SEISMIC ANALYSIS OF MEDIUM RISE BUILDING BY RESPONSE SPECTRUM METHOD

Submitted in partial fulfilment of the requirements

for the degree of

Bachelor of Engineering

by

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CERTIFICATE

This is to certify that the project entitled **"Seismic Analysis of Medium Rise Building by Response Spectrum Method"**is a bonafide work of **Khan Iftekar Salim (14CE24), Mohd Aquib Mohd Mobin (14CE39), Quraishi Faiz Ahmed (14CE48), Sayed Afnan Irfan (14CE49)** submitted to the University of Mumbai in partial fulfilment of the requirement for the award of the degree of "Undergraduate" in "Civil Engineering"

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DECLARATION

We declare that this written submission represents my ideas in our own words and where others ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that, we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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ABSTRACT

In India multi-storied building are usually constructed due to high cost and scarcity of land. In order to utilize maximum land area, builders and architects generally propose high to medium rise building plan configurations. These buildings which are constructed in seismic prone areas, are likely to be damaged during earthquake. Earthquake is a natural phenomenon which can generate the most destructive forces on the structure. Buildings should be made safe for the lives by proper design and detailing of structural member in order to have a ductile form of failure.

The concept of earthquake resistant design is that the building should be designed to resist the forces, which arises due to Design Basis Earthquake, with only minor damages and the forces, which arises due to Maximum Considered Earthquake, with some accepted structural damages but no collapse. This project report comprises of seismic analysis and design of a RC building. This building is designed in ETABS and building is analysed using Response Spectrum Method as per IS-1893 (part 1):2002.

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Chapter 1

Introduction

1.1 General

Earthquake resistant structure are capable of resisting lateral and vertical force acting on a structure but the structures which are not seismically designed cannot entirelyy survive during earthquake. According to IS 1893-2016 earthquake resistant structure are designed to withstand expected earthquake at least to occur once during the design life of the structure.

Seismic analysis is a subset of structural analysis and is the calculation of the response of a building structure to earthquakes. It is part of the process of structural design, earthquake engineering or structural assessment in regions where earthquakes are prevalent. Earthquake engineering has developed a lot since the early days, and some of the more complex designs now use special earthquake protective elements either just in the foundation (base isolation) or distributed **throughout** the structure

The various recent earthquakes near Mumbai region are as follows. Alibaug 4.3 magnitude depth 10km, Chiplun 4.2 magnitude 10km depth. The highest magnitude of 7.2 was occurred in bhuj in Gujrat 17 km depth in January 2001.

The various methods of seismic analysis are response spectrum method, equivalent static method, linear dynamic analysis, on linear static analysis. In all of the above methods we are adopting response spectrum method as per suitability of our project.

1.2 Response spectrum method

This approach permits the multiple modes of response of a building to be taken into account (in the frequency domain). This is required in many building codes for all except very simple or very complex structures. The response of a structure can be defined as a combination of many special shapes (modes) that in a vibrating string correspond to the "harmonics". Computer analysis can be used to determine these modes for a structure. For each mode, a response is read from the design spectrum, based on the modal frequency and the modal mass, and they are then combined to provide an estimate of the total response of the structure. In this we have to calculate the magnitude of forces in all directions i.e. X, Y & Z and then see the effects on the building. Combination methods include the following absolute - peak values are added together

square root of the sum of the squares (SRSS)

complete quadratic combination (CQC) - a method that is an improvement on SRSS for closely spaced modes

The result of a response spectrum analysis using the response spectrum from a ground motion is typically different from that which would be calculated directly from a linear dynamic analysis using that ground motion directly, since phase information is lost in the process of generating the response spectrum.

In cases where structures are either too irregular, too tall or of significance to a community in disaster response, the response spectrum approach is no longer appropriate, and more complex analysis is often required, such as non-linear static analysis or dynamic analysis.

For planning purpose AutoCAD is used and by referring bye law of residential building plan is made. AutoCAD is a commercial software application of 2D and 3D computer aided design(CAD).

For analysing purpose, we use ETABS software which is a structural analysis and design computer program. It can make use of various forms of analysis from the traditional 1st order static analysis, 2nd order p-delta analysis, geometric non-linear analysis, Pushover analysis (Static-Non Linear Analysis) or a buckling analysis. It can also make use of various forms of dynamic analysis from modal extraction to time history and response spectrum analysis.

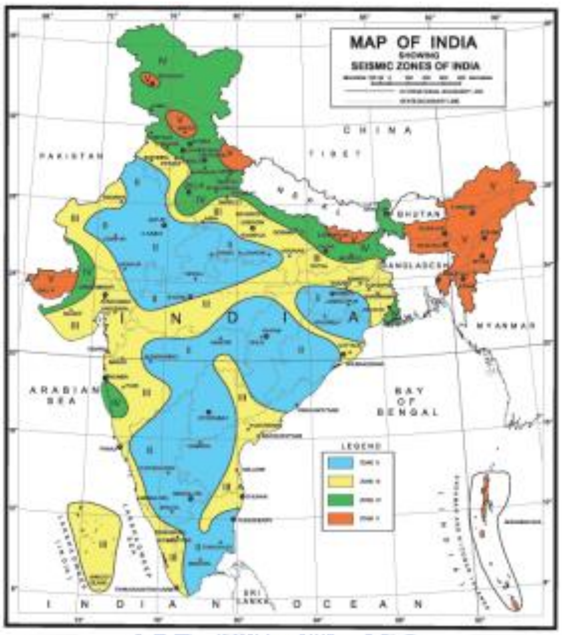


Figure 1.1 Seismic zones of India

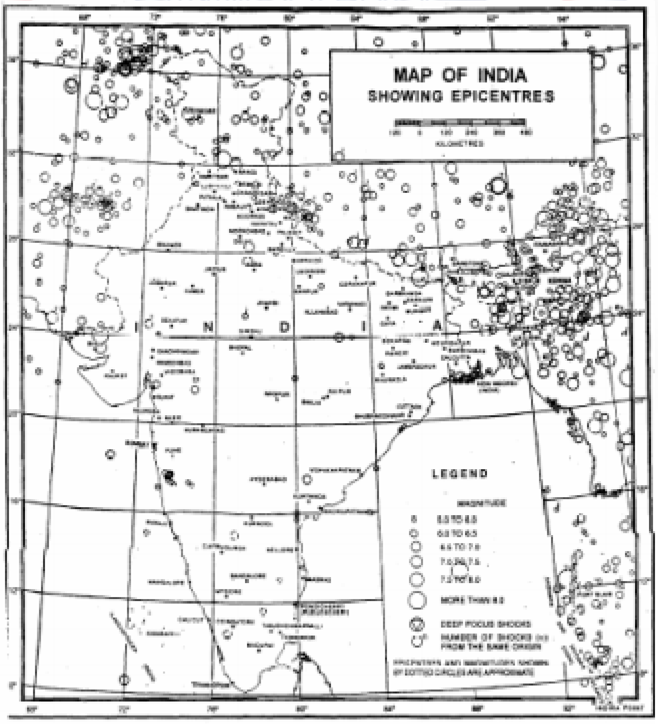


Figure 1.2 Map of India showing epicentres of past earthquakes in India

1.3 Earthquake

1.3.1 General

An earthquake is a vibration that travels through the earth's crust. The waves are called seismic waves. In an earthquake, the initial movement that causes seismic vibrations occurs when two sides of a fault suddenly slide past each other. A fault is a large fracture in rocks, across which the rocks have moved. Earthquakes are the manifestations of sudden release of strain energy accumulated in the rocks over extensive periods of time in the upper part of the earth. These elastic waves radiate outwards from the focus and vibrate the ground.

- **WHAT CAUSES EARTHQUAKE?**

Earthquakes are caused by the movement of the earth's tectonic plates. A number of Smaller size earthquakes take place before and after a big earthquake. Those occurring before the big one are called Foreshocks, and the ones after are called Aftershocks. shocks smaller than magnitudes 2.5 are usually not felt and those with magnitude 7 cause serious damage over large areas. Intensity of shaking is measured on the modified Mercalli scale, ranging from 1 far from the epicenter to a maximum near it, which can reach 12 in the strongest earthquakes.

1.3.2 Terminologies used in earthquake

- **Epicenter:** The geographical point on the surface of earth vertically above the focus of the earthquake.

- **Hypocenter or Focus:** The originating earthquake source of the elastic waves inside the earth which causes shaking of ground due to earthquake.
- **Epicenter distance:** Distance between epicenter and recording station in km.

- **Focal depth:** The depth of focus from the epicenter is called focal depth. It is an important parameter in determining the damaging potential of an earthquake. Most of the damaging earthquakes have shallow focus with focal depths less than about 70k 70km.
- **Fault**: A fracture in the rocks along which strain is occasionally released as an earthquake. By definition, only active faults are associated with earthquakes.

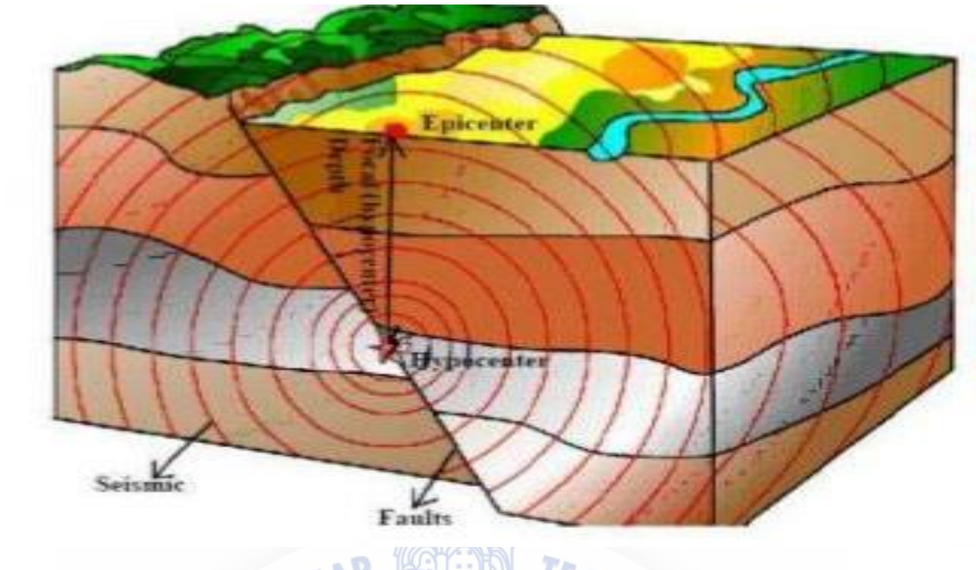


Figure 1.3 Fault

- **Seismology:** It is the scientific study of earthquakes and propagation of elastic waves through earth.
- **Magnitude of Earthquake:** Magnitude is a quantitative measure of the actual size of the earthquake. The magnitude of earthquake is a number, which is a measure of energy released in an earthquake. It is defined as logarithm to the base 10 of the maximum trace amplitude, expressed in microns, which the standard short-period torsion seismometer would register due to the earthquake at an epicenter distance of 100km.

- **Intensity of earthquake:** The intensity of an earthquake at a place is a measure of the strength of shaking during the earthquake, and is indicated by a number according to the modified Mercalli scale or M.S.K scale of seismic intensities. It is a qualitative measure of the actual shaking at a location during an earthquake, and is assigned as Roman capital Numerals. There are many intensity scales. Two commonly used ones are The modified Mercalli Intensity (MMI) scale and the MSK scale. Both scales are

Quite similar and range from I (least perceptive) to XII (most severe).

- **Importance Factor (I):** It is a factor used to obtain the design seismic force depending on the functional use of the structure, characterized by hazardous consequences of its failure, its post-earthquake functional need, historic value, or economic importance
- **Natural Period (T):** Natural period of a structure is its time period of undamped free vibration.
- **Response Reduction Factor (R):** It is the factor by which the actual base shear force, which would be generated if the structures were to remain elastic during its response to the Design Basis Earthquake (DBE) shaking, shall be reduced to obtain the design lateral force.
- **Seismic Mass:** It is the seismic weight divided by acceleration due to gravity.
- **Seismic Weight (W):** It is the total dead load plus appropriate amounts of specified imposed load.
- **Zone factor (Z):** It is a factor to obtain the design spectrum depending on the perceived maximum seismic risk characterized by Maximum Considered Earthquake (MCE) in the zone in which the structure is located. The basic zone factors included in this structure are reasonable estimate of effective peak ground acceleration.
- **Structural Response Factors (S_a/g):** It is a factor denoting the acceleration response spectrum of the structure subjected to earthquake ground vibrations, and depends on natural period of vibration and damping of the structure.

1.3.3 Seismic waves

During an earthquake there are different types of seismic waves generated, but in general there are two categories-

- **Body waves –** These waves travel through the earth's inner layers.
- **Surface waves –** These waves can only travel on the surface of the crust.

1.3.4 Body waves

Body waves consist of –

- **P-waves (Primary waves) –** These waves are the first waves that arrive during an earthquake, which move faster than S-waves. It can move through liquid and solid rock and behaves similar to sound waves. It pushes and pulls the rock that it travels through. Particles subjected to P-wave move in the same direction as that of the direction of wave propagation.

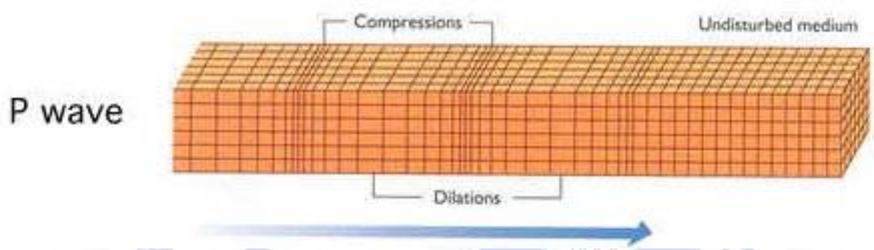


Figure 1.4 Primary waves

- **S-waves (Secondary waves) -** These waves are felt after the P-waves. They move much slower and can only travel through solid rock. The particles in their path are moved side to side, up and down, perpendicular to the wave propagation.

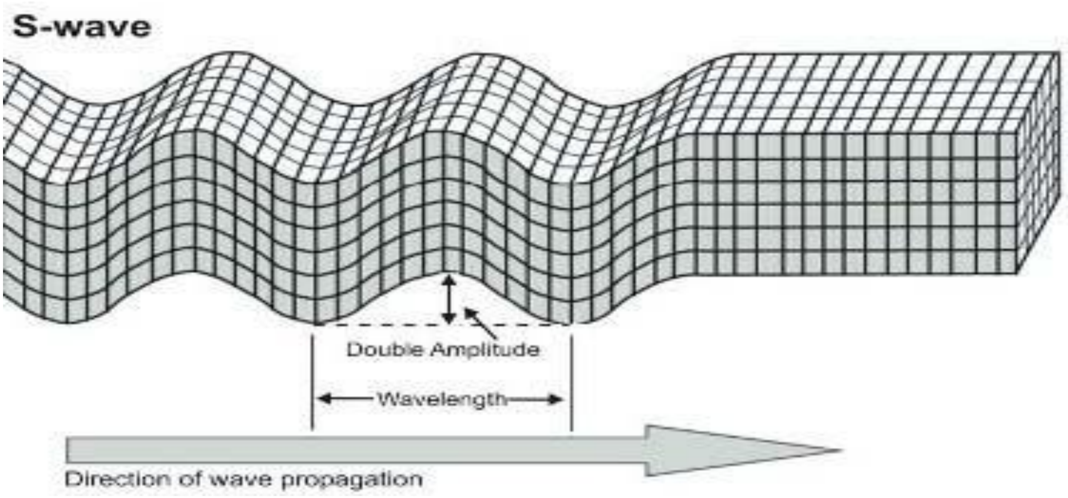


Figure 1.5 Secondary waves

1.3.5 Surface waves

Surface waves occur after the body waves, but have lesser frequencies. They can be detected easily in seismograph, as they create huge fluctuations. Damages are caused to the structure by these waves itself. Surface waves consist of –

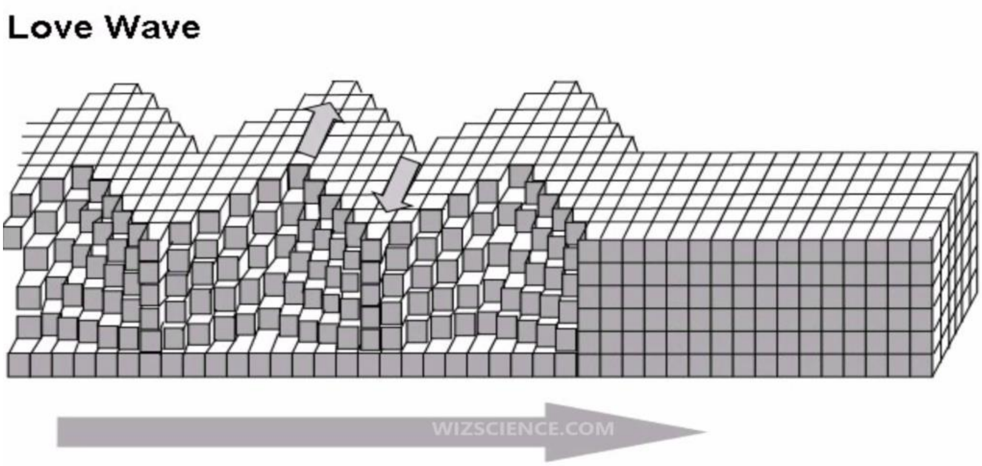


Figure 1.6 Love waves

• Love wave – This is the first kind of surface wave names after the mathematician who worked out the model for this kind of wave. Love waves move in a horizontal motion, and move the ground side to side.

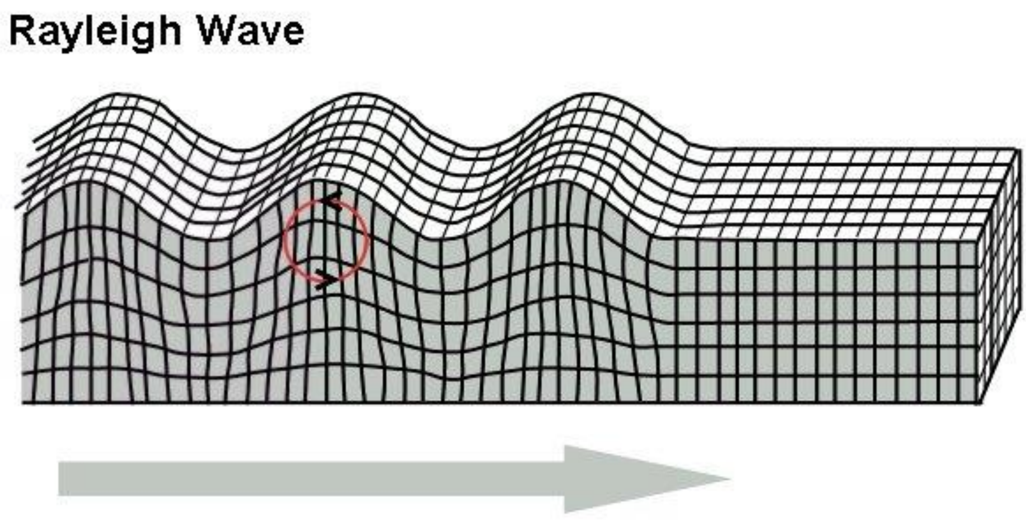


Figure 1.7 Rayleigh waves

• Rayleigh wave – It is the second type which is also named after the mathematician who predicted the mathematical method. These waves roll along the ground, exactly like waves on the sea, and can be much larger than the other waves. Rayleigh waves move the ground up and down, side to side in the direction that the wave is moving. The below figure shows the Rayleigh waves.

1.3.6 Seismic zones of India

The varying geology at different locations vary the likelihood of damaging earthquake taking place at different locations is different. Thus seismic zone map is important to identify different regions. Based on the levels of intensities sustained during past earthquakes zones are classified as zone II, zone III, zone IV and zone V as on 2002 revision. For the purpose of determining seismic forces, the country is classified into four seismic zones. About 59% of the land area of India is liable to seismic hazard damage. The different zones and their zone factor is given in the below table 3.1 and important cities under different zone are given in the table 3.2.

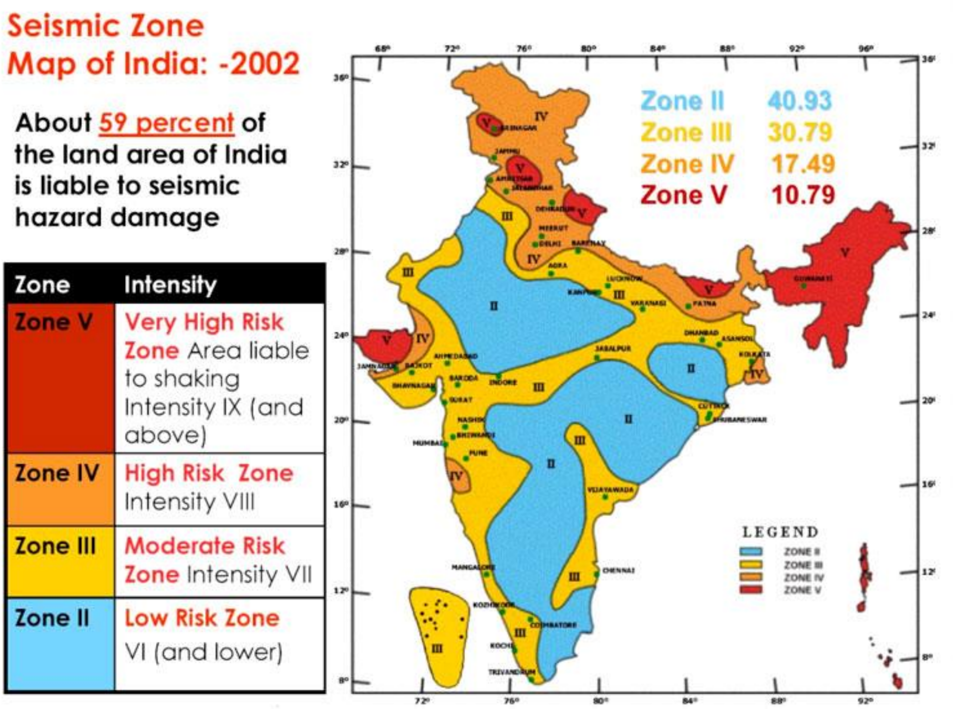


Figure 1.8 Seismic zoning of India

The different zones and their zone factor are given in the below table:

Table 1 Zone factor Z

Seismic zone	**II**	**III**	**IV**	**V**
Seismic Intensity	Low	Moderate	Severe	Very severe
Zone factor	0.10	0.16	0.24	0.36

Table 2 Important cities under different zones

Zone I	Zone II	Zone III	Zone IV
Ajmer	Agra	Ahmora	Bhuj
Allahabad	Ahmedabad	Amritsar	Darbhanga
Aurangabad	Belgaum	Barauni	Guwahati
Banglore	Bhubaneshwar	Bulandshar	Imphal
Bhilai	Bijapur	Chandigarh	Jorhat
Bhopal	Manglore	Darjeeling	Kohima
Chitradurga	Pune	Debra Dun	Mandi
Gulbarga	Chennai	Delhi	Srinagar
Hyderabad	Coimbatore	Gangtok	Tezpur
Jaipur	Kolkata	Gorakhpur	Sadiya
Jamshedpur	Cuttack	Ludhiana	
Jhansi	Dharwad	Monghyr	
Jodhpur	Dharampuri	Moradabad	
Kota	Goa	Nainital	
Kurnool	Gaya	Patna	
Madurai	Mumbai	pilibhit	
Mysore	Kalapakkam	Roorkee	
Nagpur	Kanchipuram	shimla	
Nagarjunasagar	Kanpur		

An earthquake resistant building has four attributes in it-

• **Good structural configuration:** Its size, shape and structural system carrying loads are such that they ensure a direct and smooth flow of inertia forces to the ground.

• **Lateral strength:** The maximum lateral (horizontal) force that it can resist is such that the damage induced in it does not result in collapse.

• **Adequate stiffness:** Its lateral load resisting system is such that the earthquake – induced deformations in it do not damage its contents under low-to-moderate shaking.

• **Good ductility:** Its capacity to undergo large deformations under severe earthquake shaking even after yielding is improved by favorable design and detailing strategies.

1.4 Aim

To analyse medium rise building by response spectrum method in Navi Mumbai zone-III.The main parameters of the seismic analysis of the structure are load carrying capacity, ductility, stiffness, damping and mass

Earthquake-resistant structures are structures designed to withstand earthquakes. While no structure can be entirely immune to damage from earthquakes, the goal of earthquake-resistant construction is to erect structures that fare better during seismic activity than their conventional counterparts.

According to building codes, earthquake-resistant structures are intended to withstand the largest earthquake of a certain probability that is likely to occur at their location. This means the loss of life should be minimized by preventing collapse of the buildings for rare earthquakes while the loss of the functionality should be limited for more frequent ones.

1.5 Scope

Based on the aim and objective mentioned in the preceding section, the scope of the present investigation is outlined as under

By doing this project we will come to know some software of civil engineering related to planning, analysis and designing of structures by using AutoCAD, ETABS.

By this study engineers will have sound knowledge in designing of earthquake resistant building. The structures designed by this study will be prone to less damages and provide better safety as compared other conventional structures which are not designed seismically.

Chapter 2

Literature Review

2.1 AutoCAD

Azidah Abu Ziden (2012) studied the effectiveness of AutoCAD software in learning of Engineering Drawing to enhance students understanding. He concluded that AutoCAD increase the performance of high and medium Level student group gave a positive impact on the study. Effective use of this software proved to be helpful based on the data obtained.

Asmaa G.Salil et.al. (2014), presents the significant revolution with computers usage in civil engineering business and construction process has been presented. AutoCAD software is an extremely powerful tool and can be adapted to specific needs in order to serve the intended purpose of any project. Civil engineering professionals use this software for variety of infrastructure projects, like; land development, transportation, water project and road design.

Amol A. Metkari et, al. [2015] proposed Ladies Hostel building for Rajarambapu Institute of Technology College, Rajaramnagar Institute of Technology College, rajaramnagar. In that case study, building project, included real life example of BIM and AutoCAD uses and benefits.

Also in the case study, a prototype building project, examined the 2D, 3D, 4D and 5d models by using AutoCAD& BIM tools

Prakash Chandra et. al. [2015] research on Integrate Building Information Modelling (BIM) and Construction Project Scheduling to Result in 4D Planning for a construction Project, the conventional 2d drawing are convert into 3D models in Revit Architecture 2010. the 2d drawing are convert into 3D models in Revit Architecture 2014 and the Time Scheduling is done in Microsoft Office project 2007

Raiyan Mansoori et. al. (2016) studies the planning and design of residential building (G+16) By Using AutoCAD & Revit Software's taking 4th dimension as time. In this paper study is restricted to civil engineering construction planning & scheduling by creating a 4D model, further other dimension like cost, resource, materials etc. can be taken as nth dimension.

2.2 ETABS

Abhay Guleria (2014) presents the analysis of the multi-storied building using ETABS reflected that the storey overturning moment varies inversely with storey heights. Moreover, L-shapes, I-shapes types buildings give almost similar response against the overturning moment. Storey drift displacement increased with storey heights up 6^{th} storey reaching to maximum values and then started decreasing. From dynamic analysis, mode shapes are generating and it can be concluding that asymmetrical plans undergo more deformation that symmetrical plans. Asymmetrical plans should be adopted considering into gap

Arpit . A Bhusar et. al. (2014) shows Building information models let structural engineers design, visualize, simulates, analyse, document and build project more efficient, accurately, and competitively. Among the important benefit of BIM for structural engineer are productivity, coordination and consistency of data, and improved visualization and simulation of problems and situations. Structural engineers can easily spend more time coordinating a project than performing the structural analysis. With the use of BIM, the time spent in coordination is reduced, allowing structural engineering to focus all their efforts in solving problems, instead of having to constantly be checking for errors or coordination changes made.

Sonia Longiam et. al. (2014) publishes the paper that present the plan , model, analyse and design of a vertical irregular shopping mall structure of G+10 storey and investigate its performance under various later loading conditions. The main goal is to assess current India standard design practice and to provide design guidelines using ETABS, present the manual design calculation satisfying the necessary requirements as per BIS specification as well as various Indian standard code specification.

D. Ramya et. al. (2015) principle objective of the project is comparative study on design and analysis of multi-storied building (G+10) by STAAD Pro and ETABS software. STAAD Pro is one of the leading software for design of structures. G+10 building is analysed for finding the shear forces, bending movement, deflection & reinforcement details for the structural component of building (such as Bean, columns & slabs) to develop the economic design. ETABS is also leading design software in present days used by many structural designers. Analysed the same structure using ETABS software for the design finally an attempt to the economical section of G+10 multi-storied building using both STAAD Pro and ETABS comparatively. By the intensive study come to know that the “economical section” was developed using ETABS software

S .Vijaya Bhaskar Reddy et. al. (2015), published a paper which describe the salient features of ETABS and its various applications in civil engineering, using ETABS software the analysis of two multi-storied buildings is carried out with different heights (15m and 10m). Thus it can be help the consulting engineering, construction experts, research scientists and students in analysis of concrete structure. The essential features of ETABS is explained and the capability of the important concepts of effective memory management, plots option and user interface are described.

B. Anjaneyulu et. al. (2016) studies the analysis and design of flat slab by Using ETABS Software, concludes that flats plates/slab can be designed and build either by conventional reinforced concrete. Or post tensioning However, due to issues mentioned above with post-tensioning construction in India and its higher cost, conventional reinforced concrete design should be preferred choice for spans up to 10 meters.

2.3 Various Methods of seismic analysis

D.Prajapati et al (2015) He studied that analysis and procedure adopted for symmetric high rise multi storey building under effect of earthquake and wind forces by linear dynamic analysis. Shear wall is considered to resist lateral forces. Equivalent strut method is used to calculate the width of struts base shear, storey displacement, storey drift is calculated and all models are compared by ETABS.

Wakachure m.r et al (2015) has investigated that the effect of masonry walls on high rise buildings. Linear dynamic analysis is done on high rise building with different arrangements is carried out analysis is done on G+9 Rcc frame building. Earthquake time history is applied to the models. equivalent strut method is used to calculate the width of strut. various cases of analysis are taken analysis is carried out by software ETABS base shear, storey displacement, storey drift is calculated and all models are compared.

ASHWINI BEDARI et al (2014) has done the analysis and design of high rise steel building frame with braced and without braced under effect of earthquake and wind and software used for all analysis sap2000.dynamic analysis is carried out by using equivalent static method and response spectrum method for earthquake zone v as per IS CODE the natural period design base shear lateral displacement is compared for the different slope supporting model. The braced system used the economical result as compared to unbraced system in terms of frequency and displacement.

Himanshu Bansal et al (2015) He studied mass irregular building in his study he found the storey shear force was found to be maximum for the first storey Shear force was found to be minimum for top storey. Stiffness of irregular building has less base shear and are larger in regular structure.

a.b.m saiful Islam et al (2014) in this study analysis results show that isolation system considerably reduce earthquake induce load on building. Furthermore, method of analysis has been found to have considerable effect on the response of low to medium rise buildings. Time history analysis show significant less base shear than that from response spectrum analysis. Also, less isolator displacement is obtained from time history analysis than that from response spectrum analysis.

MR.K.Lova Raju et al (2015) He analyzed G+7 building without considering shear wall and in next process analyzed by considering shear wall at various positions. The building was analyzed on e-tabs in various zones (2,3,4,5). The lateral load increases with the increase of height of building. The pushover curve is generated by plotting base shear and roof displacement. The pushover curve is generated by plotting base shear and group displacement. Frame with shear wall perform better and the base shear increased when compared to the frame without shear wall. He concluded that performance was better by using shear wall and less lateral displacement was seen

Lakshmi K. O et al (2014) He determined the effect of shear wall location in building to seismic loads They provided 3-D model of G+15 residential building having floor to floor height of 3m with support at base. They concluded that drift value is reduced when shear wall is provided at corner. The reinforcement requirement in column is affected by location and orientation of adjacent shear wall and column

Nitin Choudhary et al (2014) performed pushover analysis of RC frame building with shear wall. In this project, a 4 storied reinforced concrete frame building situated in zone 4, is taken for the purpose of study. Euro codes EC2 and EC8 are also based on performance based design philosophy, but Indian codes are still silent over this method. FEMA-273, FEMA-356 and ATC-40 gives the detailed procedure of nonlinear pushover analysis. The performance base seismic design obtained by above procedure satisfies the acceptance criteria for immediate occupancy and life safety limit state for various intensity of small reduction in steel reinforcement when compared to code based seismic design (IS 1893-2002) obtained by staad pro.

Aslam et al (2014) He analysed G+5 storey hospital building in agartala which was undertaken by L&T The loads applied on the structure was based on IS-875 (part 1) 1987 [dead load], IS:875(part 2) 1987 [live load], IS:875 (Part 3)-1987 [wind load], IS:1893-2002[earthquake load]. Scale factor is calculated from design base shear to the base shear calculated using fundamental time period. Once the analysis was completed all the structural components were designed their dimension was determined and also the area and quantity of steel required for the safe working of the building under the occurrence of an earthquake according to IS:456-2000 this includes footings, columns, beams, slabs, staircases and shear wall.

Ankur Agarwal et al (2015) He analysed institute building of NIT Rourkela in which seismic loading was not considered when it was constructed. He reanalysed the building by considering seismic loading to know whether it is safe or not. He carried out Demand Capacity Ratio (DCR) for beams and columns in order to evaluate the member for seismic loads. As reinforcement details were unavailable. He prepared Design-1 applying only dead load & live load according to IS 456-2000 to estimate the reinforcement present in building & assuming this much reinforcement present in building. In design-2 seismic loads are applied & for this demand obtained from design-2 &capacity from design-1 the DCR is calculated. If demand is more than capacity of member fails vice versa.

Kalyan Chowdary Kodali, et al (2014) has carried out analysis of conventional beam slab and flat slab models. G+30 storey building models with shear walls are considered, which are subjected for different load conditions. The seismic considered is v. they concluded that, the time period of conventional beam slab is more when compared to flat slab. They found that storey drift of flat slab model is high when compared to beam slab model. Due to the higher drift ratio in flat slab additional movement will develop. In such case the column should be designed considering additional moments. In beam slab model base shear is more when compared to flat slab building.

Chandurkar Pajgade et al (2013) He analysed 10 storey building with seismic shear wall using ETABS v 9.5. main focus was to com pare the change in response by changing the location of shear wall in the multistoried building. Four models were studied 1 bare frame & 3 dual type structural system. Excellent results were obtained for shear wall in short span at corners. Large dimension of shear wall was ineffective in 10 & less than 10 storey building. Shear wall is an effective and economical option for high rise building. Proper positioning of shear wall is vital. Major amount of horizontal forces is taken when dimension is large Shear wall at subsequent location reduced displacements due to earthquake

Vishwanath.K.G et al (2010) He used concentric bracings & analysed 4,8,12,16 storey building in seismic zone 4 using STAAD Pro. He provided bracing for peripheral column and the effectiveness of steel bracing distribution along the height of the building, on the seismic performance of the building was studied. Displacements of floors reduced after X type bracing & also flexure shear demands of beams, columns & transferred lateral load by axial load mechanism. Buildings with X type bracings found to have minimum bending compared to other type bracings. Steel bracing system was found to be a better alternative for seismic retrofitting as they do not increase the total weight of the building significantly.

Chapter 3

Methodology

3.1 General

The project a residential building is software based, planning, analysis and designing will be done by using AutoCAD, ETABS .This project consist of three main parts as follows.

3.2 Preliminary data

Type of structure: RC Building

Zone: III

Layout: as shown in figure 3.1

No. of story: G+10

Floor to floor height :3m

Ground storey height :3m

Wall thickness: 0.23m

Total depth of slab: 150mm

Size of beam: density of RCC concrete: 25 kN/m^3

Unit weight of brick masonary : 20 KN/m^3

Weight of floor finish: 2 KN/m^2

Live load on floor: 21 KN/m^2

3.3 Planning

Planning of a residential building has been done as per building bye laws and IS Code requirements. The building consists of 11 floors .

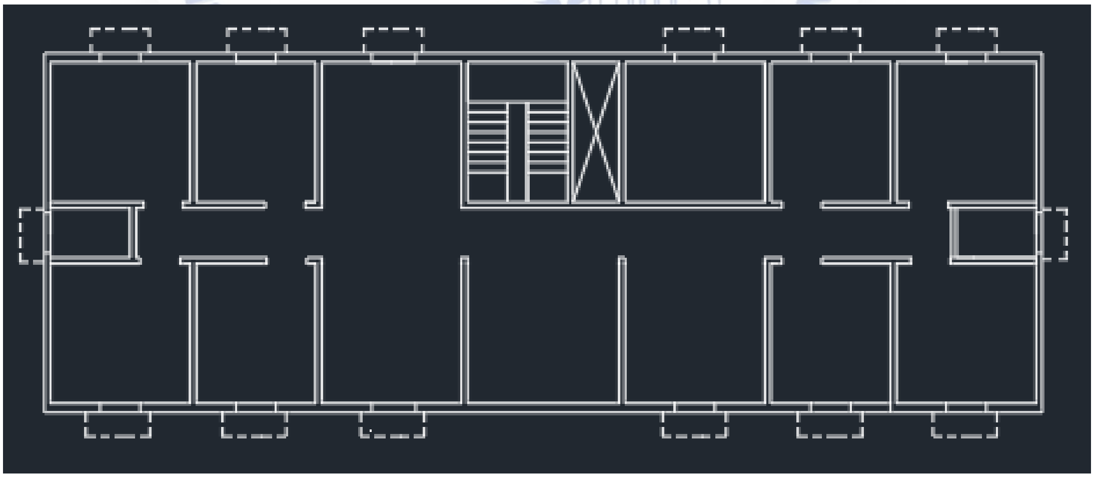


Figure 3.1. Plan

3.4 Analysis

After completion of planning the project will move ahead by analysing and designing process with the help of ETABS offers a single users interface to perform. Analysis, design, Detailing, and Reporting. This software will analyse and design a residential building with much ease. ETABS gives analysis and design for beams and columns only.

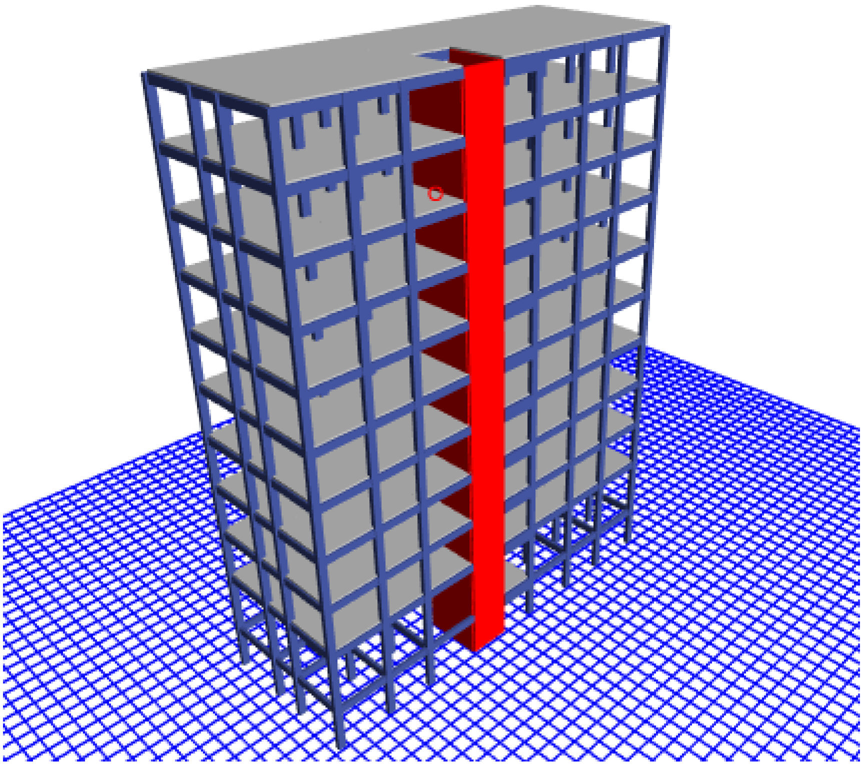


Figure 3.2. Three dimensional view of residential building

There is a step by step procedure followed by us for analysing and designing the structure. The steps are explained by in details in proper sequence below:

1.Saving AUTOCAD file as DXF file.

2.Opening .DXF file in ETABS and provide units in meters.

3. Define material like M30, M35 etc. grades of concrete & Fe-415,

Fe-500 etc. Steel as per IS code provided in options.

4.Define section properties:

5 Frames sections: In this section beams and columns can be defined.

Beam dimensions are as follows:

Beam B1: 230 x500 mm

Beam B2: 350 x 700 mm

Beam B3: 350 x 850 mm

Column dimensions are as follows:

C1: 300 x 500 mm

C2: 300 x 600 mm

Slab section: From this section thickness of slab section is defined as150mm.

Wall section: From this section thickness of wall is defined as 230 mm.

Grade of concrete is M35.

6. Assign beams, columns, slabs and shear wall. Placement of beams and columns are placed as indicated in centreline plan. After placement of beams and columns, the view of typical floors are as follows.

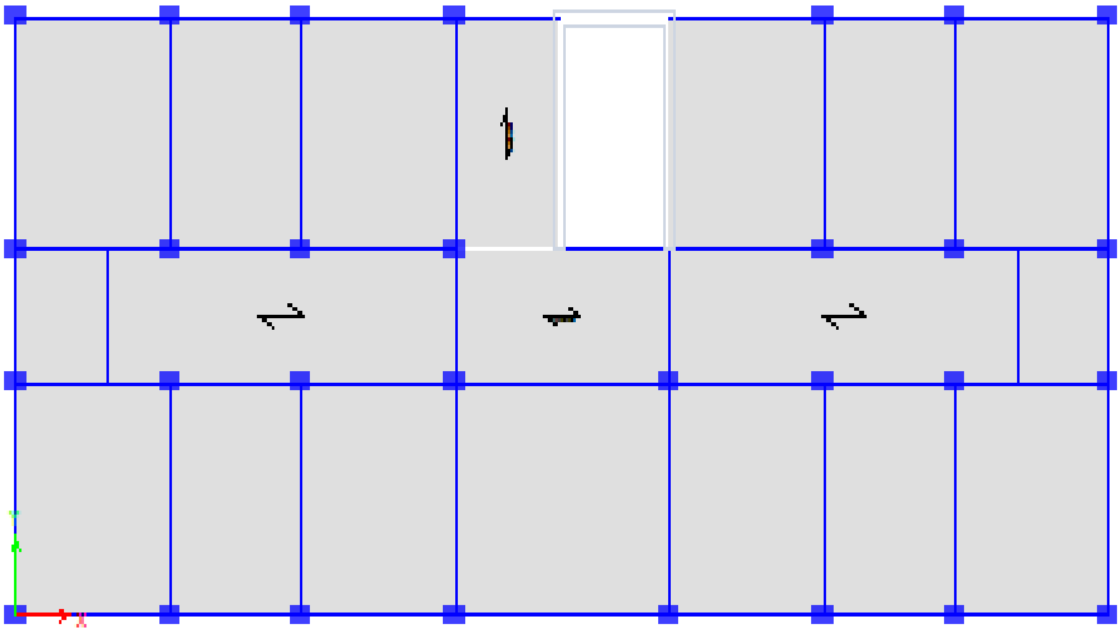


Figure 3.3 Centreline plan

7. Load definition:

We will define loads as follows:

(a) Static load cases:

The loads we assigned are shown in following figure:

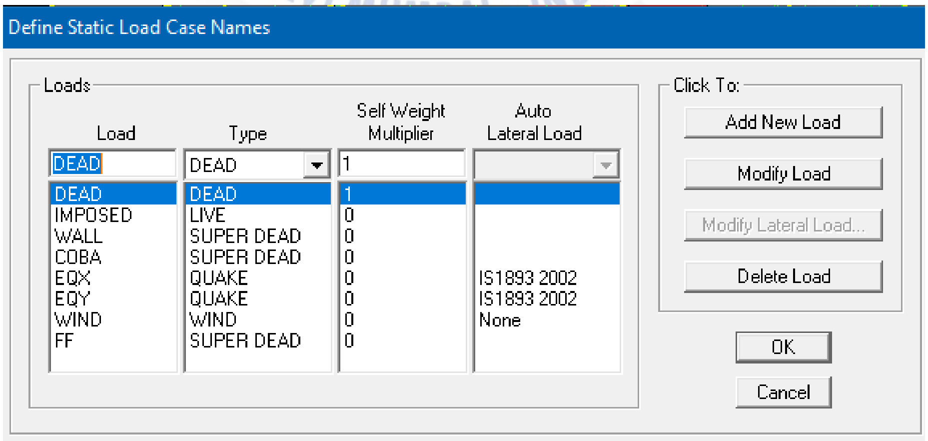


Figure 3.4 Static load cases

Now for defining seismic loads we have selected IS 1893-2002 and modified lateral loads. We have inputted all seismic data from doing calculations and referring IS code.

Zone factor: 0.16

Soil type: II

Table 3 Seismic Zone Factor *Z*
(*Clause* 6.4.2)

Seismic Zone Factor (1)	II (2)	III (3)	IV (4)	V (5)
Z	0.10	0.16	0.24	0.36

Figure 3.5. Seismic zone factor

Response reduction factor according to IS code should be within 3-5. We have provided 3.739.

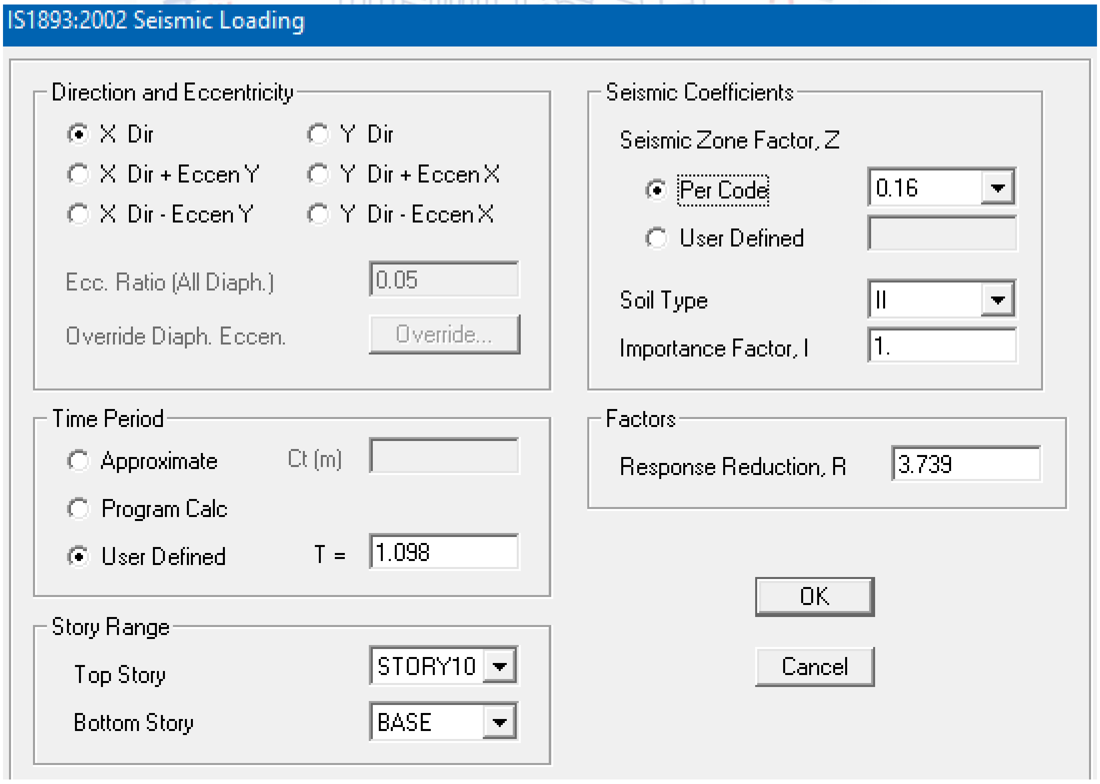


Figure 3.6. Seismic loading

Time period is calculated by formula of IS code 1893-2002.

T = 0.075h^0.75

H = height of building.

Now for response spectrum case data we will choose CQC method

Damping ratio = 0.05

The Multiplying factor for obtaining values for damping.

Table 3 Multiplying Factors for Obtaining Values for Other Damping
(*Clause* 6.4.2)

Damping, percent	0	2	5	7	10	15	20	25	30
Factors	3.20	1.40	1.00	0.90	0.80	0.70	0.60	0.55	0.50

Figure 3.7. Damping factor

For defining response spectrum functions, we will go to

Define response spectrum function in ETABS and we have calculated it earlier.

Now for acceleration value we will calculate referring IS code.

First we will take Sa/g value from IS 1893-2002.

For rocky, or hard soil sites

$$\frac{S_a}{g} = \begin{cases} 1 + 15T; & 0.00 \le T \le 0.10 \\ 2.50 & 0.10 \le T \le 0.40 \\ 1.00/T & 0.40 \le T \le 4.00 \end{cases}$$

For medium soil sites

$$\frac{S_a}{g} = \begin{cases} 1 + 15T; & 0.00 \le T \le 0.10 \\ 2.50 & 0.10 \le T \le 0.55 \\ 1.36/T & 0.55 \le T \le 4.00 \end{cases}$$

For soft soil sites

$$\frac{S_a}{g} = \begin{cases} 1 + 15T; & 0.00 \le T \le 0.10 \\ 2.50 & 0.10 \le T \le 0.67 \\ 1.67/T & 0.67 \le T \le 4.00 \end{cases}$$

Figure 3.8. Sa/g value

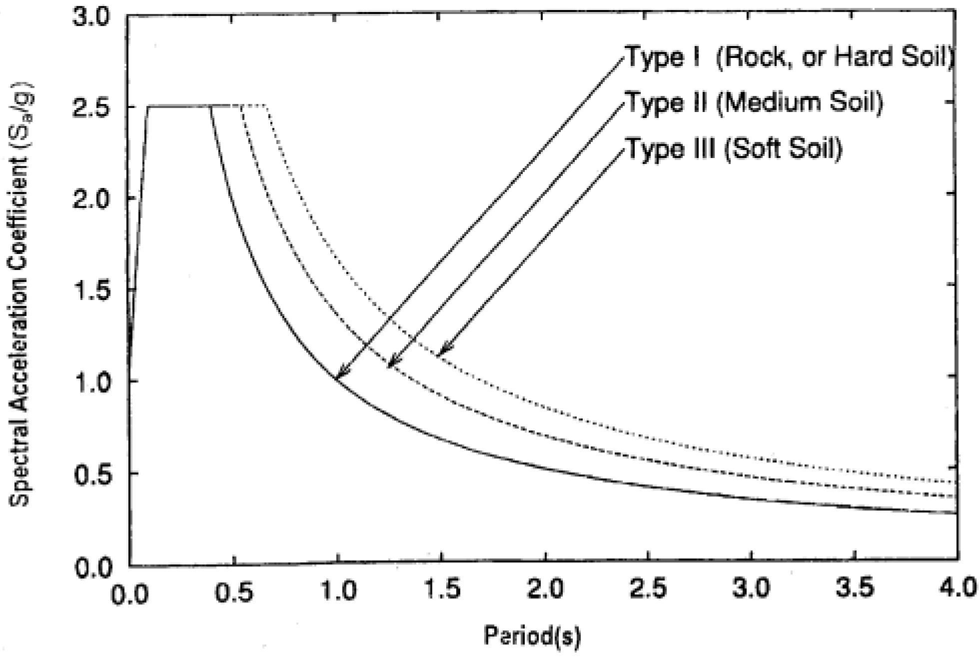
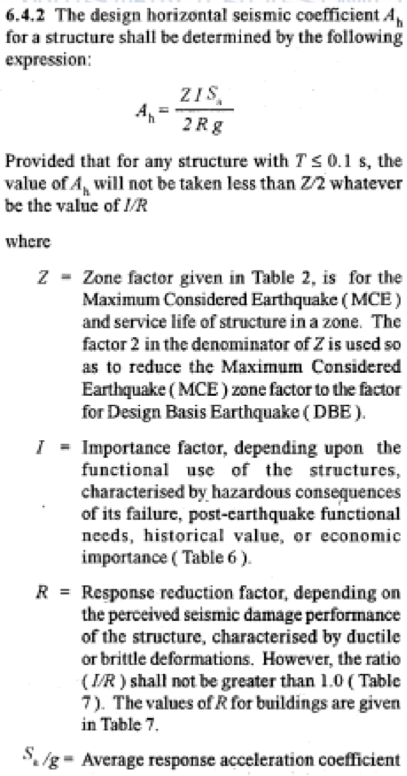


Figure 3.9. Sa/g graph

Then we will put Sa/g formula for acceleration from IS code 1893-2002 clause 6.4.2



6.4.2 The design horizontal seismic coefficient A_h for a structure shall be determined by the following expression:

$$A_h = \frac{Z\, I\, S_a}{2\, R\, g}$$

Provided that for any structure with $T \leq 0.1$ s, the value of A_h will not be taken less than $Z/2$ whatever be the value of I/R

where

Z = Zone factor given in Table 2, is for the Maximum Considered Earthquake (MCE) and service life of structure in a zone. The factor 2 in the denominator of Z is used so as to reduce the Maximum Considered Earthquake (MCE) zone factor to the factor for Design Basis Earthquake (DBE).

I = Importance factor, depending upon the functional use of the structures, characterised by hazardous consequences of its failure, post-earthquake functional needs, historical value, or economic importance (Table 6).

R = Response reduction factor, depending on the perceived seismic damage performance of the structure, characterised by ductile or brittle deformations. However, the ratio (I/R) shall not be greater than 1.0 (Table 7). The values of R for buildings are given in Table 7.

S_a/g = Average response acceleration coefficient

Figure 3.10. Formula for acceleration

Now we will assign the created loads on beam and slab.

Loads on slab:

Floor furnish load (FF) =2 KN/m^2

Imposed load (LL) = 3KN/m^2

Coba =4KN/m^2

Loads on beam:

Udl of wall on beam is been defined according to wall dimensions.

Element type chosen for concrete design-ordinary. In analyse choose dynamic analysis and then we will run analysis.

3.5 Design and detailing

After analysing the structure, detailing of the structural members is done. Under this head, we can provide the number of main bar, number of distribution bar and spacing between the stirrups as per the area of steel obtained from the analysis structure. different structural members on different floor may or may not have same design and same schedule.

Some of the reinforced section as shown below .it consist of longitudinal section of column beams and shear wall.

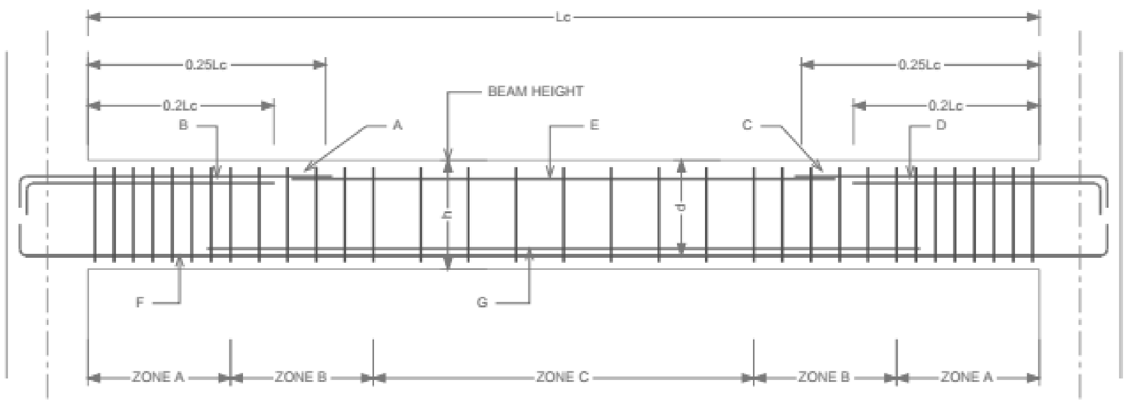


Figure 3.11 Reinforcement detail of typical beam for single slab

The above figure shows the reinforcement detail of typical beam for single slab

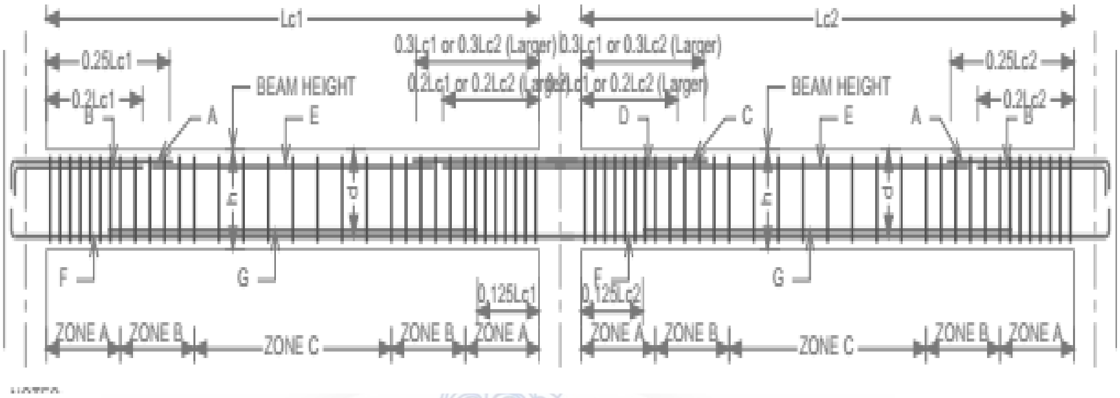


Figure 3.12 Longitudinal section reinforcement section for typical beam beneath the two adjacent slabs

The above figure shows the longitudinal section reinforcement section for typical beam beneath the two adjacent slabs

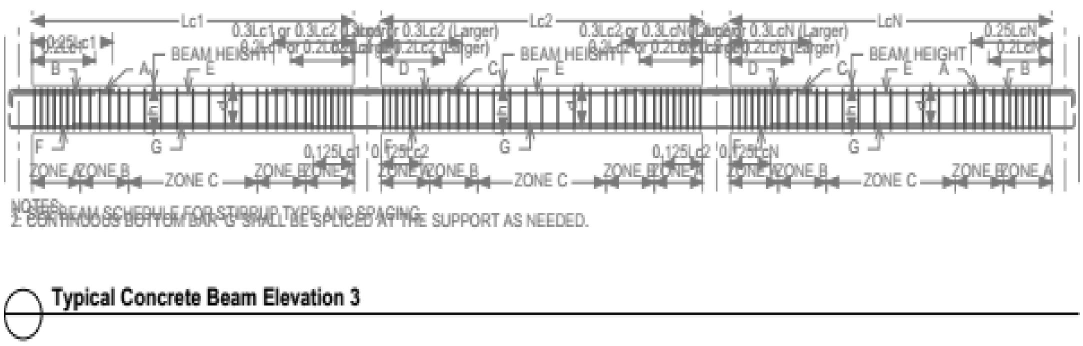


Figure 3.13 Longitudinal section reinforcement section for typical beam beneath the three adjacent slabs

The above figure shows the longitudinal section reinforcement section for typical beam beneath the three adjacent slabs

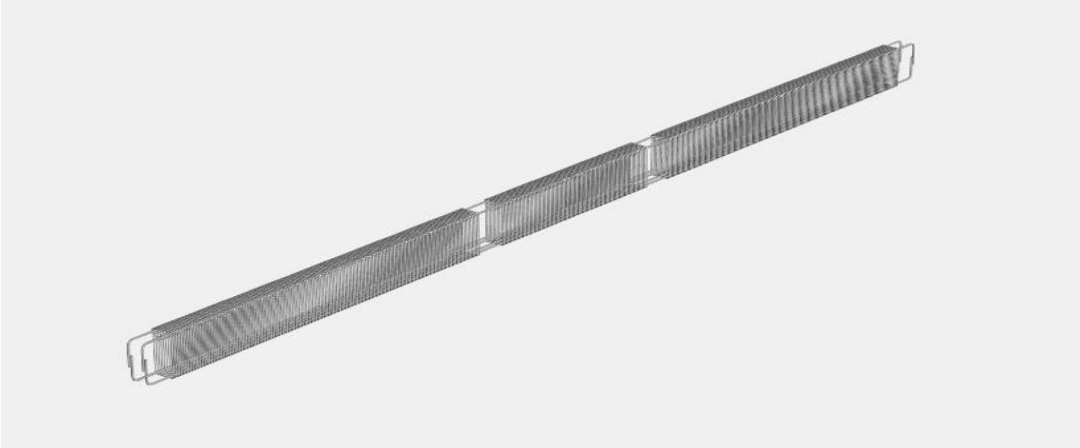


Figure 3.14 Typical three dimensional view of beam 12CB1

The above figure shows typical three dimensional view of beam 12CB1

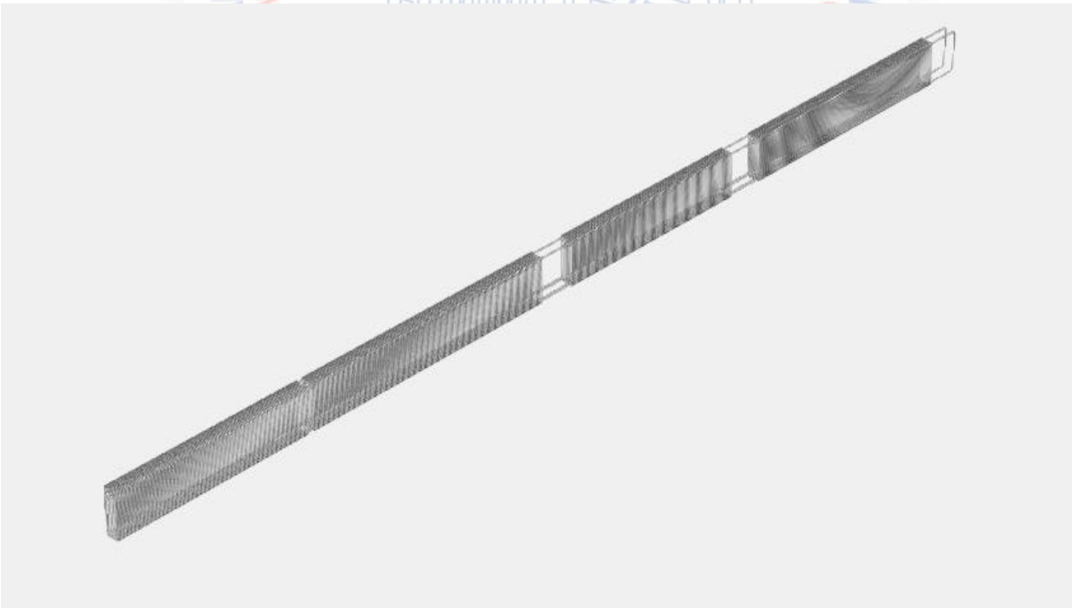


Figure 3.15 Typical three dimensional view of beam 2CB10

The above figure shows typical three dimensional view of beam 2CB10

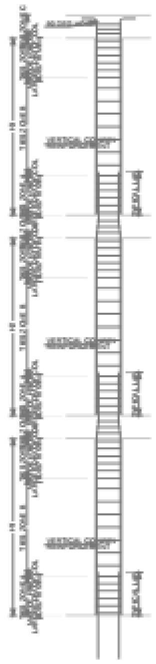


Figure 3.16 Concrete column typical elevation-intermediate

The above figure shows concrete column typical elevation-intermediate.

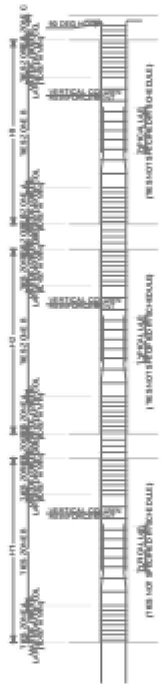


Figure 3.17 Concrete column typical elevation-special

The above figure shows concrete column typical elevation-special.

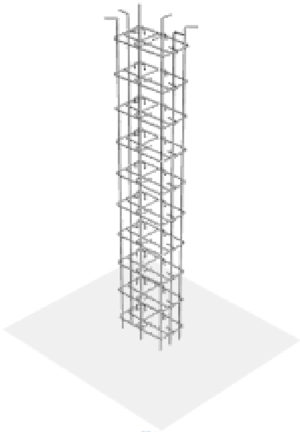


Figure 3.18 Typical three dimensional view of column CC1.

The above figure shows typical three dimensional view of column CC1.

Figure 3.19 Typical three dimensional view of column CC7.

The above figure shows typical three dimensional view of column CC7.

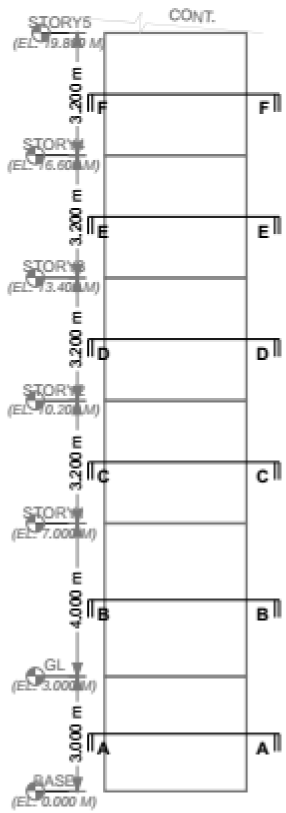


Figure 3.20 Spacing of main bars in shear wall CW1F1

The above figure shows the spacing of main bars in shear wall CW1F1.

Chapter 4

Result and Discussion

4.1 ETABS

After the detailed analysis of structure, the following results is obtained which shows the area of steel required in respective structural members (beams, columns, shear walls). Along with the steel area, the bending moment details, shear force details and deflections in each beam is also obtained in a systematic manner. All these details are obtained in an auto-generated "docx" file which is generated automatically by ETABS software while we work on the structure. Necessary snapshots are provided below.

Following are some of the cross-sections and longitudinal sections from the structure along with the reinforcement details:

Figure 4.1 Beam section A

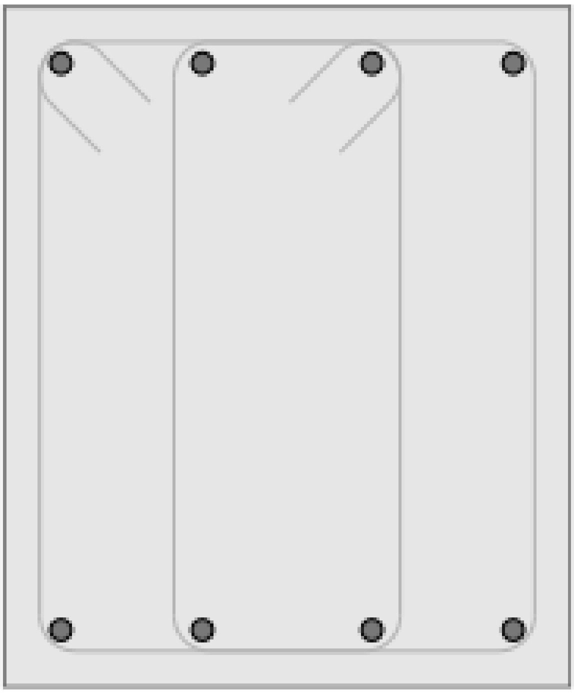


Figure 4.2 Beam section B

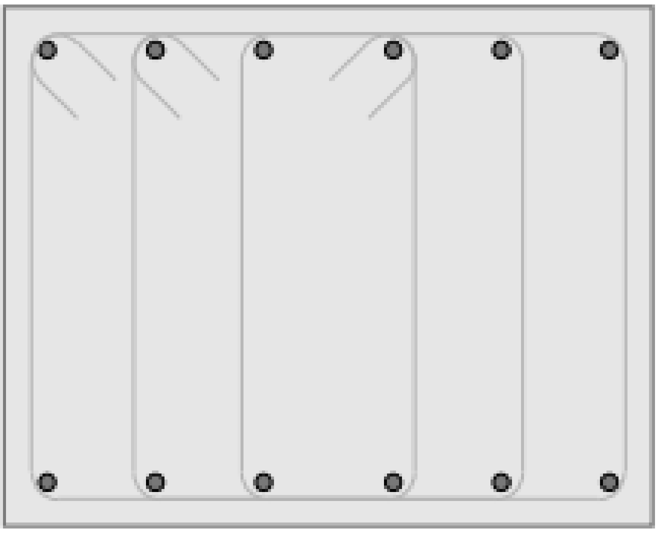


Figure 4.3 Beam section C

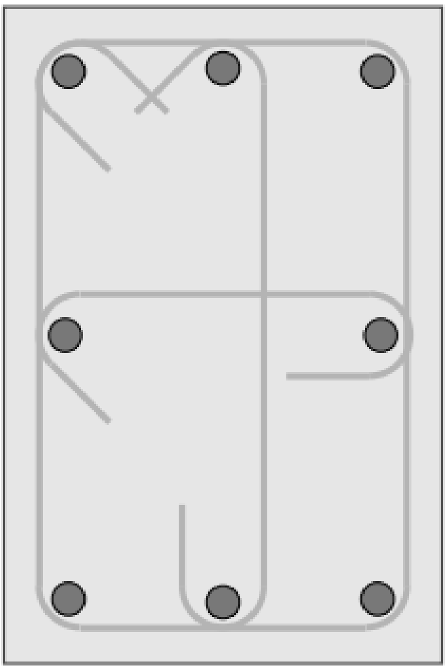


Figure 4.4 Column section A

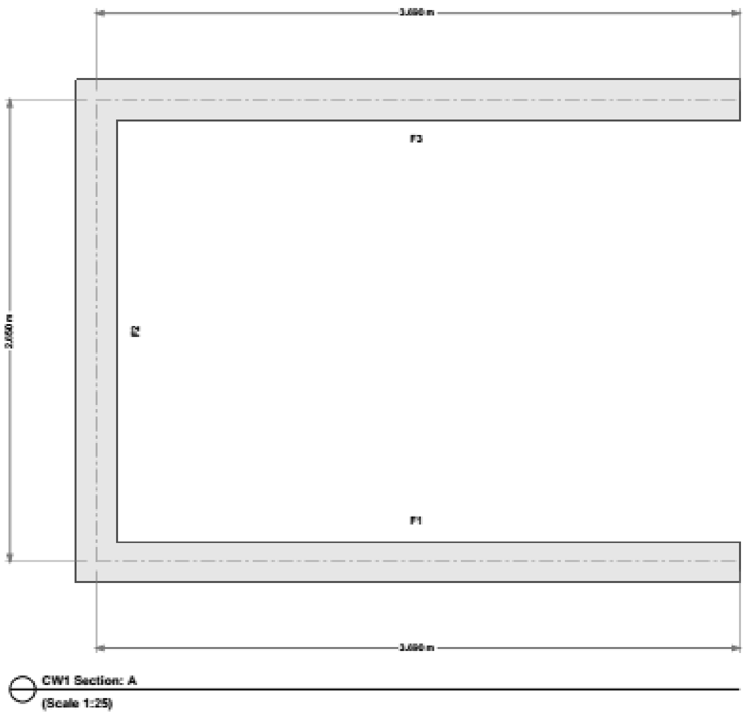


Figure 4.5 CW1 section A

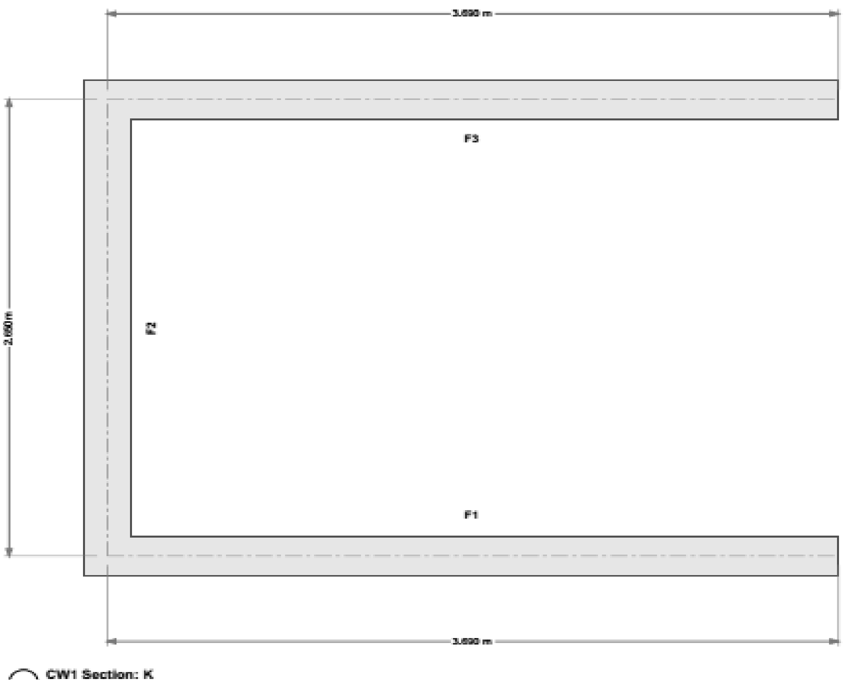


Figure 4.6 CW1 section K

CONCRETE BEAM REBAR TABLE (1 OF 8)

BEA	SPA	SPA	SECTIO		LONGITUDINAL BARS							STIRRUPS			TYPICA
M ID	N N	N L	WI	DE	A	B	C	D	E	F	G	ZONE A	ZONE	ZONE	L ELEV
12CB 1	1	3.390	230	500	3-#5	-	-	-	2-#4	2-#4	-	-	-	#3 @ 225	ELEVATIO
	2	1.850	230	500	-	-	3-#4	-	2-#4	2-#4	-	-	-	#3 @ 225	ELEVATIO
	3	3.390	230	500	2-#5	-	2-#4	-	2-#4	3-#4	-	-	-	#3 @ 225	ELEVATIO
12CB 2	1	3.190	230	500	3-#4	-	-	-	2-#4	2-#4	-	-	-	#3 @ 225	ELEVATIO
	2	2.650	230	500	-	-	2-#4	-	2-#4	2-#4	-	-	-	#3 @ 225	ELEVATIO
	3	3.190	230	500	-	-	3-14	-	2-#4	2-#4	-	-	-	#3 @ 225	ELEVATIO
	4	4.650	230	500	-	-	2-#6	-	2-#4	2-#5	-	-	-	#3 @ 225	ELEVATIO
	5	3.190	230	500	-	-	2-#6	-	2-#4	2-#4	-	-	-	#3 @ 225	ELEVATIO
	6	2.650	230	500	-	-	3-14	-	2-#4	2-#4	-	-	-	#3 @ 225	ELEVATIO
	7	3.190	230	500	3-#4	-	2-#4	-	2-#4	2-#4	-	-	-	#3 @ 225	ELEVATIO
12CB 3	1	3.440	230	500	3-#6	3-#6	-	-	5-#4	2-#6	1-#6	-	-	#3 @ 225	ELEVATIO
	2	2.650	230	500	-	-	2-#4	-	2-#4	2-#4	-	-	-	#3 @ 225	ELEVATIO
	3	3.190	230	500	3-#4	-	2-#4	-	2-#4	2-#4	-	-	-	#3 @ 225	ELEVATIO
12CB	1	2.250	350	850	2-#6	1-#6	4-#6	3-#6	9-#4	2-#6	1-#6	-	-	#3 @ 125	ELEVATIO
12CB 5	1	3.190	230	500	3-#4	-	-	-	2-#4	2-#4	-	-	-	#3 @ 225	ELEVATIO
	2	2.650	230	500	-	-	2-#4	-	2-#4	2-#4	-	-	-	#3 @ 225	ELEVATIO
	3	3.190	230	500	2-#6	1-#6	2-#4	-	2-#4	2-#6	-	-	-	#3 @ 225	ELEVATIO
12CB	1	3.390	230	500	2-#5	-	2-#5	-	2-#4	2-#5	-	-	-	#3 @ 225	ELEVATIO
12CB 7	1	3.190	230	500	3-14	-	-	-	2-#4	2-#6	-	-	-	#3 @ 225	ELEVATIO
	2	2.650	230	500	-	-	2-#5	-	2-#4	2-#4	-	-	-	#3 @ 225	ELEVATIO
	3	3.190	230	500	2-#4	-	2-#5	-	2-#4	2-#4	-	-	-	#3 @ 225	ELEVATIO
12CB 8	1	3.190	230	500	2-14	-	-	-	2-#4	2-#6	-	-	-	#3 @ 225	ELEVATIO
	2	2.650	230	500	-	-	2-#5	-	2-#4	2-#4	-	-	-	#3 @ 225	ELEVATIO
	3	3.190	230	500	-	-	2-#5	-	2-#4	2-#4	-	-	-	#3 @ 225	ELEVATIO
	4	4.650	230	500	-	-	2-#4	-	2-#4	3-#4	-	-	-	#3 @ 225	ELEVATIO
	5	3.190	230	500	-	-	2-#5	-	2-#4	2-#4	-	-	-	#3 @ 225	ELEVATIO
	6	2.650	230	500	-	-	3-14	-	2-#4	2-#4	-	-	-	#3 @ 225	ELEVATIO
	7	3.190	230	500	2-14	-	2-#5	-	2-#4	2-#6	-	-	-	#3 @ 225	ELEVATIO
12CB	1	2.150	230	500	2-#4	-	2-#4	-	2-#4	2-14	-	-	-	#3 @ 225	ELEVATIO
12CB 10	1	3.390	230	500	2-14	-	-	-	2-#4	2-#5	-	-	-	#3 @ 225	ELEVATIO
	2	1.850	230	500	-	-	2-#5	-	2-#4	2-#4	-	-	-	#3 @ 225	ELEVATIO
	3	3.390	230	500	2-#6	1-#6	3-#4	-	2-#4	2-14	-	-	-	#3 @ 225	ELEVATIO
12CB 11	1	2.650	230	500	2-#4	-	-	-	2-#4	2-#4	-	-	-	#3 @ 225	ELEVATIO
	2	3.440	230	500	-	-	2-#6	1-#6	3-#4	2-#6	-	-	-	#3 @ 225	ELEVATIO
	3	2.650	230	500	-	-	3-#4	-	2-#4	2-#4	-	-	-	#3 @ 225	ELEVATIO
	4	3.190	230	500	3-#4	-	2-14	-	2-#4	2-#6	-	-	-	#3 @ 225	ELEVATIO

Figure 4.7 concrete beam rebar table

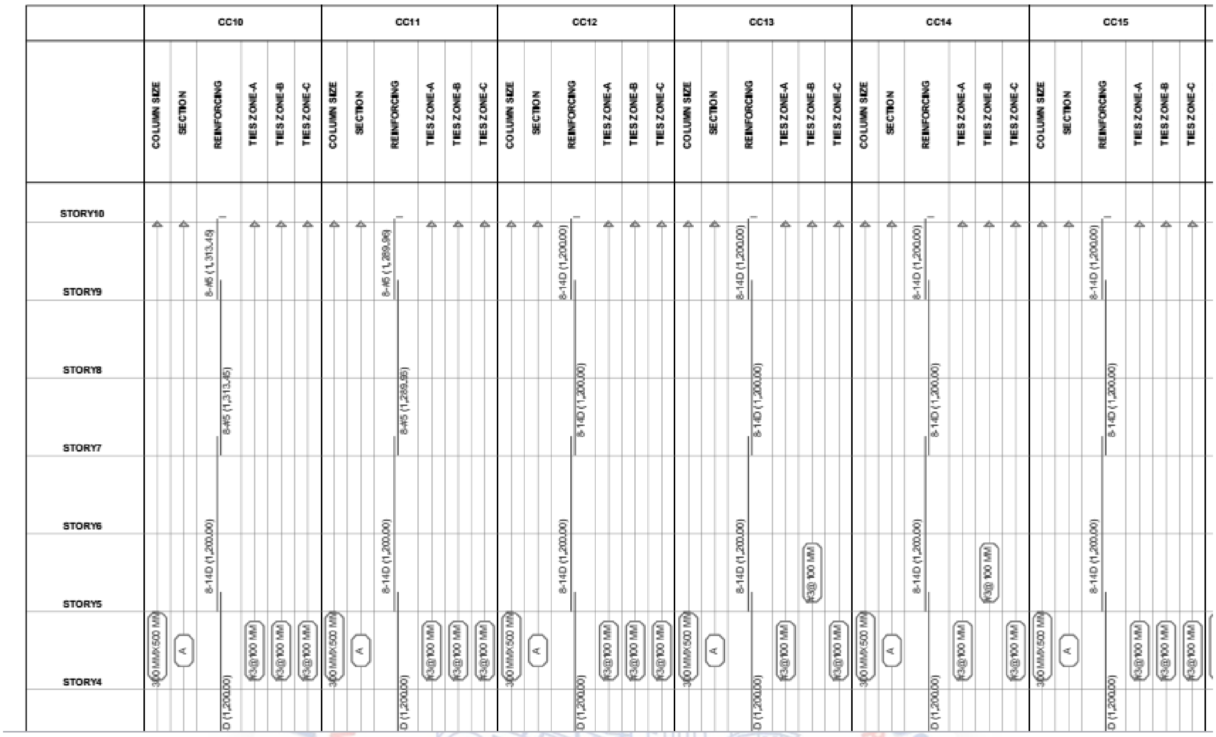


Figure 4.8 concrete column schedule

After analysis of building following are the results:

1) The deflected shape of building was found safe and is shown below:

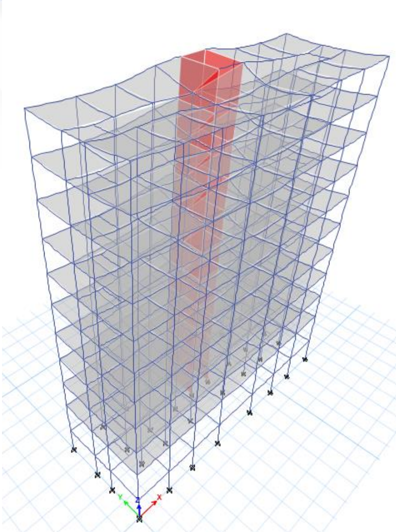


Figure 4.9. Deflected shape of building

2) The resultant stress diagram of building was green in colour i.e safe and is shown below:

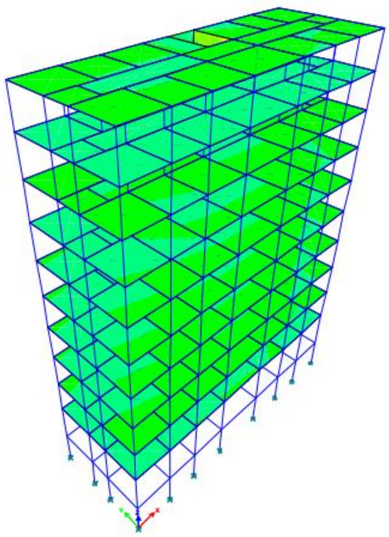


Figure 4.10. Resultant stress diagram

3) The moment diagram of building is shown below:

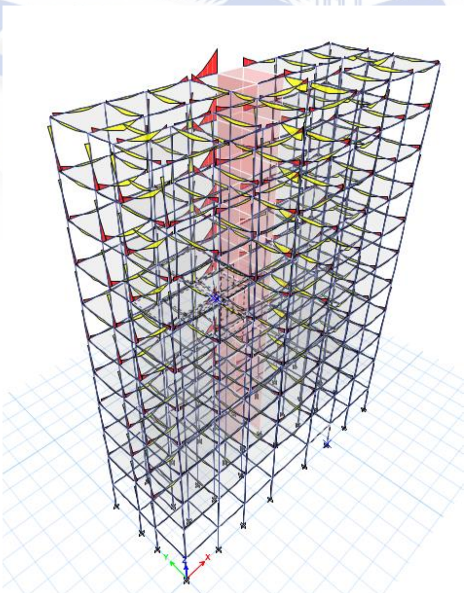


Figure 4.11. Moment diagram

4) Now the response of building with respect to modes of response spectra are shown:

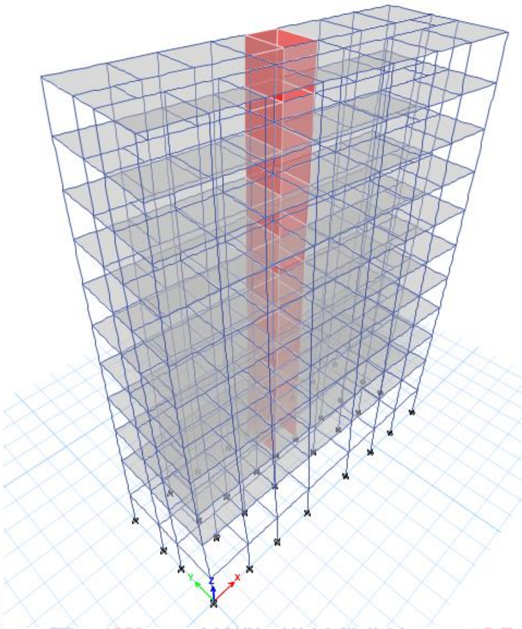


Figure 4.12. Mode 1

The above figure shows structure response to 1 mode and it was safe in 1 mode

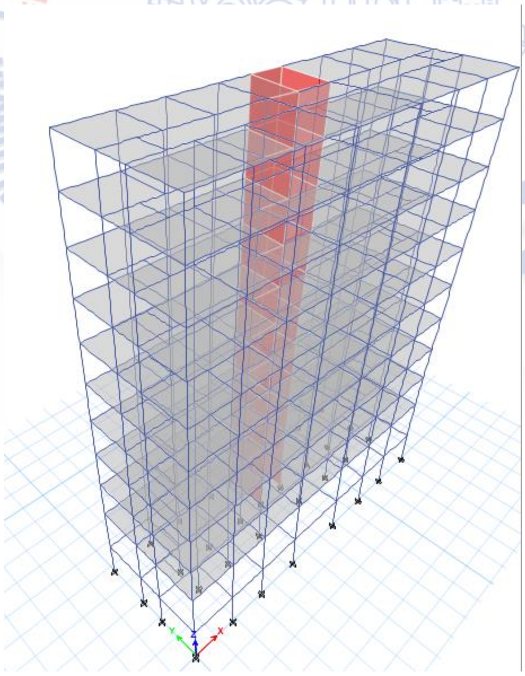


Figure 4.13.Mode 2

The above figure shows structure response to 2 mode and it was safe in 2 mode.

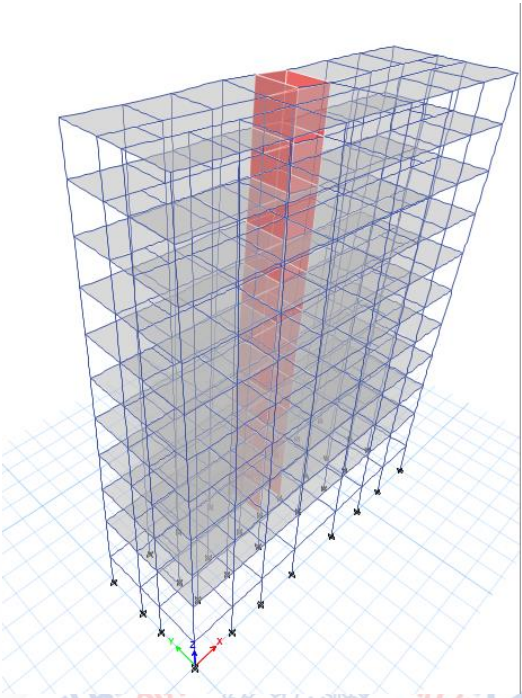


Figure 4.15.Mode 3

The above figure shows structure response to 3 mode and it was safe in 3 mode.

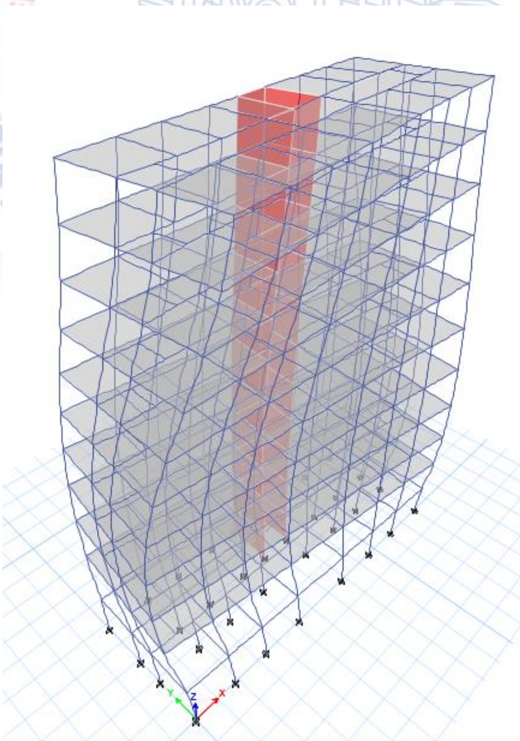


Figure 4.14.Mode 4

The above figure shows structure response to 4 mode and it failed in 4 mode.

The storey drift of the structure was in the permissible limit and safe and is shown below:

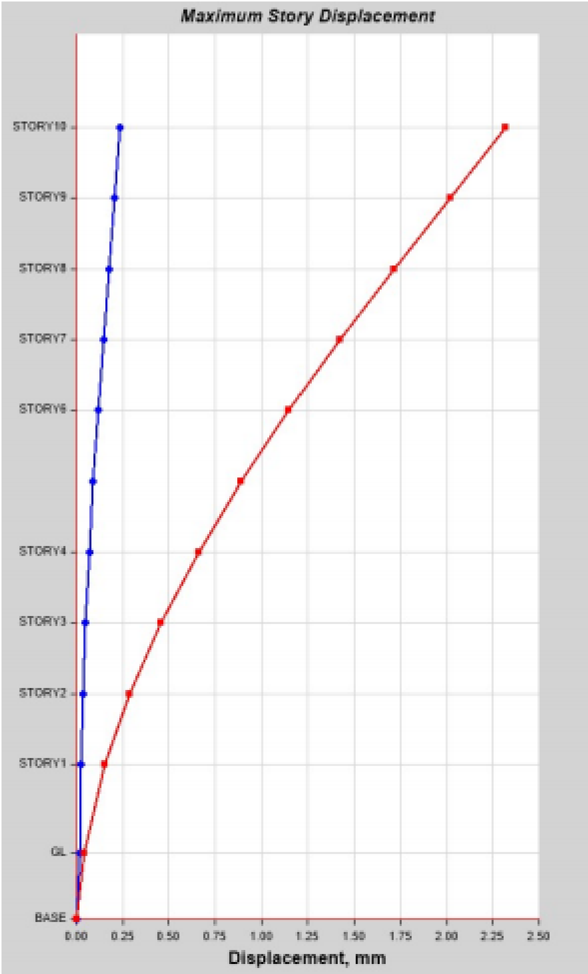


Figure 4.16. Storey displacement

Chapter 5

Conclusion

- The seismic response is affected by height, symmetry, soil condition, zone & design procedure of the structure.
- Shear wall plays vital role in during earthquake and provides stiffness to the structure.
- The building, we designed successfully withstanded the seismic load and all structure element loads with assumed dimension and had passed the analysis.
- For the building to be safe it is necessary that building should not compulsory fail at first two fundamental modes & our structure did not failed at third mode &failed at 4^{th} modes due to more drift storey & base shear.
- The shape & symmetry of building plays vital role as symmetrical building observes less twisting moment, torsion. As our structure is symmetrical it is safe and withstanded the seismic analysis.

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