MAJOR PROJECT PART B REPORT

ON

SEISMIC ANALYSIS & DESIGN OF MULTI STOREY BUILDING IN DIFFERENT SEISMIC ZONES.

Submitted in partial fulfilment of the requirements

for the degree of

BACHELOR OF ENGINEERING IN CIVIL ENGINEERING

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(2022-23)

CERTIFICATE

This is to certify that the project entitled "**Seismic Analysis & Design of Multi Storey Building in Different Seismic Zones.**" is a bonafide work of submitted to the University of Mumbai in partial fulfillment of the requirement for the award of the degree of Undergraduate in "Civil Engineering"

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Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my 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

There is an excess demand for construction of multi storied buildings due to increasing urbanization and spiraling populations. Seismic load has Ultimate adverse effect on building. Earthquake forces are tremendous as it is unforeseeable in nature and unpredictable, the engineering tools require to be improving for analyzing structures under the action of these forces and to determine seismic reactions over those structures. In this study the seismic response of the structures is investigated under earthquake excitation expressed within the kind of Member Forces, Joint Displacement, Support Reaction, Base Shear and Story Drift. This research is based on Seismic Analysis and Design of G+10 building which is located in zone III & IV. A multi-storied RC framed building with Light weight concrete and conventional concrete is taken for Seismic analysis in different earthquake intensities III and IV according to IS 1893 PART 1 (2016). The analysis results are used to confirm the effect light weight concrete and conventional concrete building in different seismic zones.

Keywords: *Earthquakes, seismic force distribution, Base Shear, Story Drift, storey displacement,*

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CHAPTER 1

INTRODUCTION

1.1 General

Where urbanization is at the faster rate in the country essentially adopting the methods and type of the constructing buildings that have seen tremendous growth over the past few decades. Around the world, there is a tremendous need for the construction of multi-story buildings due to expanding urbanisation and a constantly growing population. It is difficult to study and design structural systems for seismic stresses in multi-story reinforced concrete structures, because they are unpredictable and unpredictably strong earthquakes are most likely to cause damage to tall buildings. To analyse the structures under the influence of these stresses, the engineering techniques must be improved.

Building catastrophe is one of the most unpleasant effects of most natural disasters, especially earthquakes. In the past, seismic design codes focused on ensuring the providing a requisite level of life safety, not on reducing damage. Determining seismic responses over those buildings is therefore now required. The major goal is to analyse the construction in such a manner that it can withstand the high seismic zone as a result.

Seismic load, wind load, dead load and live load is calculated and applied on structure. From Maximum protection against a building failing due to overloading during natural disasters comes from these load combinations. Earthquakes has the probable for causing the greatest damages to the structures. Therefore, it is essential to design the structure for various seismic zones.

The current work is therefore focused on "Analysis and Design of G+10 Multi-Story Residential Building in the Seismic Zone III and IV" and compares the seismic effects of traditional RC framed and light weight concrete buildings.

1.2 Earthquake in India

The ground trembling is all that constitutes an earthquake. Natural events lead to it. Energy is released as a result, causing waves to flow in all directions, which causes it to occur. Seismographs can pick up seismic waves produced by the Earth's vibrations during an earthquake.

Medium-sized earthquakes happen every day. Strong tremors t.hat cause significant damage, however, are less frequent. Earthquakes occur more often along plate borders, especially along convergent boundaries. In the region of India where the Indian Plate and the Eurasian Plate collide, there are more earthquakes. Take the Himalayan area as an example.

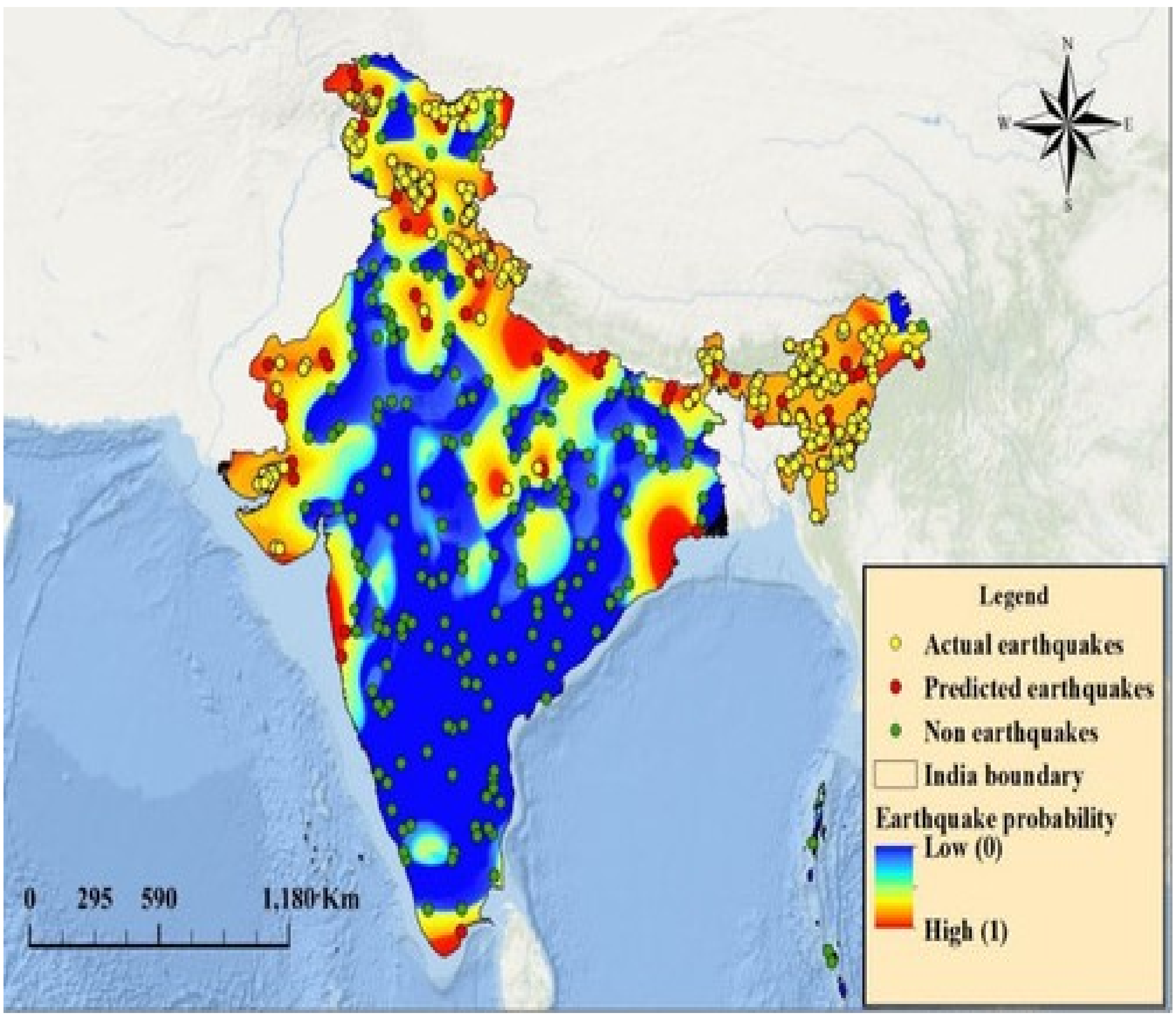


Fig 1.1 Earthquake Probability Map

Table 1.1 List of Earthquakes in India

Year	Earthquake
2022	Chennai Earthquake
2021	Assam Earthquake
2019	Maharashtra (Palghar)
2015	India/Nepal Earthquake
2011	Sikkim Earthquake
2005	Kashmir Earthquake
2004	Indian Ocean Earthquake

Year	Earthquake
2001	Bhuj Earthquake
1999	Chamoli Earthquake
1997	Jabalpur Earthquake
1993	Latur Earthquake
1991	Uttarkashi
1988	Bihar-Nepal border

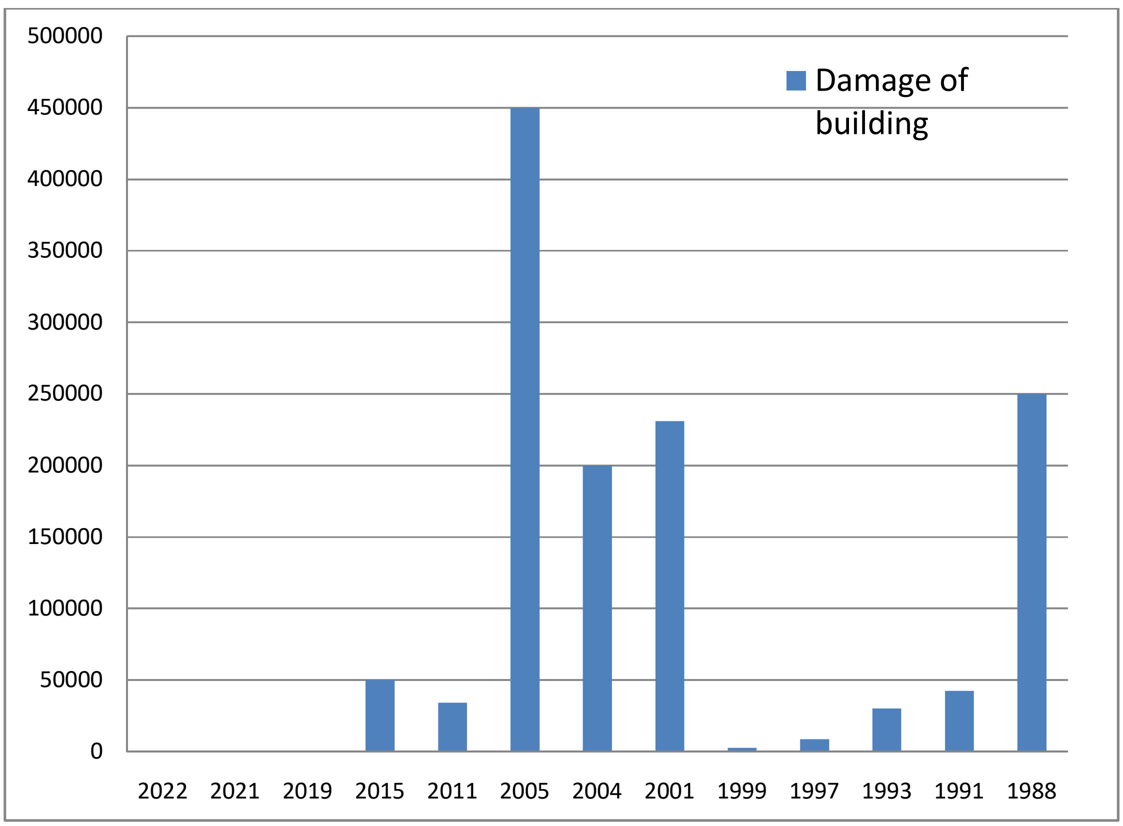


Fig 1.2 Damage of Building in India due to Earthquake

1.3 Seismic Analysis

An earthquake is a natural calamity. That results in enormous loss of life, destruction of property, and severe economic damage to a nation. An earthquake's vibrations can be felt as far away as the epicentre. One of nature's most devastating tragedies, earthquakes cause the surface of the earth to tremble when seismic energy is released. Seismic waves that are generated at the earth's surface have an impact on buildings. Seismic waves are measured using seismographs and the Richter scale. When a building is exposed to seismic waves, the foundation starts to tremble and the building eventually falls. To determine how a structure would react in the case of an earthquake, seismic analysis is used. The natural frequency of the structure, the damping factor, the kind of foundation, etc. are all factors that go into the making of an earthquake-resistant structure. The natural period of a structure determines its total seismic base shear, while the stiffness and mass distribution of the building, combined with its height, define the seismic force distribution.

The main objective of seismic analysis is to lessen the accelerations and displacements of the structure. On the other hand, few, powerful earthquakes are predicted to cause inelastic deformation of the walls. Therefore, shear walls ought to be able to withstand plastic deformation while still supporting a load and releasing energy.

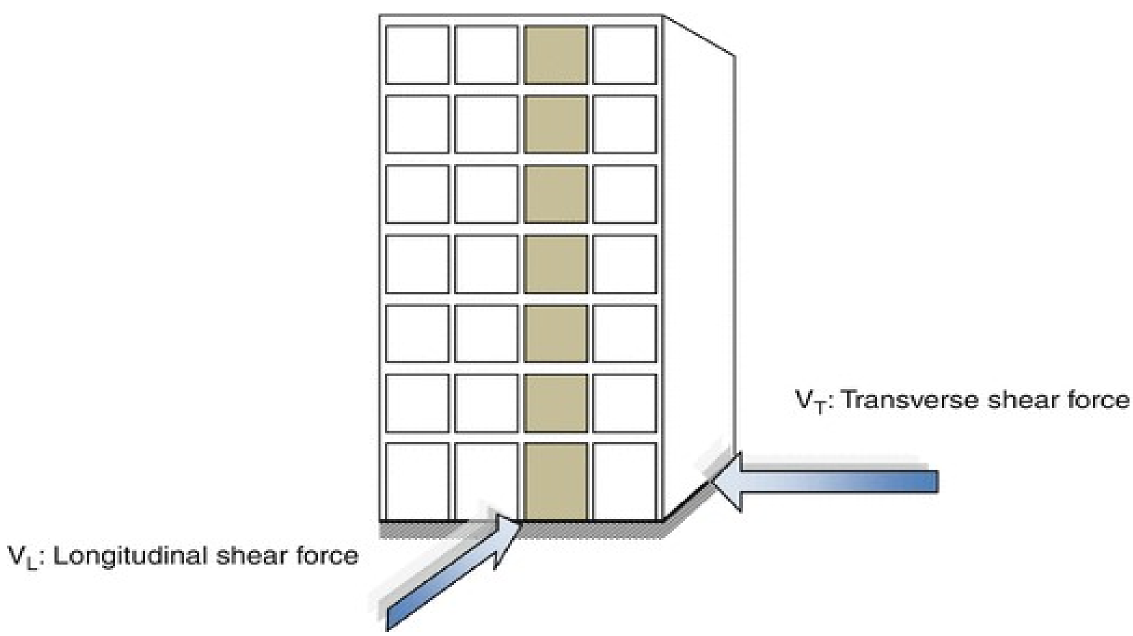


Fig 1.3 Seismic force acting on structure

1.4 Indian Standard (IS) Codes of Practice:

The following is an outline of the Indian Standard codes utilised in the analysis and design of the building:

1.5.1. List of Indian standards dealing with Earthquake resistant construction are:

- IS 1893 (Part 1): 2016 Rev 'Criteria for Earthquake Resistant Design of Structures : Part 1 General provisions and Buildings'
- IS 1893 (Part 4): 2005 “Criteria for Earthquake Resistant construction and Design of Structures”
- IS 13920:1993 Ductile Detailing of RCC Subjected to Seismic Forces - Code of Practice

1.5.2. List of Indian standards dealing with Analysis and Design of Building are:

- IS:875- 1987 - Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures:
  - Part 1: Dead Loads- Unit Weight of Building Materials and Stored Materials:
  - Part 2: Imposed Loads
  - Part 3: Wind Loads
  - Part 4: Snow Loads.
  - Part 5: Special Loads and Other load combination
- IS 456: 2000 - Plain and Reinforced Concrete - Code of. Practice

1.5.3 Brief overview on provisions of IS 1893:2016 (Part I)

The earthquake waves induce vibrations in the structure, which generate inertia forces. In order to effectively transport the inertia forces generated in the superstructure to the ground via the foundation, the structure must be able to do so. Because of this, the majority of common constructions must have a sufficient ability to carry lateral loads in order to function seismically.

- Seismic codes are used to particular areas or nations, and they can help a designer create a structure that is safe for its intended usage.
- The primary code in India that describes how to compute the seismic design force is IS 1893.

- The importance of the structure, its own stiffness, the soil on which it stands and its ductility are all elements that affect the mass and seismic coefficient of the structure.
- Seismic load evaluations for various structures and buildings are covered in Part I of IS1893:2016 (hence referred to as the code).
- This code covers the evaluation of seismic loads on various structures and the construction of buildings that are earthquake-resistant.

The entire code is concentrated on calculating the base shear and distributing it over height. The type of analysis, such as static or dynamic is depending on the height of the structure and the zone to which it belongs.

1.5 Seismic analysis method

The following method is used to seismic analysis of building/structure, which are-

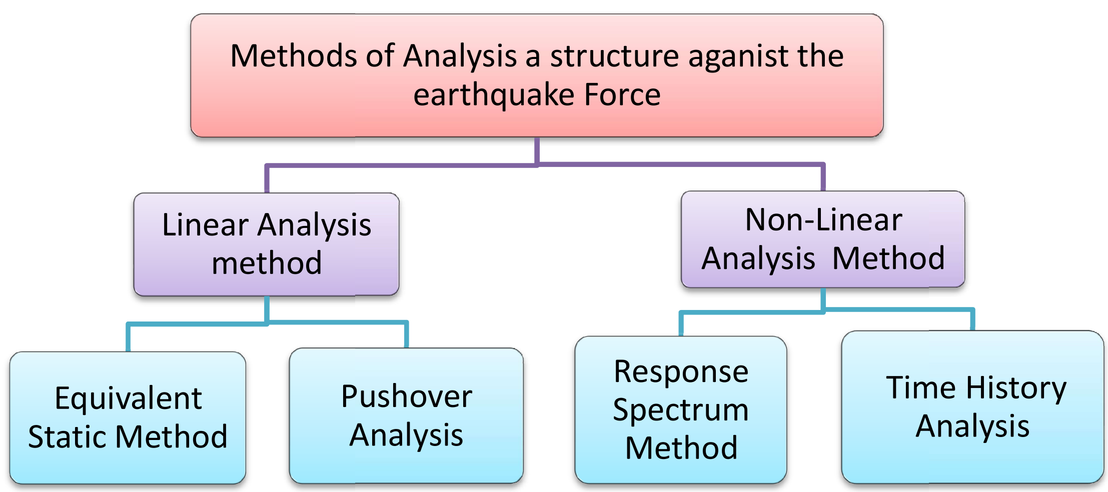


Fig 1.4 Seismic Analysis Method

1. Equivalent Static Analysis –

The equivalent static lateral force approach is a streamlined method for designing structures that replaces the dynamic loading caused by a projected earthquake with a static force distributed laterally.

In this research, the effects of earthquake ground motion are represented by a variety of forces. It is predicated on the idea that the structure is responsive in its most basic state. This is relevant to low-rise structures and structures that rotate very little around their axes. Additional studies have been conducted to expand its application to high-rise structures and low-level axial rotation.

2. Pushover Analysis -

Pushover Analysis used to calculate the seismic demand for the specified earthquake and the strength and drift capability of the current structure.It may also be used to evaluate the suitability of new structural designs. It is a type of study where a mathematical model is used to account for the nonlinear load-deformation properties of the various building parts and components that will be subjected to increasing lateral loads that represent inertia.A lateral force distribution that represents the inertia forces is physically applied to the structure in the pushover study, with the intensity rising until the ultimate condition is exceeded. The base shear-top displacement curve, also known as the pushover or capacity curve, illustrates the overall reaction. factors causing earthquake.

3. Response spectrum of analysis –

When modes other than the basic one have a major impact on how the structure responds, this study is done. Since each modal response is derived from the spectral analysis of a Single-Degree-of-Freedom System (SDOF), the response of a Multiple-Degree-of-Freedom System (MDOF) is shown here as the superposition of modal responses. The overall reaction is then calculated by combining all of these..

4. Time history analysis -

When the assessed structural response is nonlinear, it is a crucial approach for structural seismic analysis. A representative earthquake time history for the structure under consideration is needed to do such a study. Time history analysis is a step-by-step examination of a structure's dynamic response to a given stress that may change over time. To ascertain how a structure will respond to a typical earthquake's dynamic loads, time history analysis is performed.

1.6 Seismic Zones in India

India is susceptible to earthquakes of varying intensity in all, 59% of India's geographical mass (including all of its nations) is affected. The entire area is divided into four seismic zones according to the India seismic zoning map. Zone II has the lowest seismic activity, whereas Zone V has the most.

Table no 1.2 Seismic Zones in India

Zone	Intensity	Area Affected by Seismic Activity (%)
Zone II	VI (Low Risk Zone)	40.93
Zone III	VII (Moderate Risk Zone)	30.79
Zone IV	VIII (High Risk Zone)	17.49
Zone V	IX (Very High Risk Zone)	10.79

India has been classified into four seismic zones: Zone II, Zone III, Zone IV, and Zone V, as seen on the map drawn by Indian seismologists. The whole Himalayan area, as well as the states of North-East India, Western and Northern Punjab, Haryana, Uttar Pradesh, Delhi, and parts of Gujarat, are given the designations of zones V and IV. The northern lowlands and western coastal sections are still in the moderate danger zone, but quite a bit of the peninsular region is now in the low-risk zone.

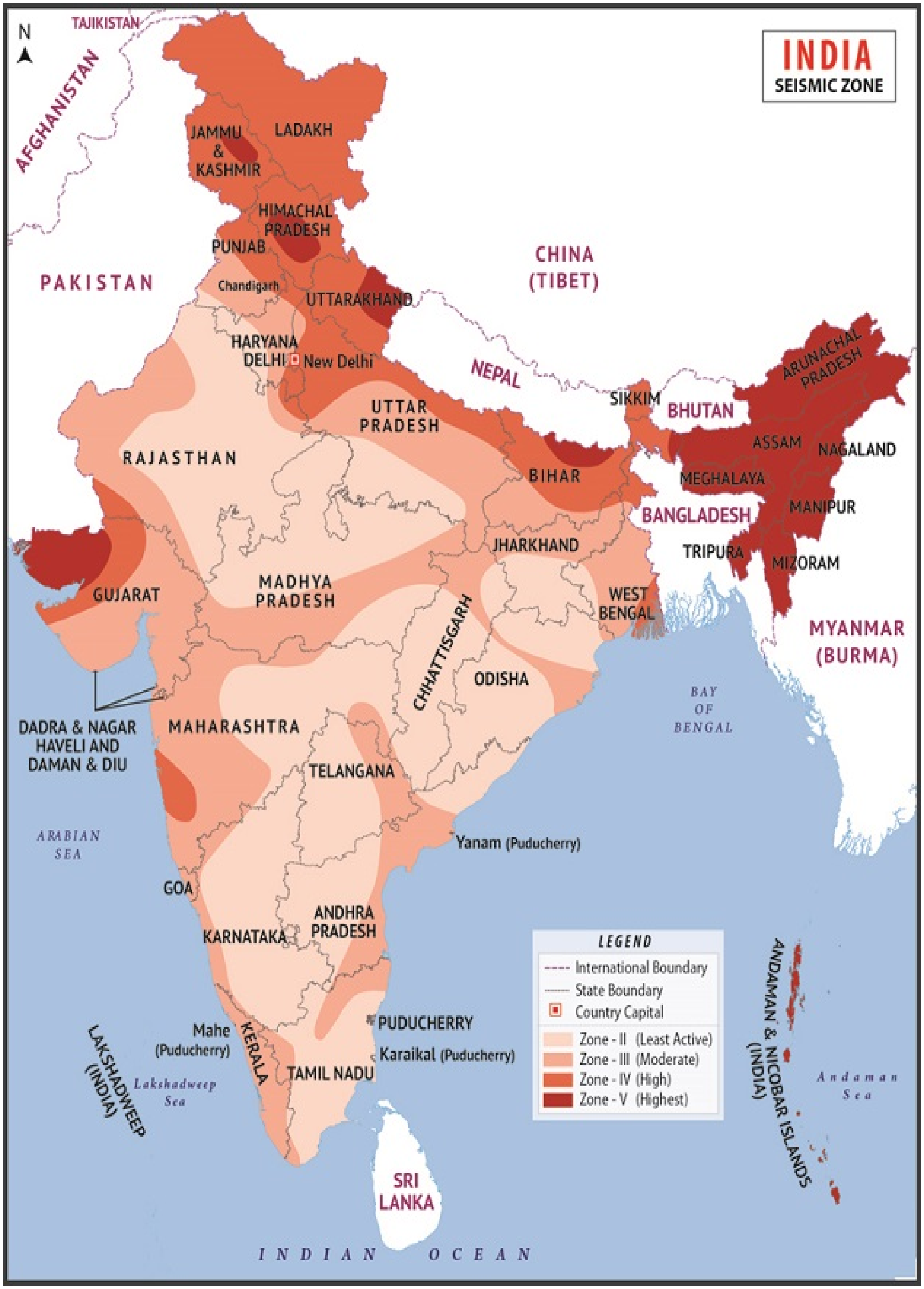


Fig 1.5 Seismic Zones in India Map

Zone II

It falls into the low-intensity category. It constitutes up 40.93% of the nations total land area. It includes the peninsula region as well as the Karnataka Plateau.

Zone III

The intensity in this region is moderate. It occupies 30.79% of the landmass of the country. Along with parts of Punjab, Rajasthan, Madhya Pradesh, Bihar, Jharkhand, Chhattisgarh, Maharashtra, Odisha, and Tamil Nadu, the state includes Kerala, Goa, and the Lakshadweep Islands.

Zone IV

The area is known as a high-intensity zone. 17.49% of the country's land area is covered by it. It includes all of Jammu & Kashmir, and remaining area of Himachal Pradesh, the National Capital Territory (NCT) of Delhi, Sikkim, the northern regions of Uttar Pradesh, Bihar, West Bengal, the western coast of Maharashtra, and Rajasthan.

Zone V

It defines as a an extremely severe zone. 10.79 percent of the country's land area is covered by it. The Rann of Kutch in Gujarat, a portion of North Bihar, Himachal Pradesh, Uttarakhand, and the Andaman and Nicobar Islands are also included.

1.7 Important Terminology

- **Base shear**

  Base shear is an assessment of the greatest predicted lateral stress from seismic activity on the base of the structure. It is determined using the lateral force formulae for the seismic zone, soil type, and building code IS 1893:2016

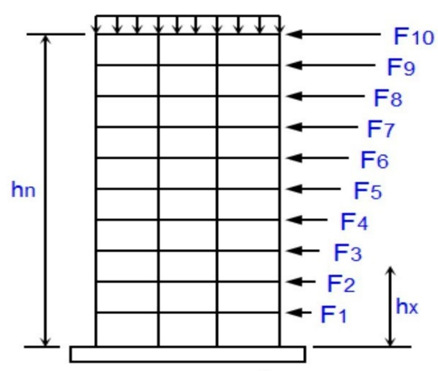


Fig 1.6 Seismic Base Shear

Storey Drift

The horizontal movement of a building or structure caused by an external force, such as a wind or earthquake, is known as storey drift. Usually, it is expressed in millimetres or tenths of an inch. Although storey drift is a relatively small amount of movement, it can significantly affect a building or structure's performance and safety. Storey drift can be caused by a variety of events.

- The nature of the building
- The size of the construction or building
- Weight of the Structure or Building
- the foundation's kind.

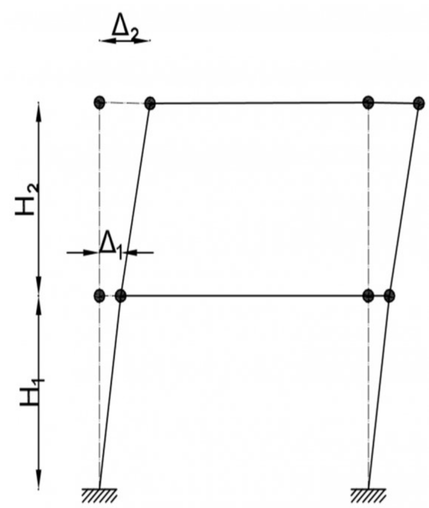


Fig1.7 Storey Drift

Calculate the Storey drift.

Storey Drift = (Δ2 – Δ1) / H2

Where,

Relative movement = Δ2 – Δ1

Story height = H2

Storey Drift Limiting Values

By limiting the structure's drift, one could also indirectly govern the structure's lateral displacement. In the standards, limiting values for drift for wind and earthquake could have been given. It maximum storey drift should not be eceed o.oo75 times of height of building.

Storey Displacement

storey displacement is the deflection of a single storey with respect to the structure's foundation or ground level. As we travel up the structure, it makes sense to assume that the overall displacement values will increase. Consequently, a graph of the story displacement in relation to the structure's height resembles the deflected shape exactly. and there is maximum permissible limit prescribed in IS codes for buildings.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction:

This chapter focuses on the review of the relevant literature for the project. It includes articles on the seismic analysis of multi-story buildings in various seismic zones.

2.2 Review of Literature

Study of seismic effect on RCC and precast construction of buildings is demonstrated by Adesh Thakare and Salman Shaikh (2022) [1]. When analysing a building during an earthquake, the severe damage, in the case of RCC, is at the beam-column joints. However, in a precast structure, the severe damage is at the joint of the secondary and primary beams. More so than other joints, the design and details of the beam-column junction is crucial.

Ashwini Dnyaneshwarrao Bode *et al.* (2021) [2], concentrated his examination on the G+15, Ordinary RC moment-resisting frame (OMRF). The models' analyses are compared to ascertain how well-performing a structure is against lateral stiffness. Node displacement also increases with additional zones. If soft soil is present and the support reaction increases from zone IV to zone V. Node displacement increases as the number of storeys rises.

Asadullah Dost (2021) [3], conducted a comparative study on Seismic Resistant Design and analysis of (G+15), (G+20) and (G+25) Residential Building. In order to reinforce the structural measures in the relevant treatment of the significant components and achieve superior seismic performance, the structure and layout of the overall design process are optimised as necessary. The outcome demonstrates that the height/number of stories and shape of the structure have an impact on lateral displacement. The investigation showed that the lateral displacement increased when shear walls were eliminated from each model, the author came to this conclusion.

A review of seismic Analysis of multi-storied building was performed by Mirza Mahaboob Baig, C Mahalingam and Yalavarty Nithin (2021) [4] is concluded that the seismic behaviour of lightweight concrete structure gives the best performance in low seismic zones. In this paper, seismic behaviour of a G+15 high-rise building constructed of structural lightweight concrete (SLWC) and normal weight concrete (NWC) is compared for various soil conditions and seismic zones. The results show that using SLWC under extreme conditions reduces the maximum bending moment and shear force by 40% and 34%, respectively, and the maximum member sizes and steel reinforcement by 31% and 38%.

Athira Haridas and Dr S.A Rasal (2020) [5], concentrated on the Seismic behaviour of high rise building with composite shear wall. After investigation, the author came to the conclusion that the composite shear wall performs better than the RCC shear wall in terms of resistance and ductility. In comparison to conventional shear walls, composite shear walls experience less displacement.

Dr.S.G. Makarande and Vikas.V. (2019) [6] is The shear divider arrangement for the construction was found to be more resistant to the parallel loads in this structure and for safe plan, as shown by study and design of composite buildings in zone 4, which has significant earthquake frequency. Because composite structures are more ductile, they will perform better in areas with frequent earthquakes and when subjected to lateral forces.

Shashidharprasad K. T. and Dr M. N. Shivakumar (2019) [7] is demonstrated by a model is subjected to different seismic zones along with their corresponding behaviours and results are extracted and interpreted. The author came to the conclusion that as a building's height rises, storey acceleration likewise rises and is closely correlated with seismic intensity. The paper's conclusion states that because seismic forces are more concentrated at the base of the building, the building's resistance to seismic forces will be greater at the lower storey, and the building's seismicity—or resistance to seismic forces—is directly proportional to the intensity of the quake, i.e., increases proportionately as intensity rises.

Divya Joshy and Dr. M. Helen Santhi (2018) [8] has experimental study reported that as included about the seismic performance of irregularity of the structure. The biggest displacement will occur in locations where storey stiffness is lowest as the structure's irregularity rises. It has been observed that pushover analysis and time history analysis are used to evaluate the seismic performance of regular and irregularly framed structures.

The term composite walling is introduced by Brijesh Kumar Tondon and Dr. S. Needhidasan (2018) [9], which describes a Seismic Analysis of G+8 Storied Building in Zones in zone II and IV according to IS 1893 by using Equivalent static lateral force and Response spectrum methods. The study's findings show that when the peak story drift lowers as one ascends from the ground to the top floors, the impact of seismic load is greatest at the bottom and thereafter diminishes, increasing when the zone factor is changed. As the seismic zone increases from 2 to 4, the parameters for base shear, lateral force, story shear, maximum story displacement, and overturning moment all increase in both directions.

B. Gireesh Babu et al. (2017) [10] has experimental study found that in a earthquake resistant design of G+7 RC framed building the steel quantity increased by 1.517% to the convention concrete design. The primary source of the structure's damage is caused by seismic forces. The base drift is 0.0 for each storey under the Storey drift condition for a structure deemed to be G+7. According to the author, the structure is secure in a drifting situation. As a result, shear walls and braced columns are not required. The G+7 building's storey drift status is therefore examined.

Imam Usman Shekh and Udaysinh Redekar (2017) [11] concentrated his examination on analysing the G+7 storey building structure, Member dimensions (Beam, Column, Slab, Footing) are changed by calculating the load type and it’s quantity applied on it. By altering the structure's height and plan dimensions, the entire study may be done again. By varying the grade of the steel and concrete, one may compare costs.Analysis and design of dual system frames. The quantity of material used will be kept to a minimum, making the construction safe for people and the environment.

Krishna G Nair1 and Akshara S P (2017) [12] further, conducted an assessment of reinforced concrete's seismic analysis. when a part is intended to yield but is really stronger than expected. In the study, numerous techniques for analysing buildings in diverse seismic zones are discussed. It might be difficult to locate pertinent time records for the specified site. Alternative approaches are required.

Shubham R. Kasat et al. (2016) [13] reported the behaviour of a comparative study of a multi-storey building under the action of a shear wall using ETAB software for achieving economy in reinforced concrete building structures. In order to achieve suitable concrete sizes and optimal steel consumption in members, the design of crucial sections is meticulously completed. For an 18-story structure with a base storey height of 2 metres and storey heights of 4 metres, a typical 20 m X 20 m design is taken into consideration. Static analysis approach is used to create models of 18-story buildings with and without shear walls for seismic zone III. Software called ETAB v9.2.0 is used to examine the structure. The outcomes are contrasted in terms of base, storey drift, and displacement

Mohit Sharma et al. (2014) [14] considered a G+30 storied regular reinforced concrete framed building. There was a dynamic examination of the multi-story building. These structures have a plan area of 25 x 45 metres, each story is 3.6 metres tall, and the depth of the foundation is 2.4 metres. The overall height of the chosen structure, including the depth of the foundation, is 114 metres. STAAD-Pro software was used to perform the static and dynamic analysis on a computer utilising the design parameters specified in IS-1893-2002-Part-1 for Zones 2 and 3. The values of axial forces as determined by static and dynamic analyses were found to be very similar.

Chaitanya Kumari J.D and Lute (2013) [15] It has been decided to analyse the breakdown reaction of the structural system, which comprises of load-bearing walls and one-way slabs for gravity and lateral loads. For various load combinations, different wall forces, displacements, and moments have been calculated. The investigation of structural components simply, not the specifics of the connections, is the scope of this work.

2.3 Summarized Finding from Literature

It is deduced from the literature review that:

- Seismic intensity and building story acceleration are inversely correlated.
- Node displacement grew along with the growth in storeys.
- The areas with the greatest displacement are those with the lowest storey stiffness.
- Composite structures have better performance in flexible, storey drift, and deflection and are more ductile.
- In low seismic zones, light weight concrete constructions perform better than regular concrete.
- Structural Lightweight Concrete (SLWC) at critical conditions results shown that maximum bending moment and shear force got reduced by 40% and 34% respectively and maximum member sizes and steel reinforcement got reduced by 31% and 38% respectively.
- Building height directly correlates with earthquake intensity, and storey acceleration likewise rises as height does.
- Structure is observed that during earthquake, it is severely damage at beam joint.
- Shear force, bending moment and displacement parameters are increased as the seismic zone goes from II to IV.

2.4 Problem Statement

- Seismic analysis of light weight concrete building is not executed in high seismic zones. Hence the detailed study of light weight concrete building as in high seismic zone is required.
- From the analysis of literature review, seismic analysis of multi storey building (i.e. 4 to 12 floor) have been less research work obtained.
- So much more research works in multi-storeyed building with light weight concrete is required.

2.5 Aim of Project

Seismic analysis and design of residential building in seismic zone III and zone IV.

2.6 Objective of Project

The specific objectives are:

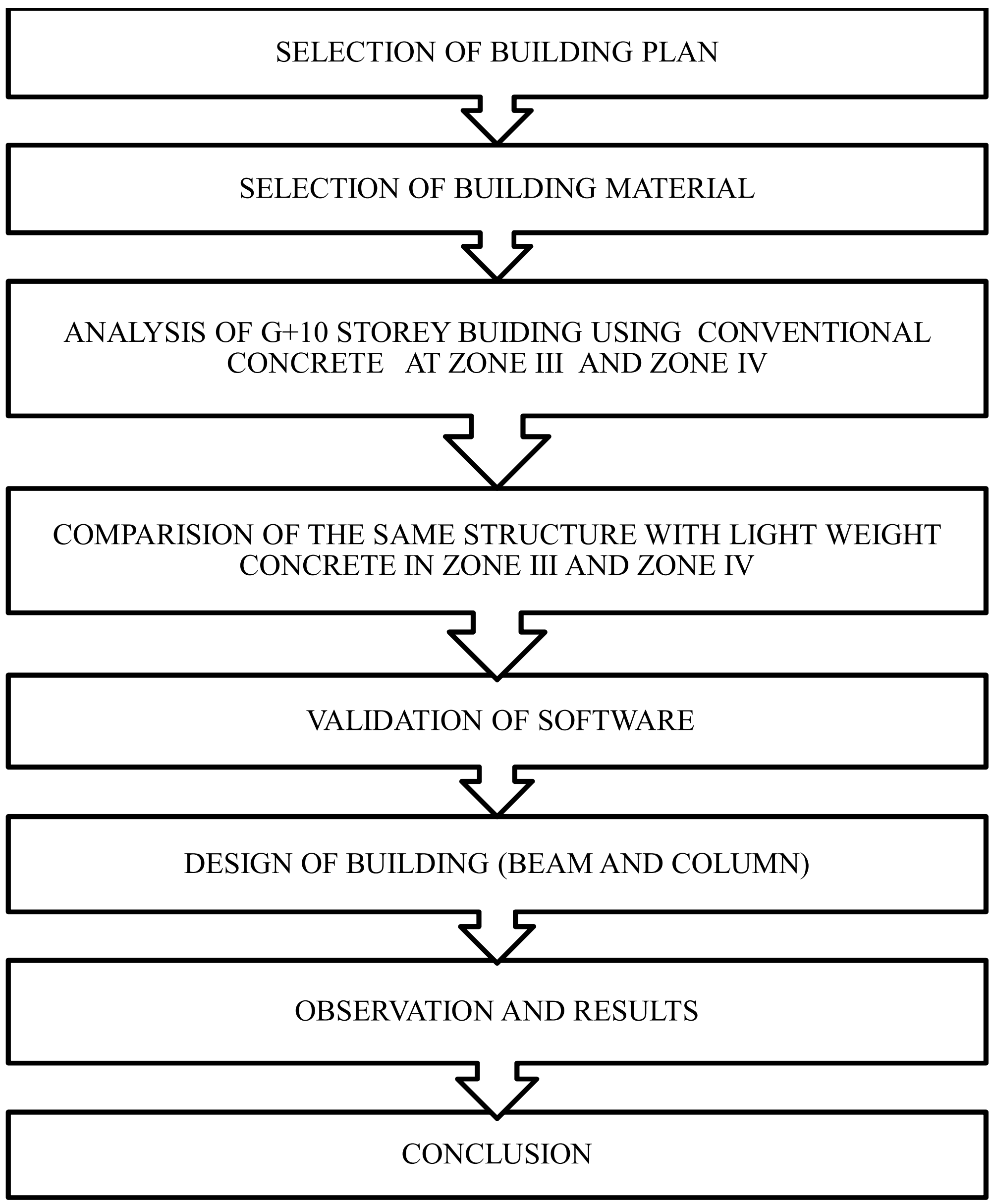
- Comparison between seismic response of on residential building in zone III & zone IV data by.
- Design of various structural components.
- Detailed structural analysis of the building using Stadd pro.
- The effect of Light weight concrete in seismic analysis is taken.
- To analysis the structure in LWC and compare with NWC.
- To Check the responses of building in terms of base shear, story drift, story shear, stiffness.

CHAPTER 3

METHODOLOGY

3.1 Methodology

Table no 3.1:-Methodology of Seismic Analysis of Building



3.2 Selection of Building Plan

The building's design consists of a multi-story RCC residential building (G+10 Storey). Drawings of the building's architecture and structural plans with accurate details include:

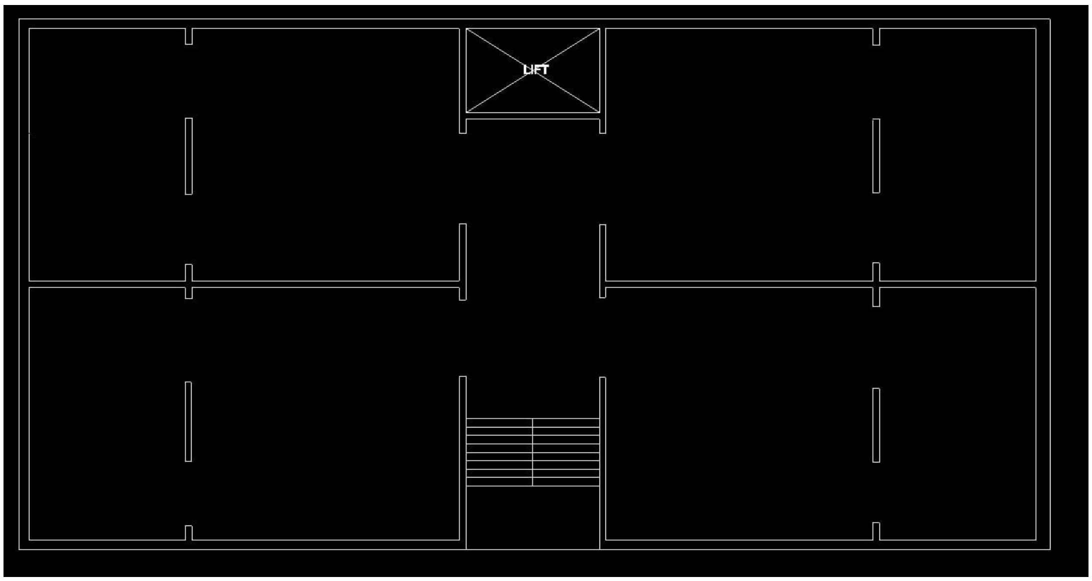


Fig 3.1 Ground Floor plan

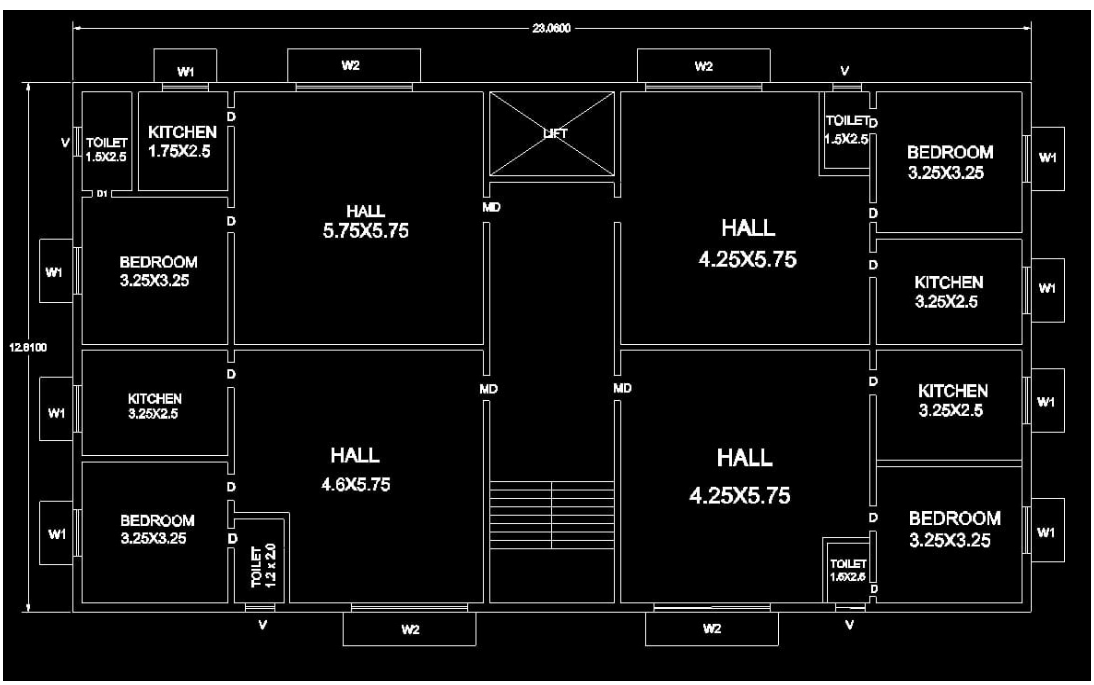


Fig 3.2 Floor plan (1st to 7th,9th,10th Floor)

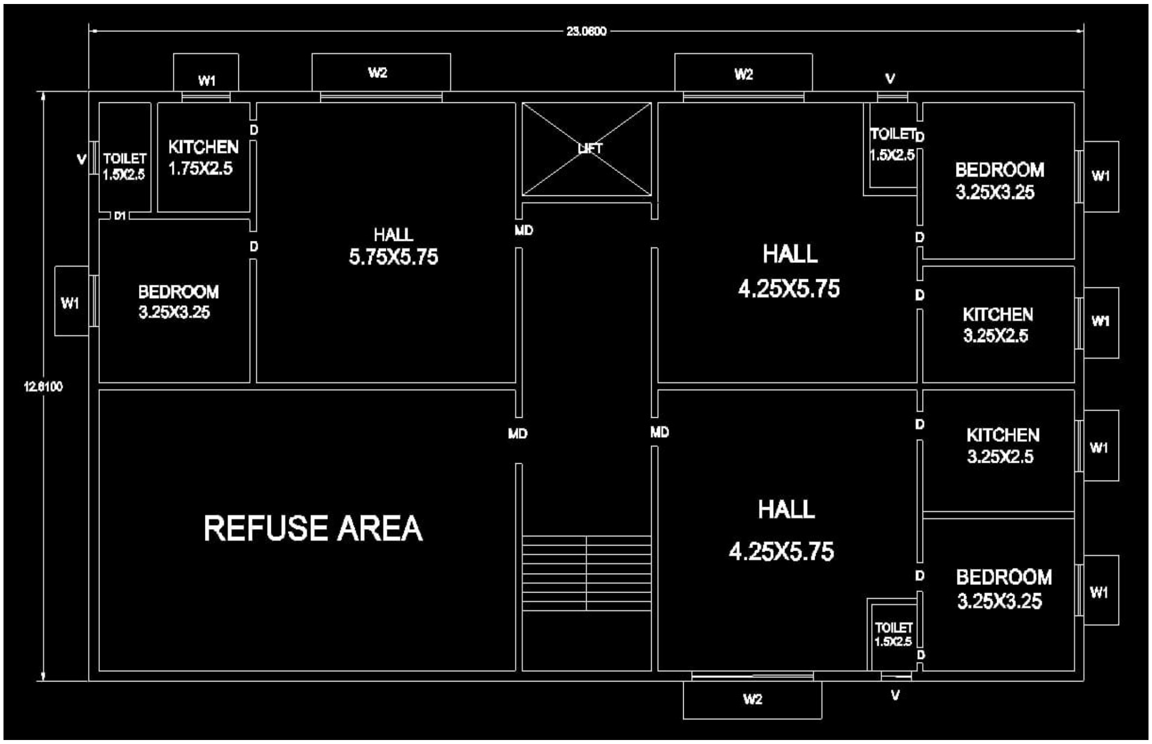


Fig 3.3 Floor plan (8th Floor)

Vertical mobility is made possible by the building's layout, open well staircase and lifts. For emergency evacuation, a fire-escape chamber (open hall) is available on the building's eight story. One refuge area is available every 24 metres of height. Everything is measured in metres. The area of the building between two succeeding beam grids is assigned a storey number. The storey numbers for the building are defined as follows:

Table 3.2 Storey numbers

Portion of the building	Storey no.	Portion of the building	Storey no.
Ground floor	1	Sixth floor	7
First floor	2	Seventh floor	8
Second floor	3	Eighth floor	9
Third floor	4	Ninth floor	10
Fourth floor	5	Tenth floor	11
Fifth floor	6	Terrace	12

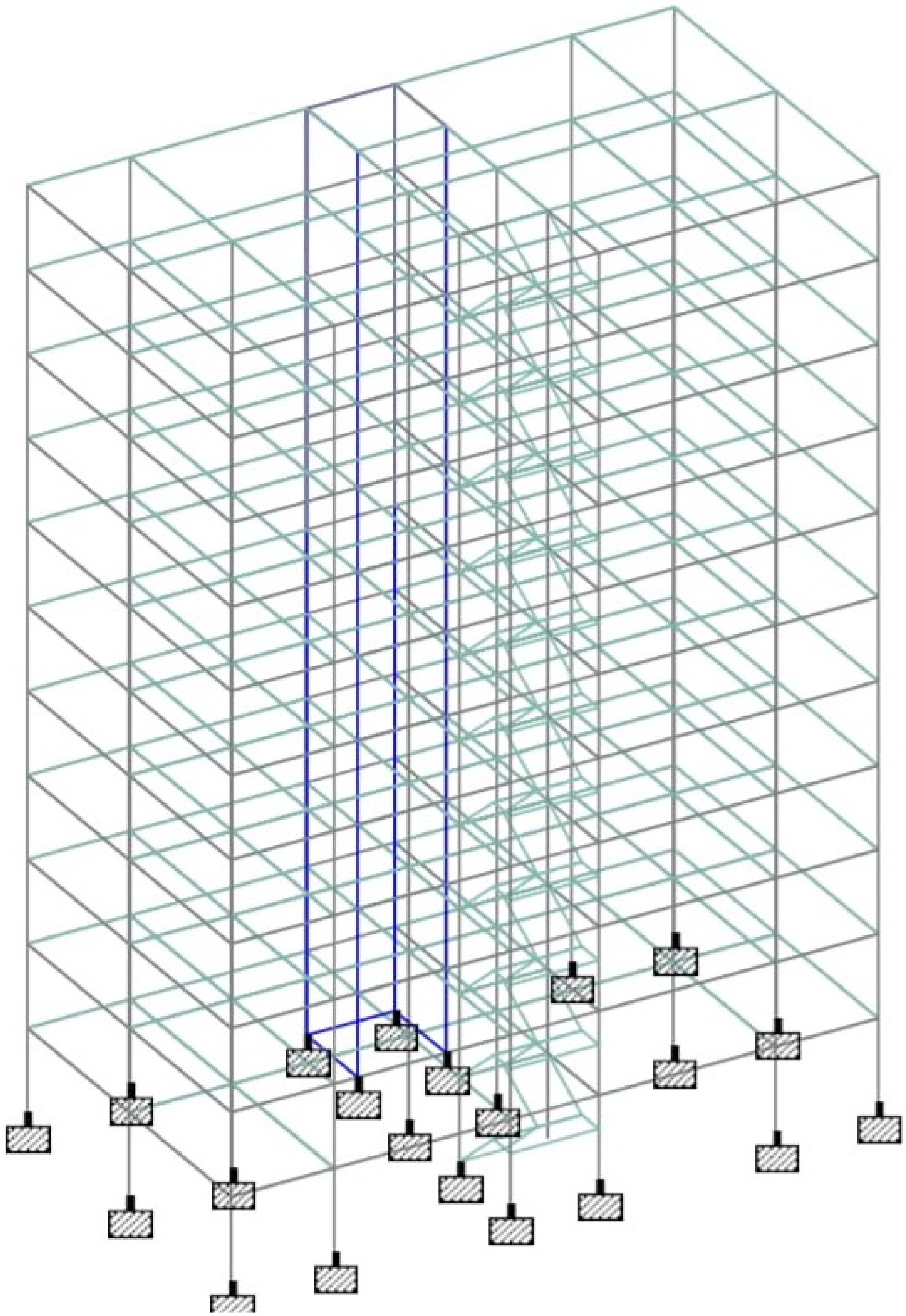


Fig 3.4 Structural plan of model

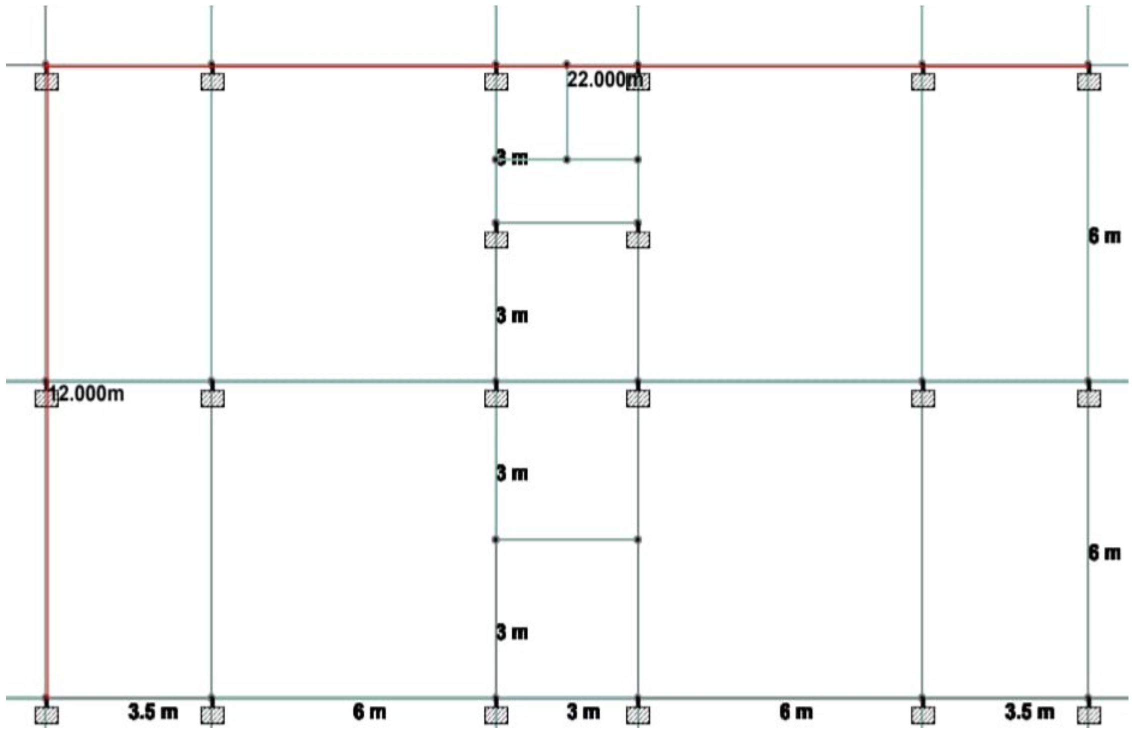
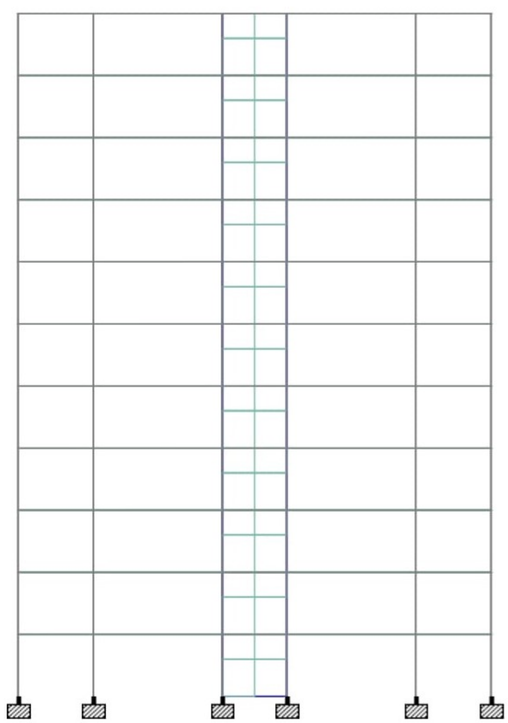


Fig 3.5 Structural plan



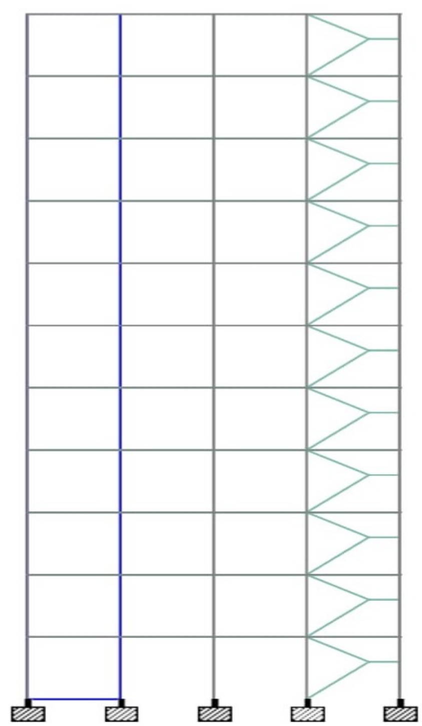


Fig 3.6 Front Elevation of Model **Fig 3.7 Side Elevation of Model**

It is a multi-story RCC apartment structure that has to be designed. All of these functional factors are taken into account while creating a grid pattern of beams for reinforced concrete frames. Most of grid intersection sites have columns. There are 231numbers of columns and a total of 594numbers of beams. The structure's total measurements are 72'18" by 39'37".

3.3 Statement of the project:-

Analysis and Design of Residential Building (G+10) Specifications are as:-
RCC Building
Size of beam= 0.30 X 0.50 m in rectangular section
Size of column = 0.50 X 0.60 m in rectangular section
Slab thickness = 0.150 m
Height of each floor = 3 m
Height of Ground floor = 2.8 m
Support = Fixed
Seismic zones = III and IV

3.4 Selection of Building Material

An ordinary G+10 story building floor plan was chosen for the project. After planning for seismic loads, it was discovered that LWC structures weigh 18000 kN less than NWC structures.The data that were utilised to analyse the structures are as follows:

- Material = Conventional concrete
- Grade of concrete (for all structural elements) = M 30
- Unit weight of Conventional concrete = 2500 kg/m^3
- Compressive strength for concrete = 30 Mpa

- Material 2 = light weight concrete
- Grade of concrete (for all structural elements) = M 30
- Unit weight of light weight concrete = 1800 kg/m^3
- Steel = HYSD 450

Fig 3.8 3D Rendering View

3.5 Load Calculation

The following design data must be used:

Live load	: 4.0 kN/m2 at typical floor
	: 1.5 kN/m2 on terrace
Floor finish	: 1.0 kN/m2
Water proofing	: 2.0 kN/m2
Terrace finish	: 1.0 kN/m2
Depth of foundation below ground	: 2.5 m
Type of soil	: Type II, Medium as per IS:1893
Walls	: 230 mm thick brick masonry walls only

3.6 Unit load calculations

- sizes of beam and column sections are:
- Columns size: 500 x 600
- Main beams and Secondary beams size : 300 x 400
- Columns (500 x 600) 0.50 x 0.60 x 25 = 7.5 kN/m
- Main & Secondary beams (300 x 400) 0.30 x 0.40 x 25 = 3 kN/m
- Slab (150 mm thick) 0.15 x 25 = 3.75 kN/m2
- Brick wall (250 mm thick) 0.25 x 19 (wall) +2 x 0.012 x 20 (plaster) = 5.23 kN/m2
- Floor wall (height 3.0 m) 3.0 x 5.23 = 15.69 kN/m
- Terrace parapet wall (height 0.9 m) 0.9 x 5.23 = 4.71 kN/m
- Total load on slab = 4 + 3.75 = 7.75 Kn/m2 (DL+LL)
- Load from Staircase Slab = 3.75kN/m2

The following load combination is used :

Table 3.3 Load combination

1	DL 1.5, LL 1.5	15	DL 1.5, EL -Z 1.5
2	DL 1.2, LL 1.2	16	DL 1.5, EL X -1.5
3	DL 1.2, LL 1.2, EL X 1.2	17	DL 1.5, EL –X -1.5
4	DL 1.2 LL 1.2 EL -X 1.2	18	DL 1.5, EL Z -1.5
5	DL 1.2 LL 1.2 EL Z 1.2	19	DL 1.5, EL –Z -1.5
6	DL 1.2,LL 1.2, EL -Z 1.2	20	DL 0.9, EL X 1.5
7	DL 1.2, LL 1.2, EL X -1.2	21	DL 0.9, EL -X 1.5
8	DL 1.2, LL 1.2, EL –X -1.2	22	DL 0.9, EL Z 1.5
9	DL 1.2, LL 1.2, EL Z -1.2	23	DL 0.9, EL -Z 1.5
10	DL 1.2, LL 1.2, EL -Z -1.2	24	DL 0.9, EL X -1.5
11	DL 1.5	25	DL 0.9, EL –X -1.5
12	DL 1.5, EL X 1.5	26	DL 0.9, EL Z -1.5
13	DL 1.5, EL -X 1.5	27	DL 0.9, EL -Z -1.5
14	DL 1.5, EL Z 1.5		

3.7 Analysis of G+10 storey buiding using conventional concrete at zone III and zone IV

This study includes the analysis and design of multistory buildings using the equivalent static approach for various seismic intensities, III and IV. Building structure modelling, definition, assignment, and analysis are being carried out with the aid of the Staad Pro programme. Base shear, maximum displacement, storey drift, and other phenomena are also being monitored. Determining thr bese shear by using following steps:

1. Calculations are made to divide grouped masses among different floor levels. It includes masses on roofs and other floors while considering the weight of walls, columns, beams, floors, infills, and slabs into mind.
2. Determined design parameters (as per IS 1893 Part 1: 2016) :
   Zone factor (Z) (as per Clause 6.4.2 , Table No. 2),

Importance factor (I) (as per Clause 6.4.2, Table No. 6)

Response Reduction factor (R) (as per Clause 6.4.2, Table No. 7)

Then fundamental natural period is determined using the formula (as per Cl 7.6.2.)

$Ta = 0.075 \times h^{0.75}$

Where,

Ta = fundamental natural period of vibration in seconds

h = height of building in meters.

3. Spectral Acceleration Coefficient (Sa/g) is depends on time period and type of soil, (as per Clause 6.4.5.)
4. The design horizontal seismic coefficient (Ah) for a structure shall be determined by the following expression (As per IS 1893 (Part I): 2002 Cl. No. 6.4.2,)
   Ah = (Z/2)*(I/R)*(Sa/g)
5. We calculate Base Shear, (As per Cl 7.6.1. of IS 1893 Part 1: 2016)
   VB = Ah×W
6. The design Base Shear is distributed along the height of the building as per expression:

$$Q_i = V_B \frac{W_i h_i^2}{\sum_{i=1}^{n} W_i h_i^2}$$

Where,

Qi = Design lateral forces at level i,

Wi = Seismic weights of the floor i

hi = Height of the floor i

n = Number of stories

Base Shear Reading by Staadpro

Conventional Concrete Structure in Zone III

```
***********************************************************
*                                                         *
* TIME PERIOD FOR X 1893 LOADING =    1.03263 SEC        *
* SA/G PER 1893=    1.317, LOAD FACTOR= 1.000            *
* VB PER 1893=    0.0211 X    41506.80=     874.64 KN    *
*                                                         *
***********************************************************
```

Conventional Concrete Structure in Zone IV

```
***********************************************************
*                                                         *
* TIME PERIOD FOR X 1893 LOADING =    1.03263 SEC        *
* SA/G PER 1893=    1.317, LOAD FACTOR= 1.000            *
* VB PER 1893=    0.0316 X    41506.80=    1311.97 KN    *
*                                                         *
***********************************************************
```

Light Weight Concrete Structure in Zone III

```
***********************************************************
*                                                         *
* TIME PERIOD FOR X 1893 LOADING =    1.03263 SEC        *
* SA/G PER 1893=    1.317, LOAD FACTOR= 1.000            *
* VB PER 1893=    0.0211 X    35571.49=     749.57 KN    *
*                                                         *
***********************************************************
```

Light Weight Concrete Structure in Zone IV

```
***********************************************************
*                                                         *
* TIME PERIOD FOR X 1893 LOADING =    1.03263 SEC        *
* SA/G PER 1893=    1.317, LOAD FACTOR= 1.000            *
* VB PER 1893=    0.0316 X    35571.49=    1124.36 KN    *
*                                                         *
***********************************************************
```

Base Shear Calculation by Manually

Reference	Step	Calculation
		Given Data, M30 concrete, Fe415 steel Zone III and Zone IV, Floor to Floor Height, Hf = 3m Parapet wall, Ht = 0.9m Wall Thick = 230mm Dessity of Concrete = 2500kg/m3 Size of Beam = 0.3x0.4m Size of Column = 0.5x 0.6m Slab Thickness = 0.15m
	1	Seismic weight of the building (W) Dead Load (DL) Slab load, Area = (22x12)-(6x6) = 228mm2 (Floor to Floor) DL = 228 x 0.15 x 25 = 855 kN FF = 228 x 1 = 228KN Slab load, Area =(22x12)-(6x6) = 228mm2 (Terrace) DL = 228 x 0.15 x 25 = 855 kN FF = 228 x 3 = 684KN Beam Load, Transverse Direction, Length = 6 – 0.6 = 5.4m Longitudinal direction, Length = 2.9x6+5.4x6+2.4x3=57m Total length= 5.4x12+57 = 120m DL = 120x3 = 360KN Column load, DL = 7.5x 18 = 135KN

		Wall Load, Transverse Direction, Length = 6 – 0.6 = 5.4m Longitudinal direction, Length = 2.9x6+5.4x6+2.4x3=57m Total length= 5.5x12+57 = 120m DL = 120x0.25x19 = 570KN/m Staircase Slab, Area = 10.95m2 DL= 10.95 x 3.75 = 41.06 KN Live Load (LL) LL (Floor) =4/2KN/m2 = 2KN/m2 LL (Terrace) = 1.5/2KN/m2 = 0.75KN/m2 DL on Terrace = 855+684+360+(135+570)x(0.9/2) =2216KN DL on FF,GF =855+228+360+41.06 + (135 +570) x 3 = 3600KN Total Load, W = DL + FF W (Terrace) = 2216+ 0.75 = 2217KN W (Floor) = 3600+ 2 = 3602KN W = 2217+3600x11 = 41839KN
IS 1893 (Part I): 2002 Table 2 IS 1893 (Part I): 2002 Table 6 IS 1893 (Part I): 2002 Table	2	Calculation Base shear For Zone III Calculation of design horizontal seismic coeffiecient Ah = (Z/2)*(I/R)*(Sa/g) Where, Z = Zone factor, for Zone III, Z = 0.16 I = Importance Factor, I = 1 for general purpose building R = Response reduction factor given by, R = 5.0 Sa/g = Average response acceleration coefficient which depends on approximate fundamental natural period of vibration $T_a = 0.075 \times h^{0.75} = 0.075 \times 33^{0.75} = 1.03$ Where, Ta =fundamental natural period of vibration in seconds

7 IS 1893 (Part I): 2002 CL no. 6.4.5		h = height of building in meters, h= 33m for Ta = 1.03 and medium soil considered Then Sa/g = 1.36/1.03 = 1.32 Ah = (Z/2)*(I/R)*(Sa/g) = (0.16/2)*(1/5)*(1.32) = 0.021 Base Shear Vb= W x Ah = 41839 x 0.021 = 878.62 KN
	3	Calculation Base shear For Zone IV Calculation of design horizontal seismic coeffiecient Ah = (Z/2)*(I/R)*(Sa/g) Where, Z = Zone factor, for Zone IV, Z = 0.24 I = 1 R = 5.0 Ta = 0.075 x $h^{0.75}$ = 0.075 x $33^{0.75}$ = 1.03 h = height of building in meters, h= 33m For Ta = 1.03 and medium soil considered Then Sa/g = 1.36/1.03 = 1.32 Ah = (Z/2)*(I/R)*(Sa/g) = (0.24/2)*(1/5)*(1.32) = 0.031 Base Shear Vb= W x Ah = 41839 x 0.031 = 1297KN
IS 1893 (Part I): 2002 Cl. No. 7.7.1		design base shear (VB) computed above shall be distributed along the height of the building as per the following expression: $Q_i = V_B \frac{W_i h_i^2}{\sum_{i=1}^{n} W_i h_i^2}$ Where, Qi = Design lateral force at floor i Wi= Seismic Weight of floor i hi = Height of floor i measured from base n = No. Of stories in the building

Calculation of Base Shear:

Table no. 3.4 Base shear calculation

Floor	Wi (KN)	Hi	Wi x Hi x Hi	Zone III, Vb= 879KN		Zone IV, Vb=1297KN	
				Qi(KN)	Vi(KN)	Qi(KN)	Vi(KN)
Terrace	2217	33.9	75156.3	83.79	83.79	123.65	123.65
10	3602	33.0	118866	132.54	216.33	195.56	319.21
9	3602	30.0	108060	120.49	336.82	177.78	496.99
8	3602	27.0	97254	108.44	445.26	160	656.99
7	3602	24.0	86448	96.39	541.65	142.23	799.22
6	3602	21.0	75642	84.34	625.99	124.45	923.67
5	3602	18..0	64836	72.29	698.28	106.69	1030.36
4	3602	15.0	54030	60.24	758.52	88.89	1119.25
3	3602	12.0	43224	48.19	806.71	71.11	1190.36
2	3602	9.0	32418	36.15	842.86	53.33	1243.69
1	3602	6.0	21612	24.1	866.96	35.56	1279.25
G.F.	3602	3.0	10806	12.05	879.01	17.78	1297.02
Total	41839		788352.3	879.01		1297.02	

3.8 Comparision of the same Structure with Light Weight Concrete in Zone III and Zone IV

Comparing the selected building structure in two different zones,i.e. zone III and Zone IV. To know the behaviour of building using the light weight concrete and conventional concrete against the seismic forces which are acting on particular zone and the results compare with conventional concrete are described in chapter no. 5.

3.9 Validation of Analysis and of Building

Following seismic analysis and software-aided building design, we manually cross-check the same structure's design by performing the following steps:

Table no. 3.5 Base Shear value computing by software and manual calculation

Base Shear	Software Calculation	Manual Calculation
Zone III	874.64KN	878.62 KN
Zone IV	1311.97KN	1297KN

Above Table shows the base shear value computing by software and manual calculation. As per seen the value of base shear obtained by software calculation and manual calculation is 875.64KN and 878.62KN respectively in Zone III. Whereas the value of base shear obtained by software calculation and manual calculation is 1311.97KN and 1297KN, respectively in Zone IV. Difference between software result and manual result is 1-2 % and it's allowable. Hence the validation of software is done. Finally the software result taken for analysis of building in different seismic parameters.

3.10 Design of Building

Design methodology

A reinforced concrete structure should be so designed that it fulfils its intended purpose during its life time with:

1. Adequate safety, in terms of strength and stability.

2. Adequate serviceability in terms of stiffness and durability.

3. Reasonable economy.

The following are used for the design of reinforced concrete structures / elements:

1. Working Stress Method (WSM).

2. Ultimate Load Method (ULM).

3. Limit State Method (LSM).

In this project, we are used limit state method of design. So, let us discuss the concept of limit state method.

Design of Beams

BEAM no. 918 , 9th floor beam

Reference	Step	Calculations	Remark
         IS13920:1993 cl.6.1.3, cl.6.1.2 cl.6.1.4	1	Known Data: Characteristics Strength of Concrete(fck)=30Mpa Grade of Steel(fy)= 415Mpa Overall Depth of Beam, D=400mm Width of Beam, B=300mm Keep nominal cover = 25 mm Take 20 mm dia. Bar Effective depth, d=400-25-20/2mm=365mm Check for member size Width of beam, B=300mm > 200mm Depth of beam, D=400mm B/D = 300/400 = 0.75> 0.3 Clear Length, L=6.000m L/D = 6.000/0.5 = 10.058> 4 OK	 Hence, OK
	2	Effective length of beam Ley = L + d = 6.000 + 0.365 = 6.365m Lez = L + b = 6.000 + 0.300 = 6.300m Adopt, Le = 6.30m	
	3	Load Calculation Slab load = 7.7KN/m Main Beam Load = 3KN/m Main Wall Load= 15.69 x 1 = 15.69KN Total Load = 7.75 + 3 + 15.69 = 26.39KN Factored Load, Wu = 1.5 x 26.39 = 39.5KN	
	4	Design for Flexure Mulim = 0.1386fck bd2 = $0.138 * 30*300*365^2$ = 165.47KN-m Bending Moment, Muz = $(Wu \times Lez^2)/12$ = $(39.5 \times 6.3^2)/12$	

		= 130.64KNm < Mulimi Shear Force,V= (Wu x Lez)/2 = (39.5x6.3)/2 =124.425KN	Singly Reinforced Section
	5	Main Reinforcement at support Ast= $\frac{0.5xfck \times b \times d}{Fy}$ (1-sq.root (1–4.6Mu/Fck bd^2)) = $\frac{0.5x30 \times 300 \times 365}{415}$ (1-sq.root (1– $\frac{4.6x130.64x10^6}{30x300x365^2}$) = 1168.38mm^2 Ast min = 0.12%×b×d = 144mm2 Astmax = 0.04bD =4800mm2 Ast min < Ast < Astmax Use 20mm bar Area of one bar = (3.14/4) x 202 = 314.16mm2 No. Of Bar = 1168.38/314.16 =3.71 ≈ 4 Ast prov. = 4 x 314.16 = 1256.63mm2 Spacing = (1256.63/ 314.16) x 100 = 399mm Provide 4-20mm dia @ 390mm for main reinforecement at support Main Reinforcement at bottom Ast= $\frac{0.5xfck \times b \times d}{Fy}$ (1-sq.root (1–4.6Mu/Fck bd^2)) = $\underline{0.5x30 \times 300 \times 365}$ (1-sq.root (1– $\underline{4.6x133.35x10^6}$)	Ok

		415 30x300x3652 = 1197.72mm2 Ast min = 0.12%×b×d = 144mm2 Astmax = 0.04bD =4800mm2 Ast min < Ast < Astmax Use 20mm bar Area of one bar = (3.14/4) x 202 = 314.16mm2 No. Of Bar = 1197.72/314.16 =3.81 ≈ 4 Ast prov. = 4 x 314.16 = 1256.63mm2 Spacing = (1256.63/ 314.16) x 100 = 399mm Provide 4-20mm dia @ 390mm for main reinforecement at bottom	
IS 456:2000 Table 19 IS 456:2000 cl no 26.5.1.6	6	Shear Reinforcement Shear force, Vu= 124.425 – 39.5(0.3/2+0.365) = 104.08KN Nominal Shear Stress,τv = (Vu/bd) =(104.08 / 0.3x0.365) = 0.95 N/mm2 %p = 100x (1256.63/300x365) = 1.14% Design shear strength of concrete, τc = 0.688 N/mm2 Here, τv > τc Hence, design shear reinforcement. Tcbd = 0.688x300x365/1000 = 75.336KN Vus = 124.425 – 75.336= 49.089KN Assuming 2-legged 12 mm ϕ stirrups, Asv =2x113.09mm2 =226.19mm2 Sv= 0.87 fy Asv d = 400mm	

		Vus But, Sv max = 0.75d = 0.75x365=273.75mm or 300mm Hence, take Sv = 200mm Provide 2L- 12 dia stirrups @ 200mm c/c	
IS 456 2000 Cl. 23.2.1;	7	Check for deflection: Effective length= Ley = L + d = 6.000 + 0.365 = 6.365m d=0.365mm ley/d=6.365/0.365=17.44 < 20	Ok
IS 456 2000 Cl 26.2.1;	8	Check for development length: $Ld = \frac{0.87xfyxdia}{4x\tau bd} = \frac{0.87x415x20}{4x1.4x1.6} = 805.91mm$ Ml = 0.87*fy*Ast*d*(1-(Ast*fy/b*d*fck)) = 0.87*415*1256.63*365*1-($\underline{1256.63x415}$) = 165.6KNm Ld = 1.3x(Ml/Vu)+Lo =1.3x(165.6 x10^3/124.425)+ 38.18 = 1768.37mm >805.91mm	Ok

Beam Reinforcement Detailing and Drawing by using Staadpro:

```
-------------------------------------------------------------------------
                B E A M   N O.    918   D E S I G N   R E S U L T S

     M30                        Fe415 (Main)               Fe415 (Sec.)

    LENGTH:  6000.0 mm      SIZE:   300.0 mm X  400.0 mm   COVER: 25.0 mm


                        SUMMARY OF REINF. AREA (Sq.mm)
-------------------------------------------------------------------------
SECTION       0.0 mm     1500.0 mm     3000.0 mm     4500.0 mm     6000.0 mm
-------------------------------------------------------------------------
 TOP         1162.23        224.28        224.28        224.28      1133.33
REINF.      (Sq. mm)      (Sq. mm)      (Sq. mm)      (Sq. mm)     (Sq. mm)

BOTTOM        224.28        241.56        572.38        249.83       224.28
REINF.      (Sq. mm)      (Sq. mm)      (Sq. mm)      (Sq. mm)     (Sq. mm)
-------------------------------------------------------------------------
```

```
                      SUMMARY OF PROVIDED REINF. AREA
-----------------------------------------------------------------------------
SECTION      0.0 mm     1500.0 mm     3000.0 mm     4500.0 mm     6000.0 mm
-----------------------------------------------------------------------------
 TOP       4-20i         3-20i         3-20i         3-20i         4-20i
REINF.   1 layer(s)    1 layer(s)    1 layer(s)    1 layer(s)    1 layer(s)

BOTTOM     3-20i         3-20i         3-20i         3-20i         3-20i
REINF.   1 layer(s)    1 layer(s)    1 layer(s)    1 layer(s)    1 layer(s)

SHEAR   2 legged 12i  2 legged 12i  2 legged 12i  2 legged 12i  2 legged 12i
REINF.  @ 155 mm c/c  @ 155 mm c/c  @ 155 mm c/c  @ 155 mm c/c  @ 155 mm c/c
-----------------------------------------------------------------------------



SHEAR DESIGN RESULTS AT DISTANCE d (EFFECTIVE DEPTH) FROM FACE OF THE SUPPORT
------------------------------------------------------------------------------


SHEAR DESIGN RESULTS AT   665.0 mm AWAY FROM START SUPPORT
  VY =    97.61 MX =     0.44 LD=    7
  Provide 2 Legged 12i  @ 155 mm c/c

SHEAR DESIGN RESULTS AT   665.0 mm AWAY FROM END SUPPORT
  VY =   -97.84 MX =     0.44 LD=    7
  Provide 2 Legged 12i  @ 155 mm c/c
```

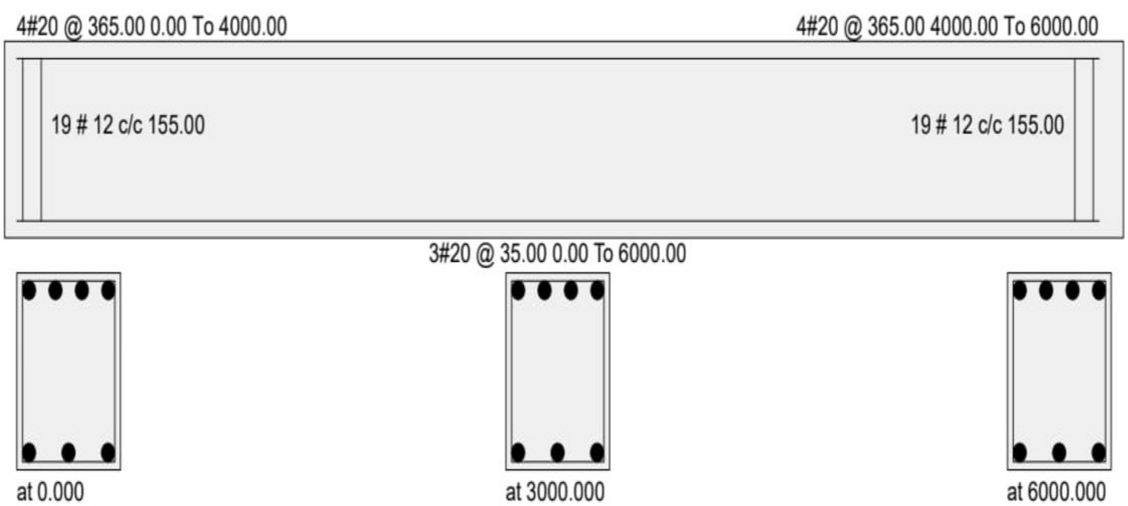


Fig 3.9 Detailing of Beam Reinforcement

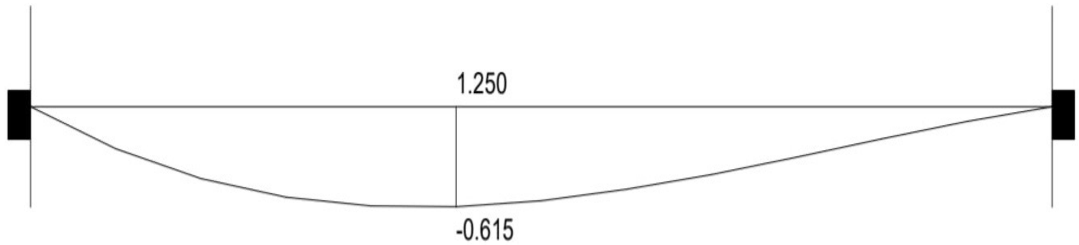


Fig 3.10 Deflection in Local Z direction Load case 20

Table 3.6 Beam reinforcement Details :

Beam No.	Top Reinf.	Bottom Reinf.	Shear reinf.
56,58,60 to 74,76to78,82to 85,87,210to 212,214, 215,221to223,225,228,231to238,240,306to310,317to319, 321,324,325,328to334,336,404to408,415to 417,419,422, 426to434,502to507,513to515,517,520,523to532,600to605, 610to613,615,617to619,621to630,698to703,708to711, 713to728,796to802,806to819,821to826,894to898,900, 903,905to909,911to914,916,917,919to924,992to996, 998,1001to1007,1009to1015,1017to1022,1090to1125	3-20 dia	3-20 dia	2 legged 12dia @ 155 mm c/c
57,59,79,81,213,216to219,224,227,230,312to315,320,323,326, 410to413,418,421,423to424,508to511,516,519,521,522, 606to609,614,620,704to707,712,803to805 ,820,899, 901to902,904,910,915,918,997,999,1000,1008,1016	4-20 dia	3-20 dia	2 legged 12dia @ 155 mm c/c
75, 86,229, 239, 335,220,226,311,316,322,327,409,414,420,425,512,518,616	6-20 dia	3-20 dia	2 legged 12dia @ 155 mm c/c

Design of Column

Columns are structural components in vertical compression that experience axial forces. The weight from the beam and slab is transferred to the column and then to the foundation.

When designing columns, the following steps were taken.

Step 1: Determine the effective length of the column and determine whether it is long or short.

On the basis of the end supports and the sway/no sway situation, the effective length of the column is calculated. A column is categorised as either short or long depending on the relationship between its effective length and its smallest lateral dimension. If its effective length to its smallest lateral dimension is less than 1,

- ≤ 12 ,Short RCC column.
- > 12 ,Long RCC column.

Step 2: Check for eccentricity

Eccentricity in columns refers to the axial load application point's displacement from the column's centre. Eccentric load causes the column to bend towards the loaded point and causes the column to experience a bending moment. According to I.S. 456-2000, we must take into account the eccentricity that is the larger of the following while designing.

I) 20mm. II) (Leff/500) + (b/30)

Where,

Leff = Effective Length of the Column

b = Lateral Dimension of the Column

The column is categorised as being under compression, uniaxially bent, or biaxially bent depending on the eccentricity.

Step 3: Design of longitudinal reinforcement

- The minimum cross-sectional area of longitudinal bars must equal at least 0.8% of the column's gross sectional area.

- The total cross-sectional area of longitudinal bars cannot be greater than 6% of the column's gross cross-sectional area.
- The bars must have a minimum diameter of 12 mm.
- The minimum number of longitudinal bars in a rectangular column must be four, whereas the minimum number of longitudinal bars in a circular column must be six.

Step 5: Design of Lateral Ties

The lateral ties' diameter shouldn't be less than 14 the greatest longitudinal bar's diameter and in no instance less than 6 mm.

The pitch of lateral ties should not exceed

- Least lateral dimension
- 16 x diameter of longitudinal bars (small)
- 300mm

Design Column No. 51

Location = Ground floor

Reference	Step	Calculations	Remarks
IS 456:2000 Table 28	1	Known data Strength of concrete (fck) = 30Mpa Grade of steel = Fe415 Preliminary Dimension of column = 500mm×600mm Dimension of Beam = 300mm×400mm Thickness of Slab = 150mm Floor height =3000mm Unsupported height of column, h = 3000 – (400 – 150) = 2750mm = 2.75m Effective height of column heff = 0.65h = 0.65*2.75 = 1.79m ≈ 1.8m	

	2	Assumptions Clear Cover = 40mm Longitudinal bar diameter = 25mm Lateral tie diameter = 12mm Effective cover d' = 40 + 25/2 + 12 = 64.5mm	
IS13920:1993 C1.7.1.2 & Cl.7.1.3	3	Member Size Check D = 600mm > 300mm B/D = 500/600 = 0.833 > 0.4	Size of column is Ok
	4	Slenderness Ratio Check heff/D = 1.8 / 0.6 = 3.0 < 12	Column is Short
IS 456:2000 Cl. 26.5.3.1	5	Limiting Longitudinal Reinforcement Minimum Reinforcement = 0.8% of BD = 2400mm2 Maximum Reinforcement = 4% of BD = 12000 mm2	
IS 456:2000 Cl. 25.4	6	Check for Eccentricity Minimum Eccentricity emin = h/500 + D/30 = 2750/500 + 600/30 = 25.5mm > 20mm	Hence, column is a biaxially loaded short column.
	7	Load acting on column Slab Area=21.00m2 Slab Load = (7.75 × 21.00 x 10) = 1627.5kN Roof slab Load = (6.75 × 21.00 x 1) = 141.75kN Main Beam Load = ((6/2) + (3.5/2)) x 3 x 11 = 156.75KN Secondary Beam Load = ((3.5/2)/2) x 3 x 11 = 28.88KN Main Wall Load= ((6/2) + (3.5/2)) x 15.69 x 11 = 819.8KN Parapet wall Load = ((6/2) + (3.5/2)) x 4.71 x 11 = 246.09KN	

		Column Load = 7.5 x 11 = 82.5KN Total Load transfer on column no. 51 = 1627.5 + 141.75 + 156.75+ 28.88+ 819.8+246.09+82..5 = 3103.27KN Factored Load, Pu = 3103.27 x 1.5 = 4654.905KN	
From Chart 49 of SP-16, IS 456-2000 CL no 26.5.3.1a	8	Design of Longitudinal Bar The reinforcement is to be distributed equally on all four sides. D'/D = 64.5/600 = 0.1075 (Take 0.15) $\frac{Pu}{fck\ bD} = \frac{4654.905 \times 10^3}{30 \times 500 \times 600} = 0.5$ Trial 1: p=1.0% $\frac{P}{fck} = \frac{1.0}{30} = 0.03$ $\frac{Mu}{f_{ck}bD^2} = 0.028$ Mux, lim = $0.028 \times 30 \times 500 x 600^2 \times 10\text{-}6$ = 151.2 kNm Muy, lim = $0.028 \times 30 \times 500^2 \times 600 x 10\text{-}6$ = 126 kNm Taking 1% steel, Pu = 0.4 fck Ac + 0.67 fy As Ag= 500x600 = 300000mm2 Asc= 0.01 Ag = 0.01 x 300000 = 3000mm2 Ac= Ag – Asc = 300000 – 30000 = 297000mm2 Puz = 0.4 fck Ac + 0.75 fy As = $(0.4 \times 30 \times 297000 + 0.75 \times 415 x 3000) x 10^{-3}$ =4497.75kN Area of steel required = 0.01 Ag = 0.01 x300000 = 3000mm2 Use 18mm dia bar Provide 12-18mm Ø for Main Reinforcement bars Provided area = 3053.62mm2	

IS 456-2000 CL no 26.5.3.2c	9	Transverse reinforcement Diameter of Transverse reinforcement Dia of T.R. ≥ (¼) x Dia of Longitudinal Reinforcement Ø ≥ (¼) x 18 = 4.5 mm Adopt, Dia of T.R = 12mm Pitch ≤ Least Lateral Dimension = 500mm ≤ 16 x Dia of Longitudinal bar =16x18 = 288mm ≤ 300mm Provide 12mm dia 300mm c/c for Tie Reinforcement	

Column Reinforcement Detailing and Drawing by using Staadpro:

```
          C O L U M N   N O.    51  D E S I G N   R E S U L T S

       M30                    Fe415 (Main)              Fe415 (Sec.)

LENGTH:  3000.0 mm   CROSS SECTION:  500.0 mm X  600.0 mm  COVER: 40.0 mm

** GUIDING LOAD CASE:    2 END JOINT:    18  TENSION COLUMN


REQD. STEEL AREA    :     2400.00 Sq.mm.
REQD. CONCRETE AREA:   297600.00 Sq.mm.
MAIN REINFORCEMENT : Provide    8 - 20 dia. (0.84%,   2513.27 Sq.mm.)
                     (Equally distributed)
TIE REINFORCEMENT  : Provide 12 mm dia. rectangular ties @ 300 mm c/c

SECTION CAPACITY BASED ON REINFORCEMENT REQUIRED (KNS-MET)
----------------------------------------------------------
Puz :   4764.60   Muz1 :    150.96   Muy1 :    123.81

INTERACTION RATIO: 0.73 (as per Cl. 39.6, IS456:2000)

SECTION CAPACITY BASED ON REINFORCEMENT PROVIDED (KNS-MET)
----------------------------------------------------------
WORST LOAD CASE:     2
END JOINT:    18 Puz :   4798.33   Muz :    160.01   Muy :    130.99   IR: 0.69
============================================================================
```

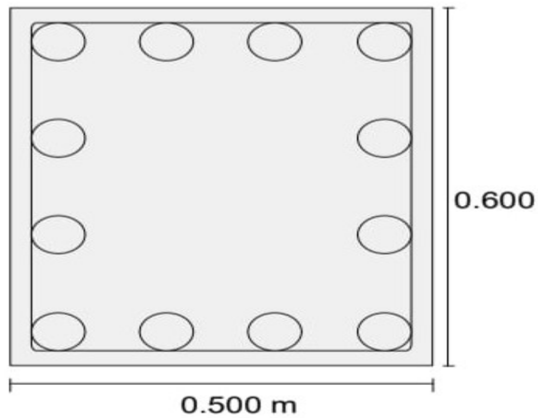


Fig 3.11 Detailing of Column Reinforcement

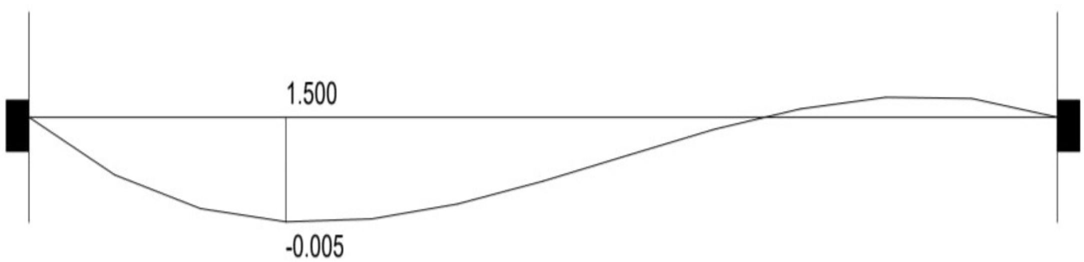


Fig 3.12 Deflection in Local Z direction Local case 20

Table no. 3.7 Column Reinforcement details :

Column	MAIN REINFORCEMENT in Zone III	TIE REINFORCEMENT in Zone III	MAIN REINFORCEMENT in Zone IV	TIE REINFORCEMENT in Zone IV
	Provide 8 - 20 dia.	Provide 12 mm dia. @ 300 mm c/c	Provide 12 – 20mm dia	Provide 12 mm dia. @ 300 mm c/c

CHAPTER 4

OBSERVATION AND RESULT

Equivalent static (linear static) seismic analysis is used for G+10 building. Using Staad Pro software, structural reactions such as lateral displacement, story drifts, and base shear for both LWC and NWC are discovered during seismic study of G+10 buildings in Zone III and Zone IV. The findings obtained as follows:

4.1 Volume of concrete and weight of steel

Volume of concrete and weight of steel required for the design of G+10 building. The volume of concrete required for design is 211.3 m^3 and Table 4.1 shows weight of steel in Newton. Fig. 4.1 shows the graph for weight of steel in Newton used for design of G+10 building.

Table 4.1 Weight of steel for different seismic zone

Sl. No.	Zone	weight of steel in (N) for NWC	weight of steel in (N) for LWC
1	Zone III, Z=0.16	365976	365976
2	Zone IV, Z=0.24	374987	374987

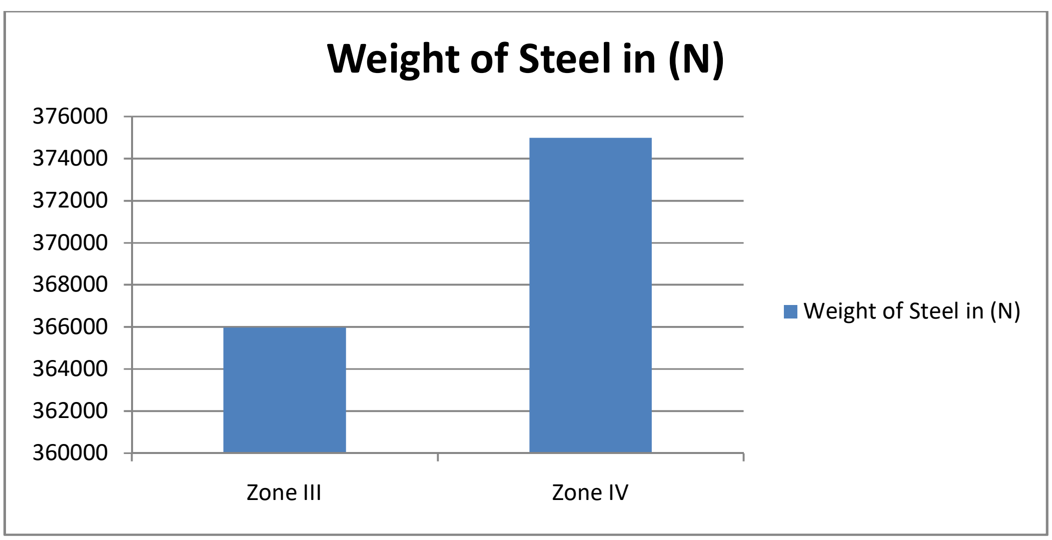


Fig 4.1. Weight of steel in Newton for different seismic zone

Above analysis the result obtained the weight of steel increase when zone factor increases. In table 4.1 shows the weight of steel in Zone III is 365976N and weight of steel in Zone IV is 374987N. When Zone factor increase 0.16 to 0.24, then the weight of steel increase 2% in both type of Structure (NWC and LWC).

4.2 Storey drift

Storey drift is the difference between a high rise building's first floor level and either the floor level above or below. Additionally, it must fall within the permitted range, which, according to IS 1893 part1, is 0.004H, where H is the structure's storey height. Storey Drift coefficient factor of 0.0045 is used for analysis in various zones.

Maximum limit = 0.004H = 0.004x33x1000=132mm

Analysis of Conventional Concrete –

Table 4.2 Storey Drift of Normal Weight Concrete in Zone III and Zone IV

Storey	Height	Storey Drift (CM) in Zone III		Storey Drift (CM) in Zone IV	
		X	Z	X	Z
1	0.0	0.0056	0.0097	0.0088	0.0107
2	3.0	0.8667	0.4267	0.9001	0.4760
3	6.0	0.8815	0.4148	0.9466	0.5229
4	9.0	0.9400	0.4243	0.8730	0.5447
5	12.0	0.9194	0.4116	0.9865	0.5323
6	15.0	0.8751	0.3921	0.9273	0.5096
7	18.0	0.8121	0.3683	0.8439	0.4795
8	21.0	0.7163	1.2635	1.0744	1.8340
9	24.0	0.8386	1.2244	1.2031	1.7751
10	27.0	0.7211	0.9205	1.0295	1.3276
11	30.0	0.5935	0.4934	0.8389	0.7096
12	33.0	0.7067	0.1666	0.9366	0.1990

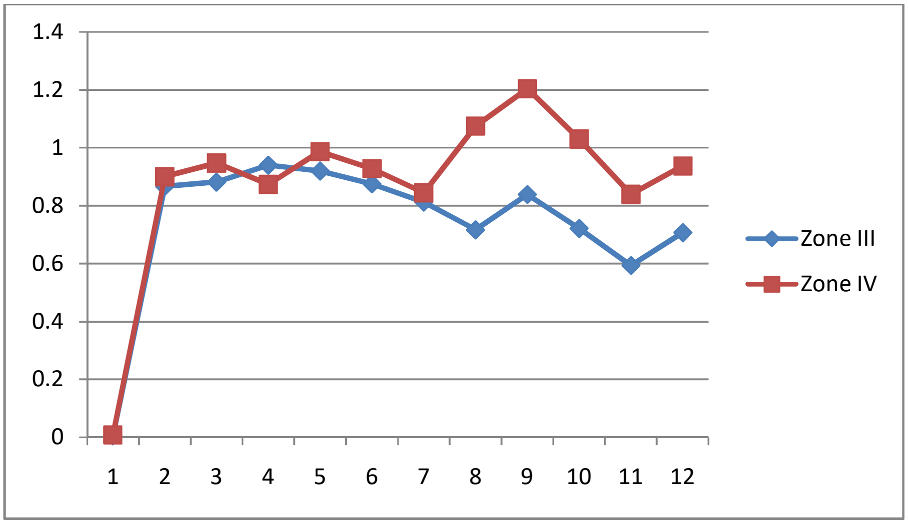


Fig 4.2 Graph of Storey Drift in X- Direction (NWC)

From the Figure 4.2 it is seen that building in Zone IV shows maximum storey drift as compared to building in Zone III. From the graph we can observed that seismic zone as change, then at storey level two to five and seven , there is a sudden change in the drift pattern.

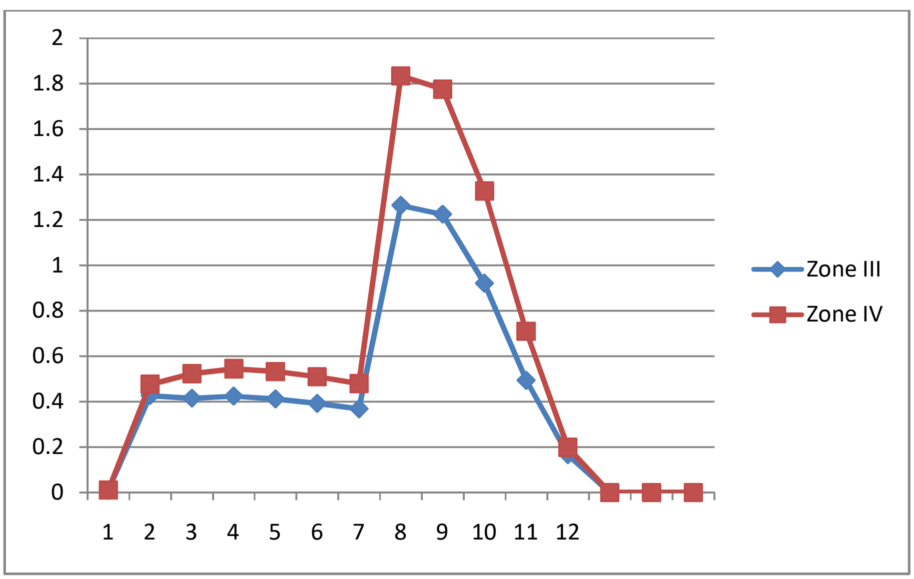


Fig 4.3 Graph of Storey Drift in Z- Direction (NWC)

From the Figure 4.3 it is seen that building in Zone IV shows maximum storey drift as compared to building in Zone III. From the graph observed that seismic zone as change, then storey drift as same at storey level Zero,Two,seven and twelve.

Analysis of Light weight Concrete –

Table 4.3 Storey Drift of Light Weight Concrete in Zone III and Zone IV

Storey	Height	Storey Drift (CM) in Zone III		Storey Drift (CM) in Zone IV	
		X	Z	X	Z
1	0.0	0.0053	0.0073	0.0068	0.0081
2	3.0	0.6262	0.3347	0.6548	0.3762
3	6.0	0.6589	0.3370	0.7150	0.4297
4	9.0	0.7059	0.3462	0.7676	0.4495
5	12.0	0.6910	0.3361	0.7492	0.4397
6	15.0	0.6556	0.3201	0.7013	0.4209
7	18.0	0.6051	0.3003	0.6335	0.3957
8	21.0	0.6307	1.0979	0.9435	1.5899
9	24.0	0.7236	1.0680	1.0426	1.5433
10	27.0	0.6206	0.8040	0.8901	1.555
11	30.0	0.5063	0.4326	0.7192	0.6193
12	33.0	0.5832	0.1295	0.7800	0.1570

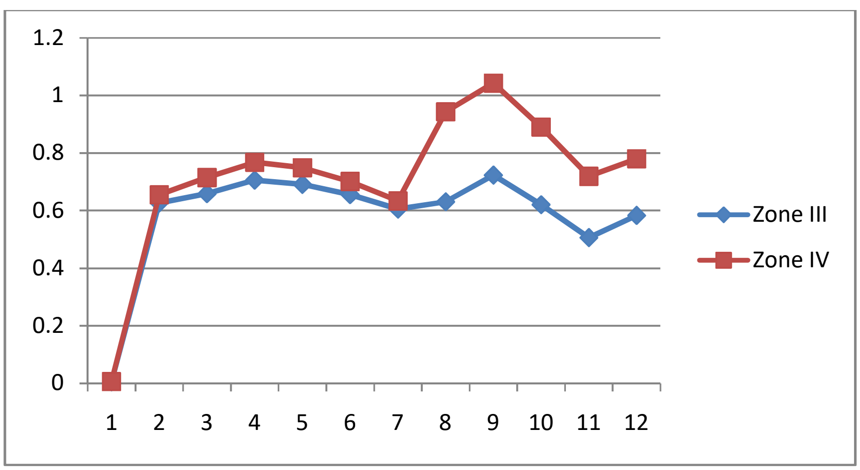


Fig 4.4 Graph of Storey Drift in X- Direction(LWC)

From the Figure 4.4 it is seen that building in Zone IV shows maximum storey drift as compared to building in Zone III. From the graph we can observed that seismic zone as change, then storey drift pattern move similar.

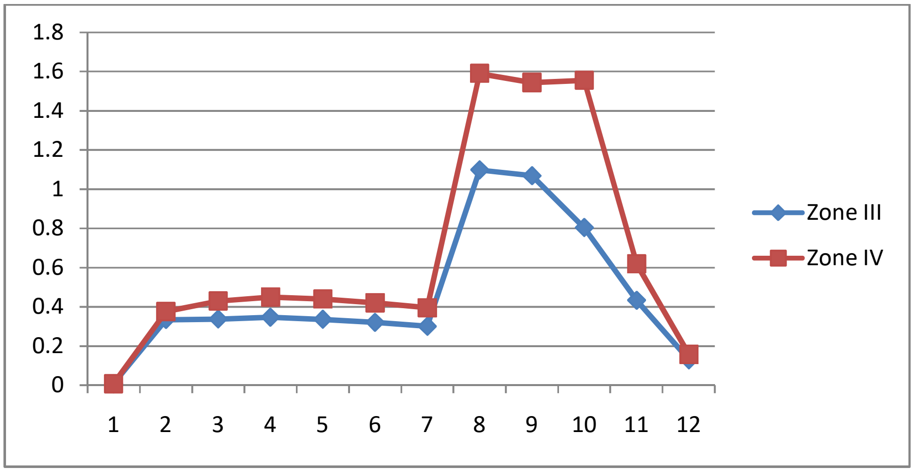


Fig 4.5 Graph of Storey Drift in Z- Direction(LWC)

From the Figure 4.5 it is seen that building in Zone IV shows maximum storey drift as compared to building in Zone III. From the graph observed that seismic zone as change

4.3 Storey Displacement

Analysis of Conventional Concrete –

Table 4.4 Storey Displacement of Normal Weight Concrete in Zone III and Zone IV

Storey	Height	Storey Displacement (CM) in Zone III		Storey Displacement (CM) in Zone IV	
		X	Z	X	Z
1	0.0	0.0056	0.0013	0.0088	0.0020
2	3.0	0.2536	0.3054	0.3640	0.4514
3	6.0	0.7078	0.8355	1.0244	1.2548
4	9.0	1.2117	1.4471	1.7600	2.1614
5	12.0	1.7220	2.0611	2.5073	3.0810
6	15.0	2.2210	2.6614	3.2399	3.9801
7	18.0	2.6961	3.2314	3.9386	4.8334
8	21.0	3.1348	3.7538	4.5843	5.6151
9	24.0	3.5232	4.2101	5.1560	6.2970
10	27.0	3.8470	4.5797	5.6318	6.8485
11	30.0	4.0946	4.8505	5.9938	7.2494
12	33.0	4.0345	5.0138	5.9233	7.4965

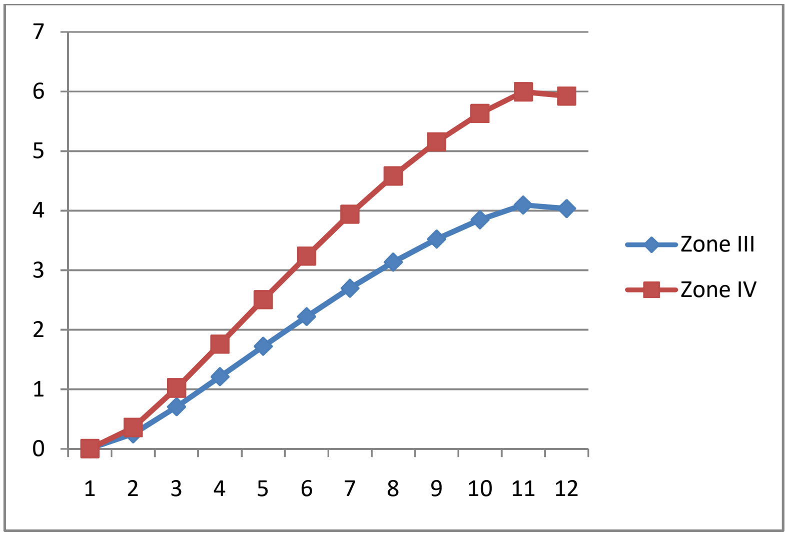


Fig 4.6 Graph of Storey Displacement in X- Direction (NWC)

From the above graph shows the value of storey displacement of building is increase. Maximum lateral displacement due to seismic force occurred in 11th storey which 40.94mm. storey displacement of building in zone IV is maximum as compared building in Zone III, which is 30- 32 percentage more.

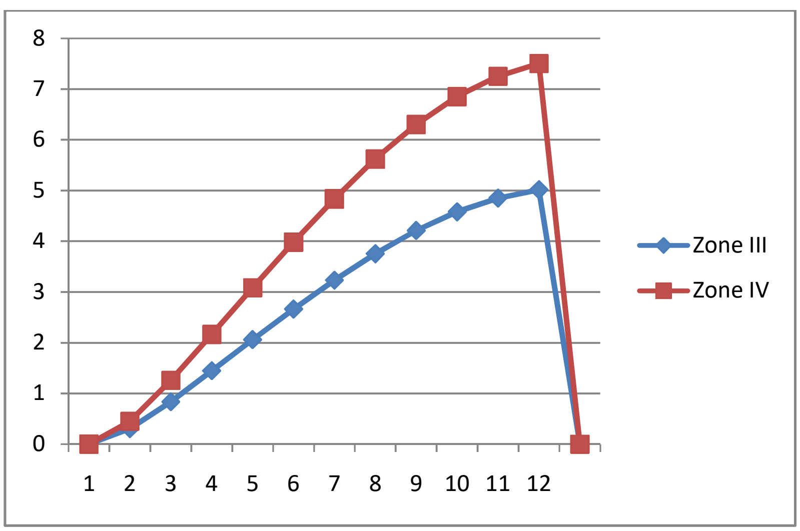


Fig 4.7 Graph of Storey Displacement in Z- Direction (NWC)

From the above graph shows the value of storey displacement of building is increase. maximum lateral displacement due to seismic force occurred in 12th storey which 50.138mm in Zone III and 74.965mm in Zone IV. storey displacement of building in zone IV is maximum as compared building in Zone III, which is 32- 34 percentage more.

Analysis of Light weight Concrete –

Table 4.5 Storey Displacement of Light Weight Concrete in Zone III and IV

Storey	Height	Storey Displacement (CM) in Zone III		Storey Displacement (CM) in Zone IV	
		X	Z	X	Z
1	0.0	0.0044	0.0011	0.0068	0.0017
2	3.0	0.2142	0.2595	0.3088	0.3848
3	6.0	0.6007	0.7181	0.8723	1.0727
4	9.0	1.0298	1.2364	1.5001	1.8492
5	12.0	1.4647	1.7624	2.1382	2.6374
6	15.0	1.8900	2.2772	2.7637	3.4082
7	18.0	2.2949	2.7695	3.3603	4.1399
8	21.0	2.6685	3.2142	3.9111	4.8100
9	24.0	2.9989	3.6054	4.3982	5.3941
10	27.0	3.2737	3.9221	4.8025	5.8660
11	30.0	3.4826	4.1534	5.1088	6.2074
12	33.0	3.4317	4.2937	5.0478	6.4186

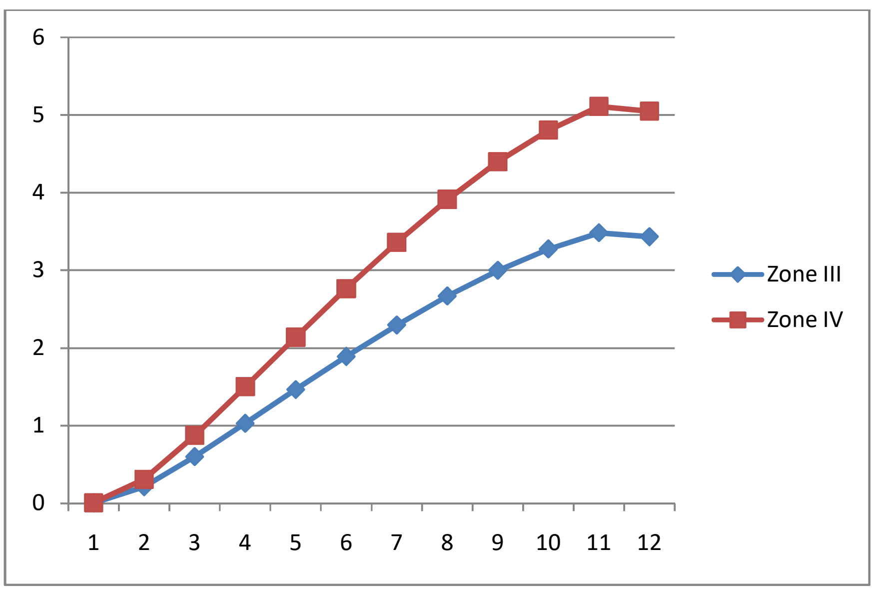


Fig 4.8 Graph of Storey Displacement in X- Direction(LWC)

From the above graph shows the value of storey displacement of building is increase. maximum lateral displacement due to seismic force occurred in 11th storey which 34.826mm in Zone III and 51.088mm in Zone IV. storey displacement of building in zone IV is maximum as compared building in Zone III, which is 30-32 percentage more.

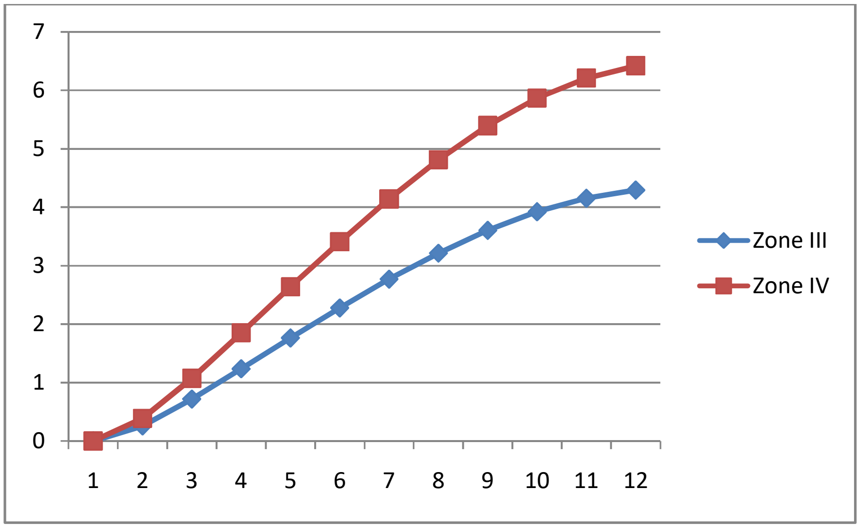


Fig 4.9 Graph of Storey Displacement in Z- Direction(LWC)

From the above graph shows the value of storey displacement of building is increase. maximum lateral displacement due to seismic force occurred in 12th storey which 42.937mm in Zone III and 64.186mm in Zone IV. storey displacement of building in zone IV is maximum as compared building in Zone III, which is 32- 34 percentage more.

Check Storey Drift

Table 4.6 Check Storey Drift of Conventional concrete

Zone	Direction	Maximum storey drift (MM)	Allowable storey drift (MM)	Remark
Zone III	X- Direction	9.400	132	OK
	Z- Direction	12.635	132	OK
Zone IV	X- Direction	10.295	132	OK
	Z- Direction	18.340	132	OK

Table 4.7 Check Storey Drift of Light weight concrete

Zone	Direction	Maximum storey drift (MM)	Allowable storey drift (MM)	Remark
Zone III	X- Direction	7.236	132	OK
	Z- Direction	10.979	132	OK
Zone IV	X- Direction	10.426	132	OK
	Z- Direction	15.899	132	OK

Check Storey Displacement

Table 4.8 Check Storey Displacement of Conventional concrete

Zone	Direction	Maximum storey displacement (MM)	Allowable storey drift (MM)	Remark
Zone III	X- Direction	40.946	132	OK
	Z- Direction	50.138	132	OK
Zone IV	X- Direction	59.938	132	OK
	Z- Direction	74.965	132	OK

Table 4.9 Check Storey Displacement of Light weight concrete

Zone	Direction	Maximum storey displacement (MM)	Allowable storey drift (MM)	Remark
Zone III	X- Direction	34.826	132	OK
	Z- Direction	42.937	132	OK
Zone IV	X- Direction	51.088	132	OK
	Z- Direction	64.186	132	OK

From the above table shows the maximum storey drift and storey displacement obtained by software is not exceed the maximum limit of storey drift as per IS 1893 part1

4.4 Base shear

Table 4.10 Base Shear of Different Structure in Seismic Zone III and Zone IV

Sl. No.	Zone	Base Shear in (KN) for NWC	Base Shear in (KN) for LWC
1	Zone III, Z=0.16	874.64	749.57
2	Zone IV, Z=0.24	1311.97	1124.36

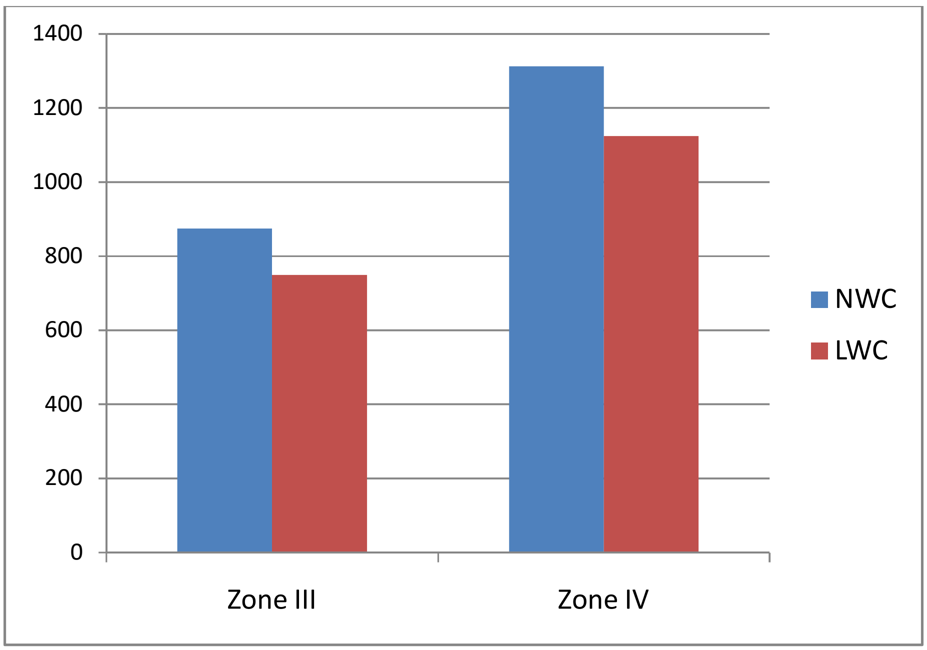


Fig 4.10 Base Shear of Different Structure in Seismic Zone III and Zone IV

From the above graph shows the value of Base Shear of building in different Seismic Zone. Conventional concrete building, maximum base shear occurred building in Zone IV as compared building in Zone III, which value of base shear of building 874.64KN in Zone III and 1311.97KN in Zone IV. Light weight concrete building, maximum base shear occurred building in Zone IV as compared building in Zone III, which value of base shear of building is 749.57KN and 1124.36KN in Zone III and Zone IV respectively. The seismic zone increase, then base shear value is increase, which as 32-34%. As shows the base shear of LWC is less than base shear of NWC which is 12-14 percent less.

CHAPTER 5

CONCLUSION

From the above analysis work and result obtained from STAAD Pro, it was found that:

- Requirement of steel, storey drift, storey displacement and base shear is more in Zone IV as compared to Zone III, which as 1-3% is more.
- Storey drift, storey displacement is maximum in Z- direction, i.e. Structure maximum displacement at least length of building (e.g. 22*12m, max. displaced at 12m length)
- The result LWCS is less as compared result NWCS. LWCS is economical than NWCS.

In this regard, the info of the structure we've got designed for used as a residential apartment building, to the best of our team's knowledge, include the specified precautionary measures that allow it to overcome the serious danger that come with being situated in an earthquake prone zone along with the nominal gravity masses which can be expected in such a structure.

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