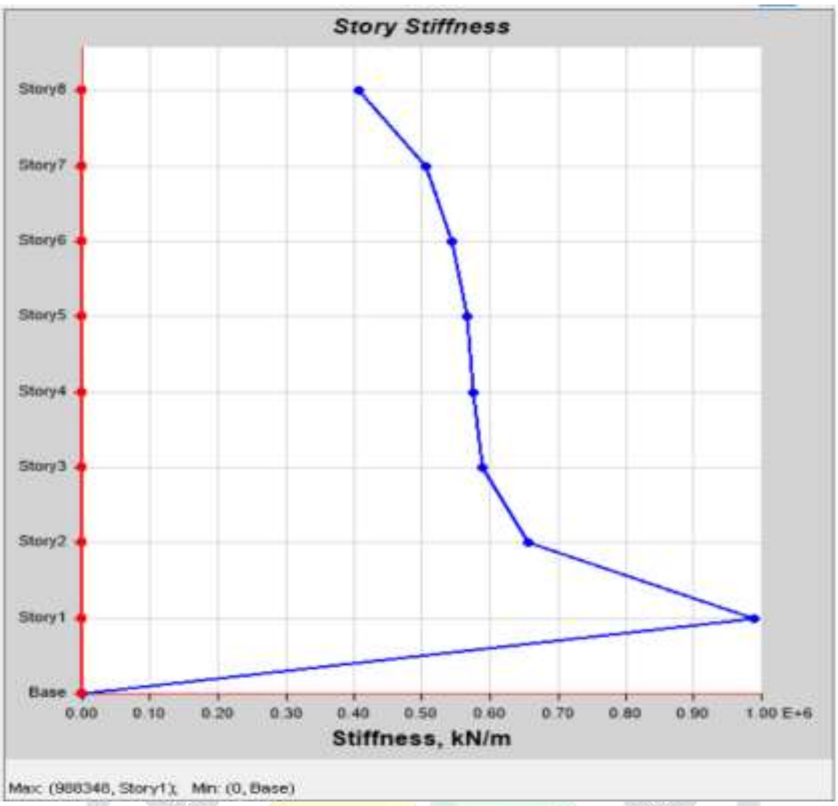


FIG- 5.7.1a STOREY STIFFNESS IN X-DIRECTION

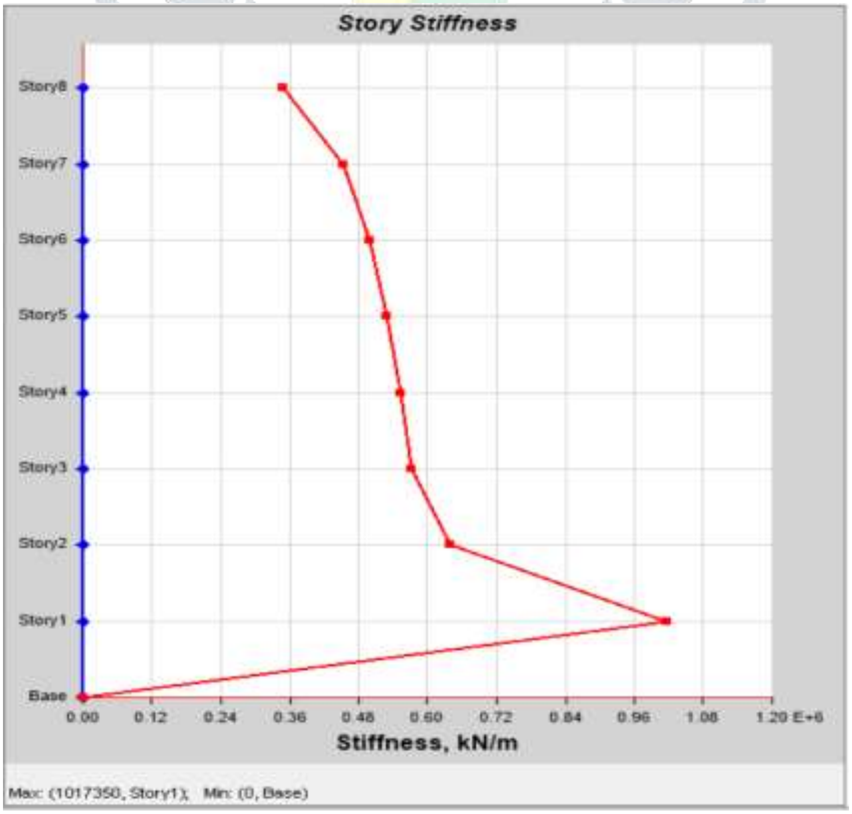


FIG- 5.7.1b STOREY STIFFNESS IN Y-DIRECTION

5.7.2 IN ZONE- V

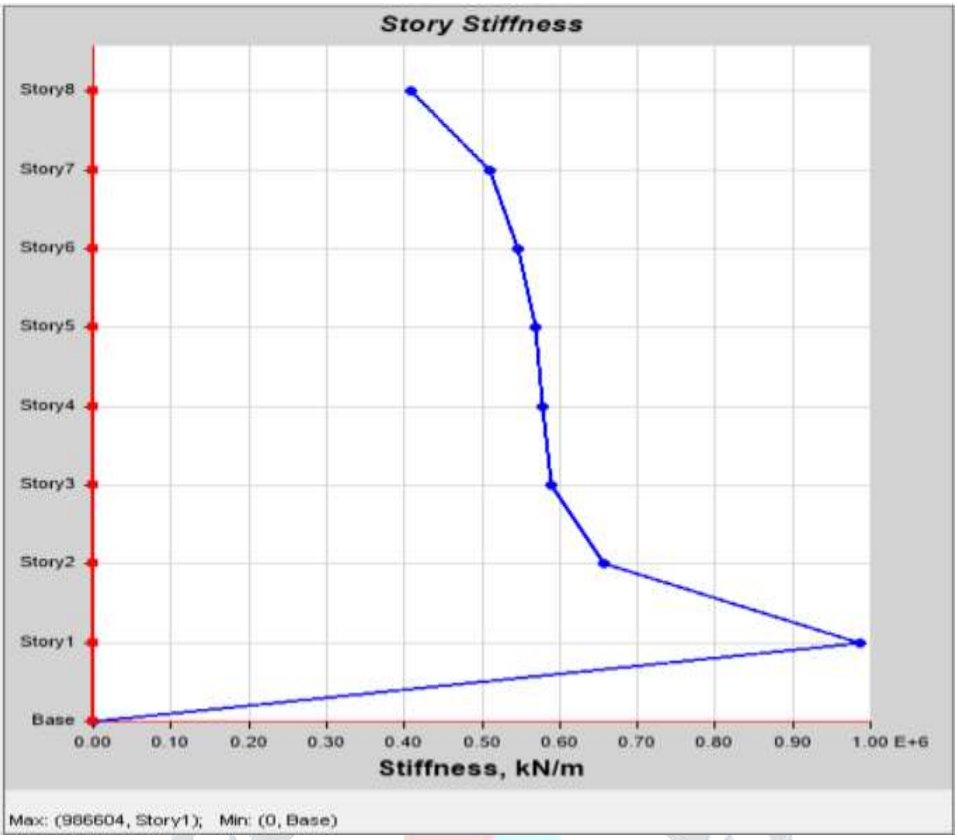


FIG- 5.7.2a STOREY STIFFNESS IN X-DIRECTION

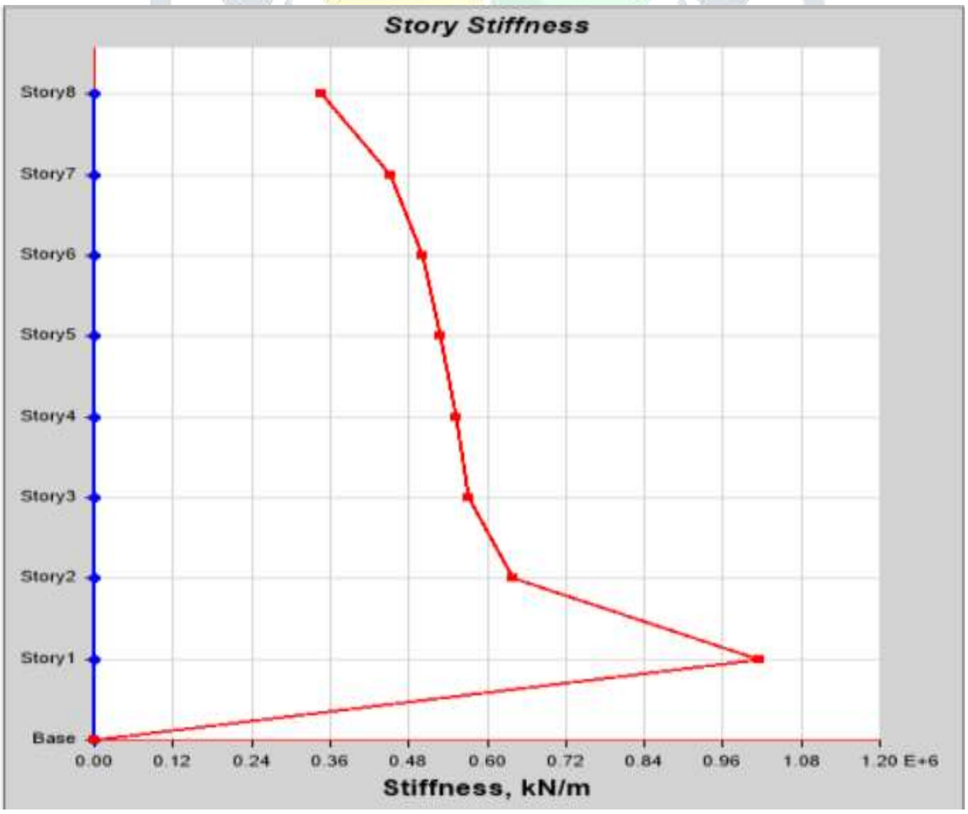


FIG- 5.7.2b STOREY STIFFNESS IN Y-DIRECTION

5.8 STOREY OVERTURNING MOMENT

Overturning moments due to static and dynamic loadings are calculated, and the results are tabulated in a spread sheet format.

When 'Consider Story Module' under 'Story Shear Force Ratio' is checked in the 'Model/Building/Control Data', accurate shear forces can be obtained for the story overlapping the upper Module and the lower Module.

5.8.1 IN ZONE IV

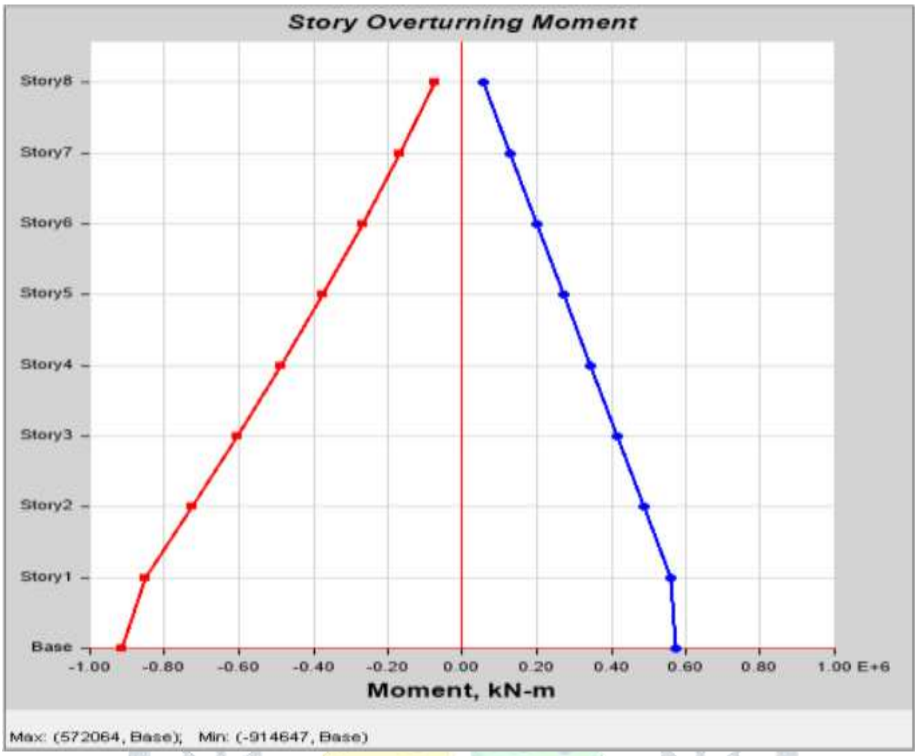


FIG.- 5.8.1a STOREY OVERTURNING MOMENT IN X-DIRECTION

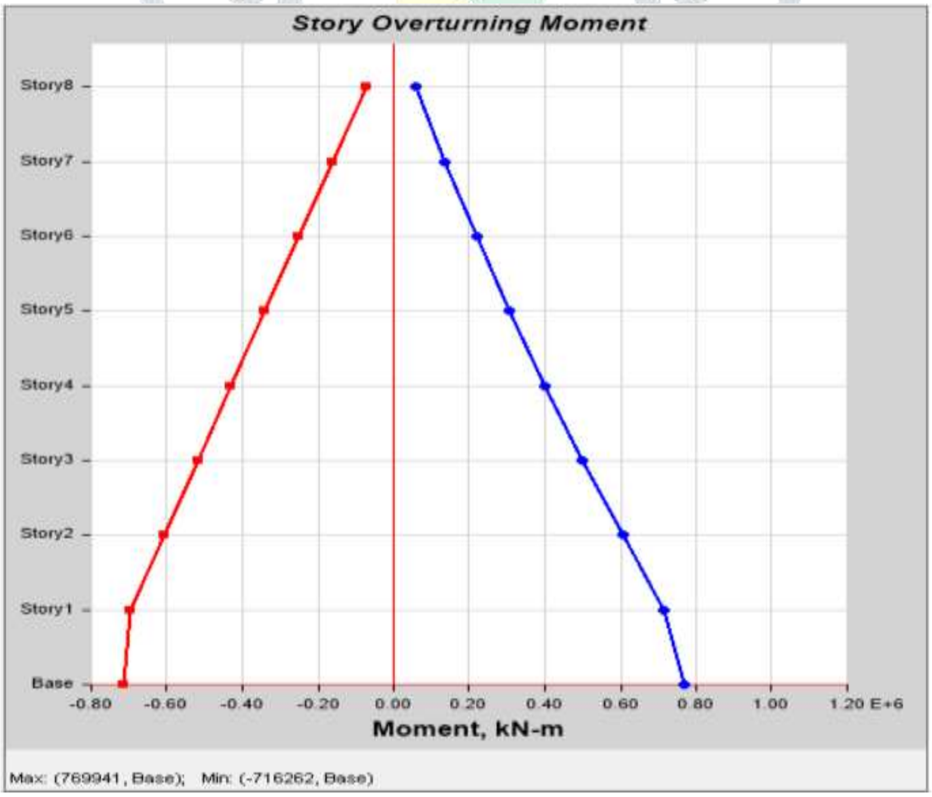


FIG.- 5.8.1b STOREY OVERTURNING MOMENT IN Y-DIRECTION

5.8.2 IN ZONE-V

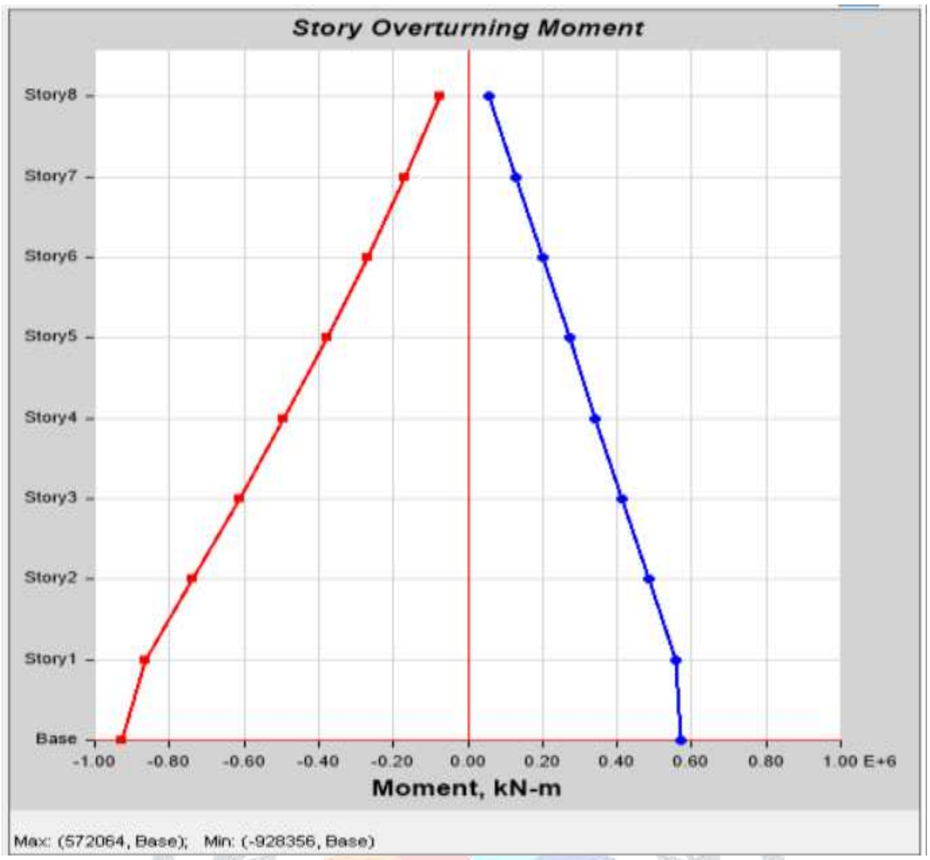


FIG.- 5.8.2a STOREY OVERTURNING MOMENT IN X-DIRECTION

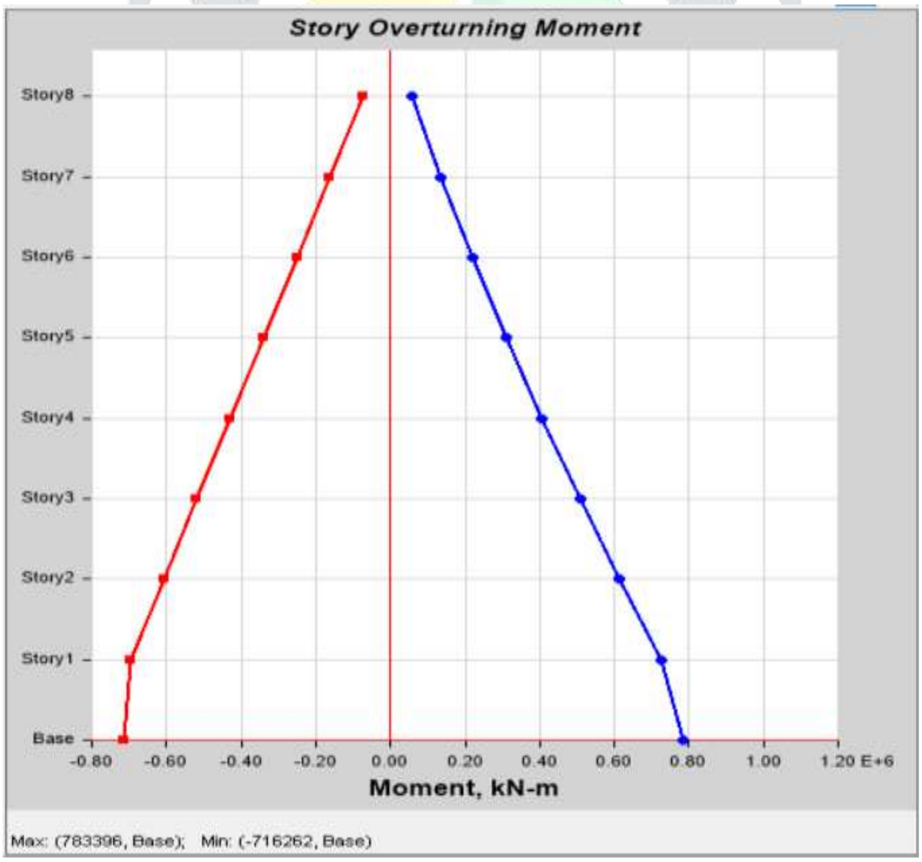


FIG.- 5.8.2b STOREY OVERTURNING MOMENT IN Y-DIRECTION

5.9 COMPARISION

TABLE -3 (COMPARISION OF DIFFERENT PARAMETERS)

SL. N0.	COMPARISION PARAMETER	ZONE-IV				ZONE-V			
		X-DIRECTION		Y-DIRECTION		X-DIRECTION		Y-DIRECTION	
		MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.
1.	STOREY SHEAR (IN KN)	-12.018	1.058	-11.995	3.867	-12.652	1.847	-12.617	4.041
2.	STOREY DRIFT	0	0.00522	0	0.00511	0	0.0055	0	0.0054
3.	STOREY DISPLACEMENT (IN MM)	0	95.348	0	97.089	0	102.334	0	103.366
4.	STOREY STIFFNESS (IN KN/M)	0	0.988	0	1.017	0	0.986	0	1.015
5.	OVERTURNING MOMENT (KN-M)	-0.914	0.572	-0.716	0.769	-0.928	0.572	-0.716	0.783

5.9.1 COMPARISION OF MAXIMUM STOREY SHEARS

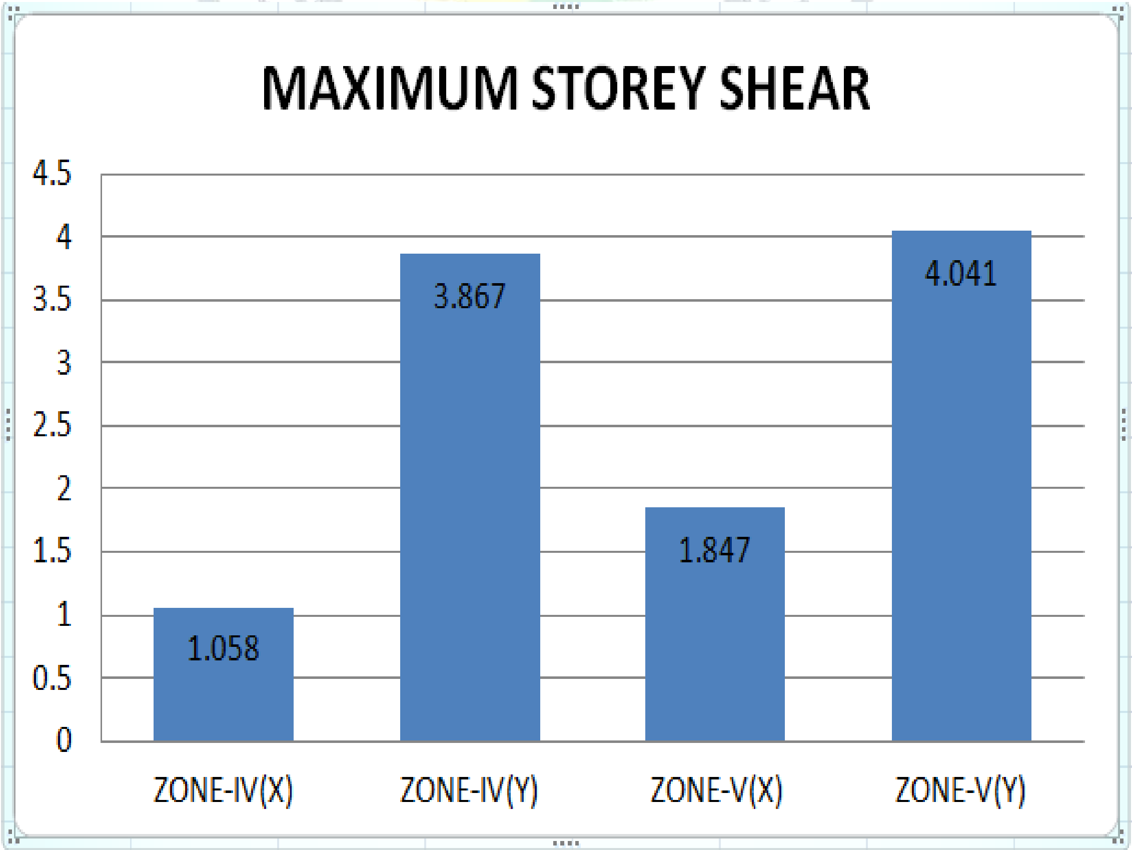


FIG 5.9.1 COMPARISION OF MAXIMUM STOREY SHEARS

5.9.2 COMPARISION OF MAXIMUM STOREY DRIFT

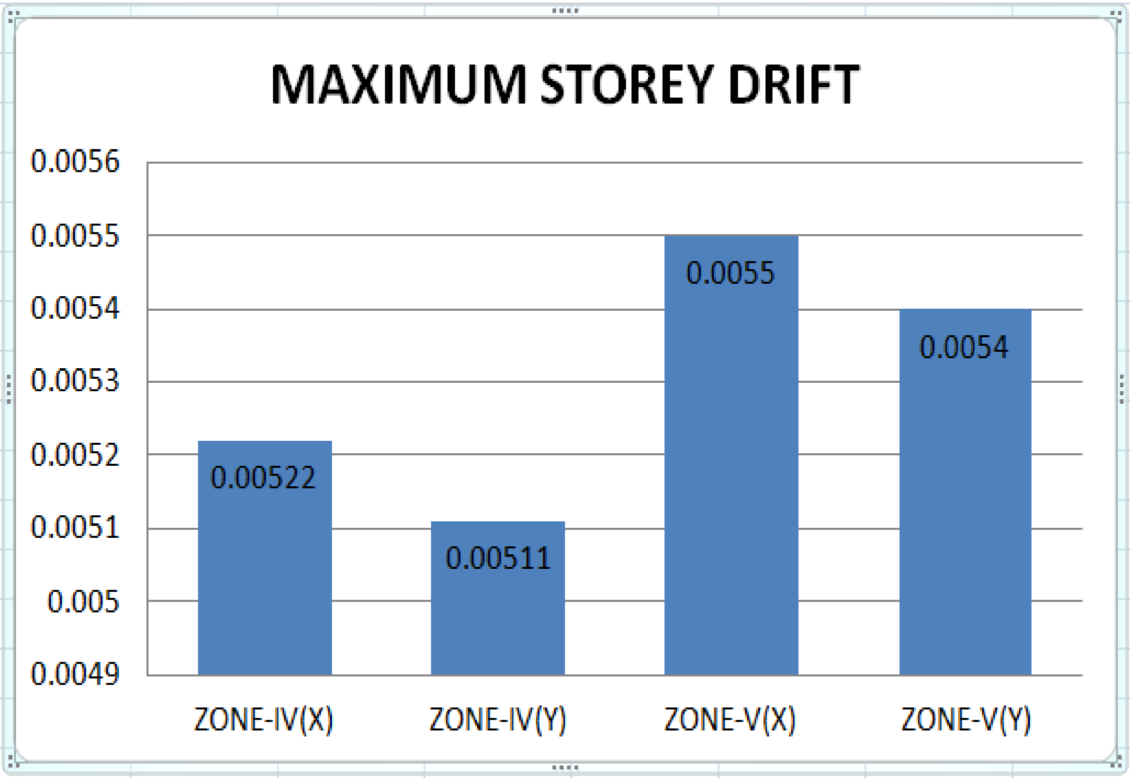


FIG-5.9.2 COMPARISION OF MAXIMUM STOREY DRIFT

5.9.3 COMPARISION OF MAXIMUM STOREY DISPLACEMENT

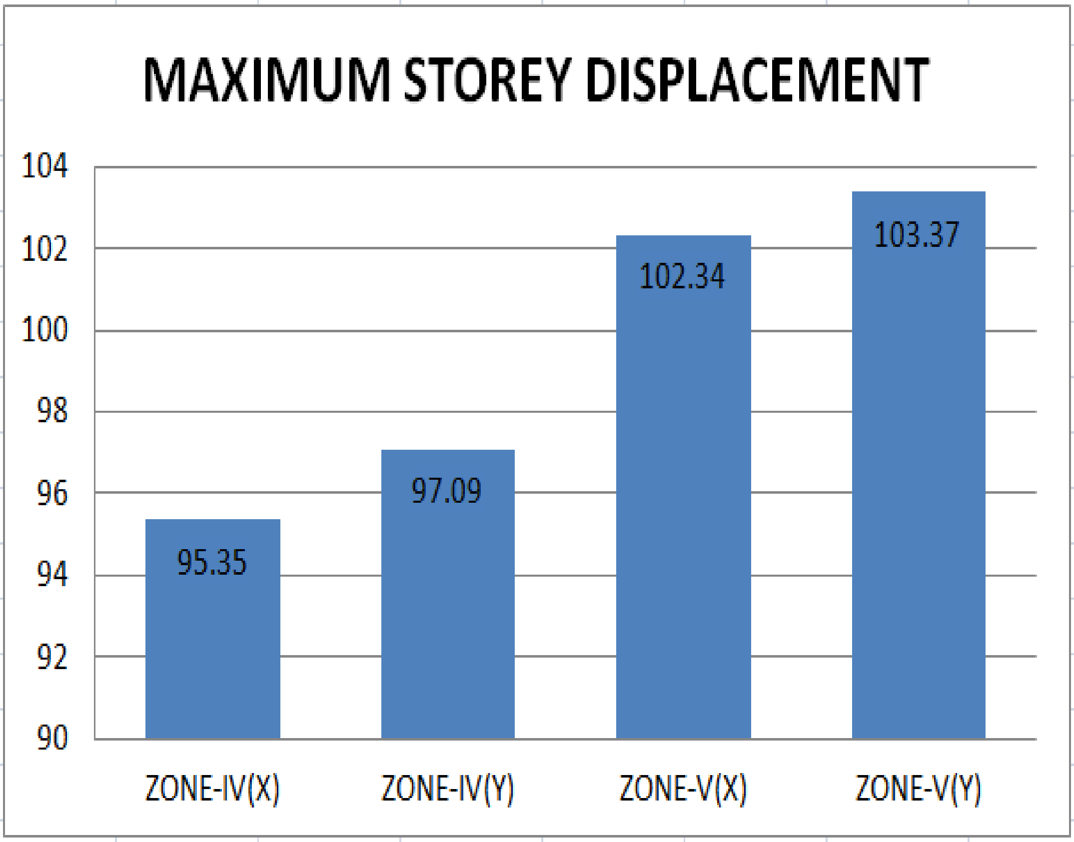


FIG-5.9.3 COMPARISION OF MAXIMUM STOREY DISPLACEMENT

5.9.4 COMPARISION OF MAXIMUM STOREY STIFFNESS

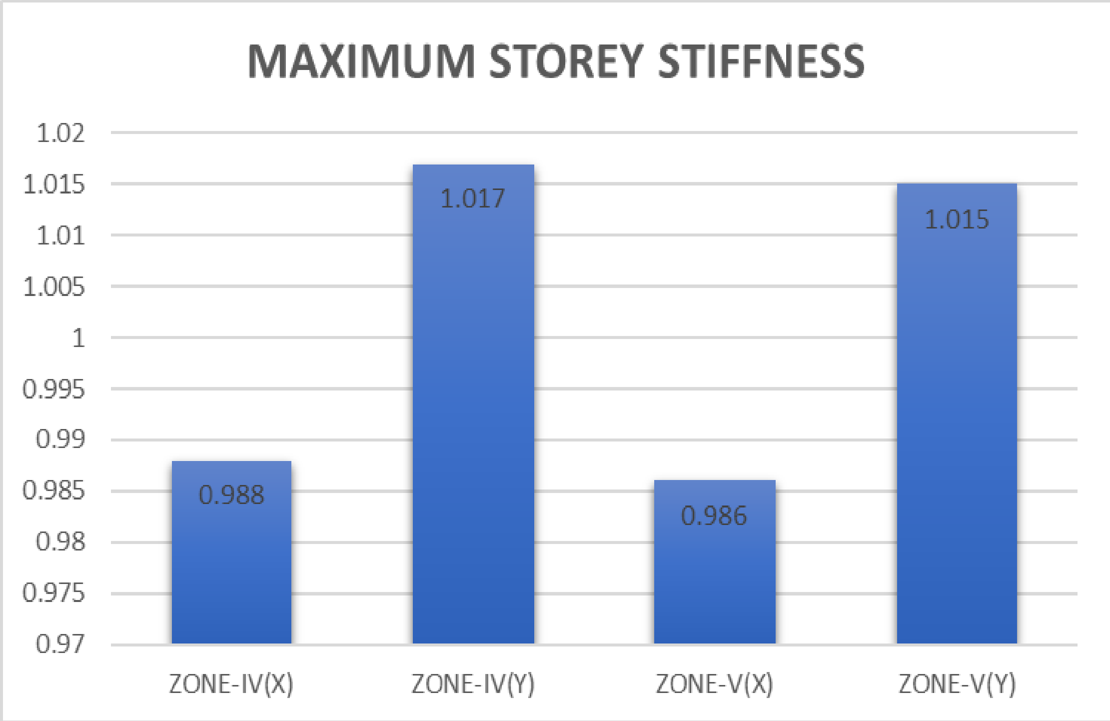


FIG-5.9.4 COMPARISION OF MAXIMUM STOREY STIFFNESS

5.9.5 COMPARISION OF MAXIMUM OVERTURNING MOMENT

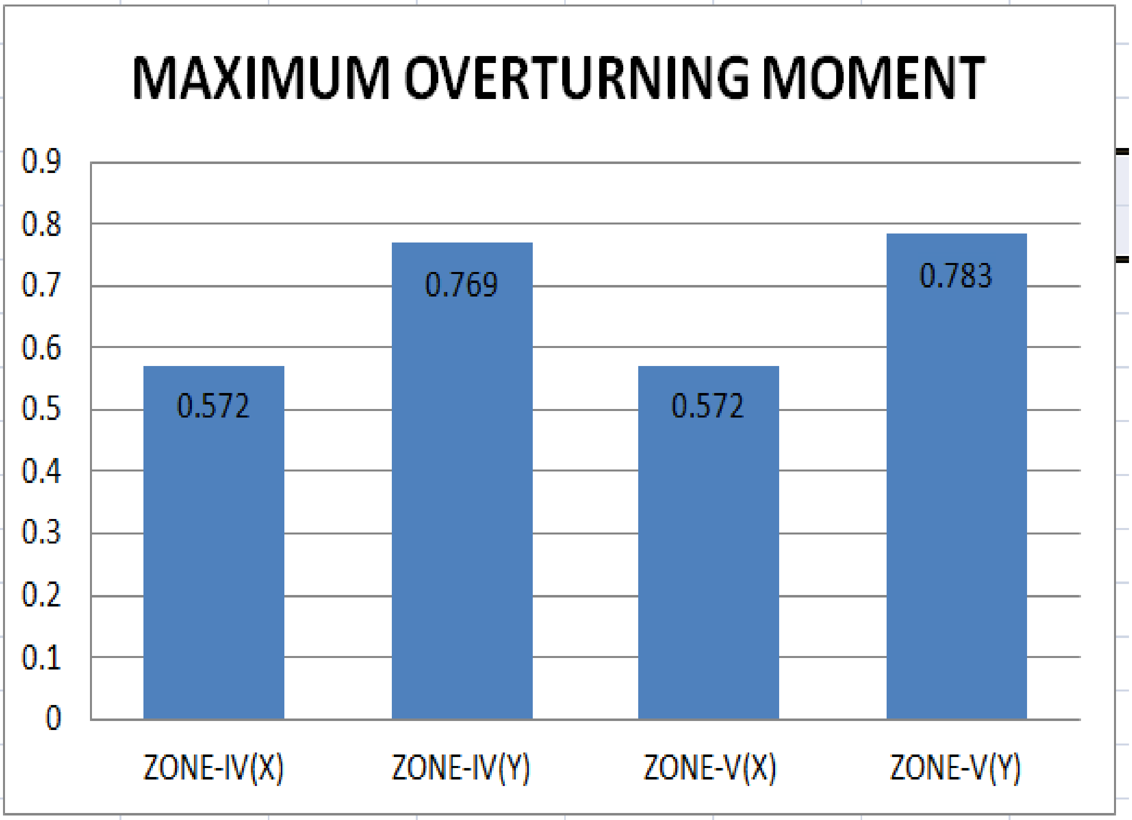


FIG-5.9.5 COMPARISION OF MAXIMUM OVERTURNING MOMENT

CHAPTER-6
CONCLUSION
&
SCOPE OF FUTURE WORK

CONCLUSIONS

The following are the major conclusions that can be made based on present work carried upon the RC buildings with different heights designed for earthquake forces in all the seismic zones-

- There is significant increase in base shear as we move from zone IV to zone V, indicating the increase in severity of earthquakes occurring in these regions.
- As far as STOREY drift is concerned, its observed that as we move from zone IV to zone V, there is significant increase in the drift in the stories.
- There is significant increase in story shear as we move from zone IV to zone V.
- There is significant increase in story displacement as we move from zone IV to zone V.
- There is significant increase in over turning moment as we move from zone-IV to zone V.
- There is significant decrease in story stiffness as we move from zone IV to zone V.

SCOPE OF FUTURE WORK

On the basis of the present work done, the scope for future study is identified on the following Aspects-

- In the present study, seismic design of buildings is carried out using Response Spectrum Analysis. Similar studies may be taken up with other methods such Push over analysis, Static Analysis, Time-History Analysis.
- In this work only the Indian Seismic design codes have been taken into account, the work can be further extended by incorporation of British, American and other design codes as well.

- Efforts may be made to take the soil-structure interaction into account as well.

- The present study is carried out on RC buildings. Similar studies may be taken up with Steel structures as well.

SUMMARY

Analysis of several past numerous seismic tremors have demonstrated that building structures have the capacity to manage without any harm the seismic constraints bigger than those they were intended for during design. For the seismic design of structures most codes, indeed, indicate just a solitary configuration tremor which the building and its segments are required to maintain without breakdown. The building is expected to experience some basic and non-structural damage amid the configuration earthquake. Furthermore, it is expected that the building outlined in this way will consequently meet the objective of no harm in a moderate intensity earthquake. Along these lines, a large number of the seismic design codes have a tendency of downsizing the design forces to record for reserve strength parameter which is crucial and simplifies the analysis as well. Other entities such as storey drift, storey stiffness, maximum displacement, storey shear, overturning moment were also compared to get an idea on the variation of these quantities with varying building heights and seismic zones. The conclusions obtained from the study and the future scopes of this research are quoted in this chapter.

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