بِسْمِ ٱللَّهِ ٱلرَّحْمَٰنِ ٱلرَّحِيمِ

EFFECT OF FLOATING COLUMN IN MULT-STORY BUILDING UNDER SEISMIC LOADING

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DEDICATION

Every challenging work, needs, self-efforts as well as

Guidance of elders especially those who were awfully close to my heart.

My humble effort I dedicate to my sweet and loving

"FAMILY"

Whose affection, love, encouragement and prays of day and night make me able to get such a success and honor.

Along with all hardworking and respected teacher.

MEHRAN UNIVERSITY OF ENGINEERING & TECHNOLOGY

CERTIFICATE

This is to certify that the work presented in this thesis **"Effect of Floating Column in Multistory Building under Seismic Loading (A Case Study)"** is written by studen under the supervision of **Mr. Azzizullah Jamali, Dept of Civil Engineering.**

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Supervisor	**Chairman**
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ABSTRACT

Pakistan is developing country in which we need the Highrise building, because it's a time of vertical growth due to less availability of land, but with the vertical growth most of the area of the building is taken by the large columns and make unpleasant for the stakeholder, so for provide more space and removal of column in between the structure concept of floating column originate and now a days it's the developing item or we say the important feature of the Highrise building. On the other hand it make the instability in the structure which cause the collapse of the structure, as we see from the researches that the vertical loading doesn't create any impact on the structure with floating column, but the lateral force cause the failure of structure in which we have common lateral forces seismic and wind force, but if we design the structure by taking into account each every factor which cause the failure and strengthen them by some shear and bracing techniques, so there is no any chance of the failure of the structure. The aim of this research is to investigate the response of a high rise building with floating column during seismic excitations by using software ETABS. The building selected for this research work is a reinforced concrete building having three shear walls, found in Hyderabad. The research method includes the linear static analysis also known as pushover analysis. The required data was extracted from Building code of Pakistan and ASCE 7-16, various displacement and drift values for different floors were seen. The results show that basement carries zero drift, and its value increases as one moves from the bottom to the top floors, it concludes that upper floors will move and vibrate for long time intervals as compared to the bottom floors. The building is analyzed and design for different loads i.e., Dead, Live, Wind and Earthquake Loads where the maximum values of shear force and bending moment diagrams were due to the Dead and Live Loads. However, this research work concludes that the proposed building with floating column is safe under seismic and wind excitations because of the shear walls provided.

Keywords: Floating Column; ETABS; Liner Analysis; Seismic Zone; Peak Ground Acceleration or Drift

Chapter # 01

Introduction

1.1 Background:

As the Pakistan is a developing nation, where urbanization occurs at extremely fast rate in the country including the different methods of constructing a building which is under vast development in the past few years. As a part of developing country construction of multi-story buildings with the architectural requirements are compulsory for a country. This is nothing but a soft story, heavy load, floating column, the reduction in stiffness etc.

Previously the building will be construct with regular shape, as it gave the more strength to the structure and able to get higher load, due to its uniformity in design, moreover due to number of columns and thicker walls were provided. The consequences of this less carpet area were left and now in developing countries this is keen concentrate to increase more carpet area specially at the ground floor and basement due to the open lobbies, receptions, halls, conference room, show rooms and parking area, also the beautification and aesthetic point of view it is recommended to provide the more open and free spaces in the building. For this purpose now in multistory building hotels, offices etc. the concept of floating column were introduce in which the column resting on the beam instead of laid to the foundation level, but this type of column features form the irregularity in the structure that cause improper transfer of load and also in seismic active area it will be highly undesirable.[1]

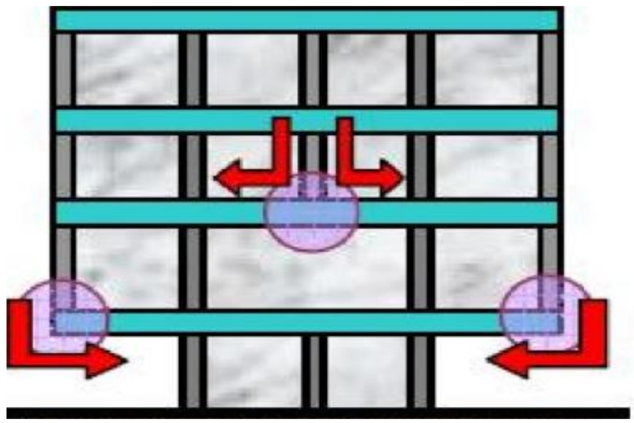


Fig 1.1: Hanging & Floating Columns

1.1.1 Floating Column:

A floating column sometimes call as hanging column or stub column. The term column is known as the vertical member which start from the foundation and the function is to transfer the load from the superstructure to substructure, but the term floating column is little different in which column is supported on either joints or rest over the beam eccentrically without any support below it, then those beams in turn transfer the load to others column under it.

1.1.2 Transfer Beam:

Transfer beam is a horizontal structure which relates to the column with rigid joint. The load of floating column rest on beams are known as "Transfer beams or girders", which is generally change from the ordinary beams. The dimension and percentage steel ratio are also higher in transfer beams. There should be greater care is required while designing and detailing the beam properly, especially in earthquake zone. The load of floating column is function as a point load in the transfer beam, so it must be designed with adequate dimension with minimum deflection. [2]

Fig 1.2: Floating Column with Transfer Beam

1.1.3 Famous Buildings with Floating Column:

Fig 1.3: Park Avenue Building South in New York, United States

Fig 1.4: The Castellar Building Madrid, Spain

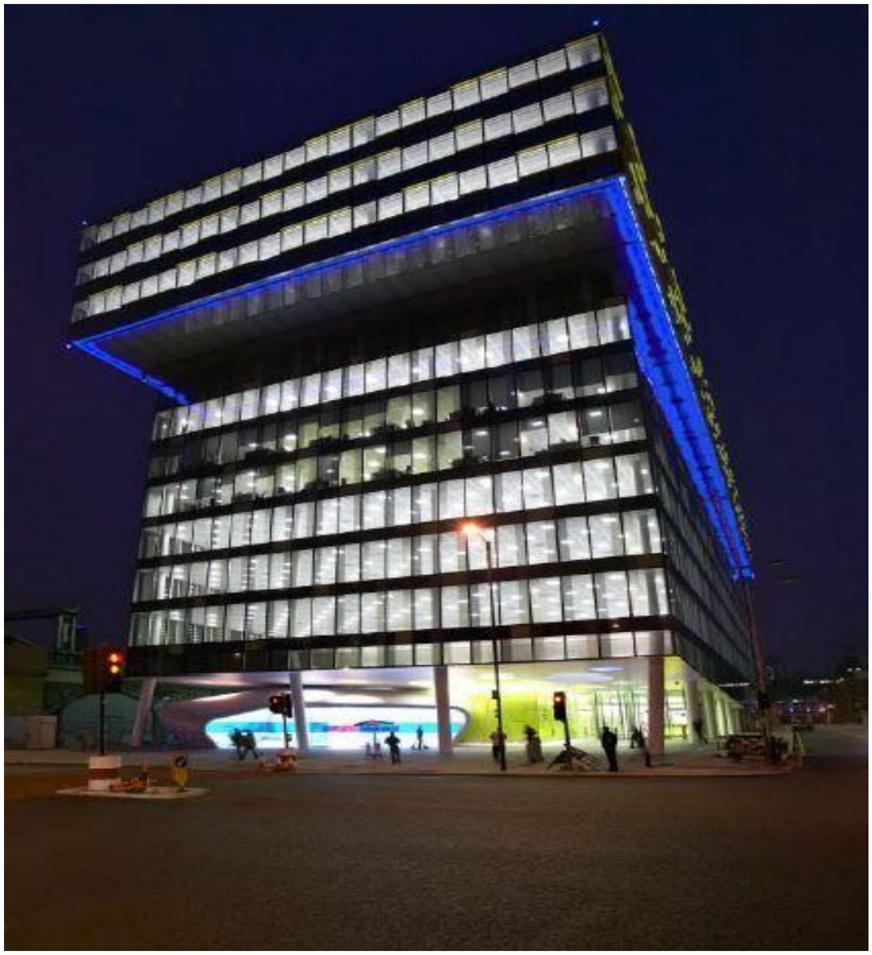


Fig 1.5: Palestra Building in London, United Kingdom

Fig 1.6: Chongqing Public Library in Chongqing, China

1.2 Problem Statement:

Earthquakes are vibration in the earth crust, due to the movement of the tectonic plate. This will be highly undesirable and unpredictable phenomena which will occur frequently without any warning and known intensity. According to the National Earthquake Information Center (NEIC) approximately 20,000 earthquakes occur around the globe in each year, which will be around 55 earthquake per day [3].

In addition, as we know that the floating column building does not create any problem or adverse effect on the building under gravity or vertical loading condition. But during the lateral or earthquake loading condition clear path of lateral load transferring to the foundation are not available, moreover the lateral force is acting at upper floor of the multi-story building due to which the overturning effect will be develop at the base or ground floor of the building, under this situation columns were deforms due to the buckling force, resulting major cracks, reduce durability or collapse of building. The most critical part is the connecting region of column to the beam. Therefore, greater care will be adopted while define the load path and also strengthen the lower part of the columns and strengthen of connecting beams that cause the discontinuous transfer of load.

Generally, in structure there are two types of loading that are acting on the structure i.e., Static loads and Dynamic loads. The static loads are dead load and live load which are act at constant rate, but dynamic load will vary with the time those are wind loads and earthquake load which are not consider often due to the complexity in the design, but sometimes neglecting the dynamic loads cause the failure of the structure. Dynamic loads cause the sudden increase in the acceleration. Due to this effect structure will be more sever. It is a fact that the entire world is facing so much natural disaster in which earthquake was one of the major natural disasters from a very long period of time.

Fig 1.7: Collapse of Building during Earthquake

The lack of awareness of the earthquake is still continued. In multistory building which are more vulnerable to the earthquake and wind forces, also the lateral forces act with the great intensity, so the chance of failure of the structure is more to make it safe enough to carry load, then ultimately the dimension or cross-section of the building from top to bottom will be increase, this leads the structure uneconomical due to safety purpose, therefore it will be necessary to design the multistory building with shear walls which counter the lateral forces and make the structure more economical as well as safe. It was seen from the figure that the lower part of the building is more vulnerable to failure, so it was the common practice to provide the shear wall at lower portion to counter the lateral forces [4].

Fig 1.8: Highrise Building with Shear Wall

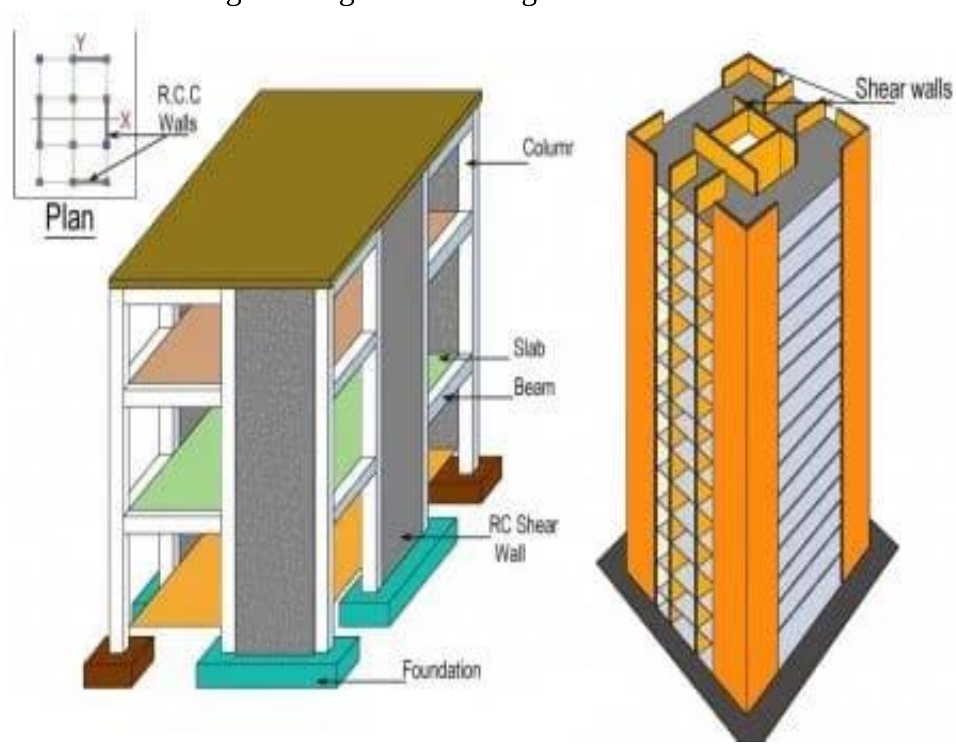


Fig 1.9: Animated view of Building with Shear Wall

1.3 Aims and Objectives of study:

The objectives which will be achieved by this research is to perform the seismic analysis of multi-story building situated at the Hyderabad city of Sindh Pakistan. The major goals of the research are listed below.

- Behavior of the multi-story building with and without floating column under the earthquake affected region.
- Transfer of load in multistory building at each floor and also the displacement, drift and base shear produce in each floor.
- Understanding of the distinctive features of the architectural drawing, and its complete modeling in ETABS, with appropriate materials and section properties.
- Effect of the building with different load combination given by the AISC, and also produce the shear force and bending moment diagram of structure.
- Figure out the highly vulnerable position of the floating column in multi-story building, by placing the floating column at different position.

1.4 Scope of study:

The scope of this research which we mainly discussed in this thesis are listed below.

- There is so much research are done on effect of floating column in multi-story building, but there will be very few literature are available for the effect of the structure by changing the position of the floating like center, corner, edge of building etc.

- The designing of the transfer beam in such a way that there will be minimum deflection will occur, and also the beam easily transfers those loads towards the below column.

- How the building will behave with floating column in earthquake prone areas, also at which factors the stability and adequacy of the structure will depends.

- The effect of the shear walls is must to be incorporated and check how the building will behave and response with and without shear walls in multi-storied building with the floating columns.

- Understanding the effect of floating column in different position helps to find the optimum location of the floating column and also the more vulnerable location of floating column, which will help the designer while designing the structure.

1.5 Layout of Thesis:

Chapter:1

It gives the brief idea about what is floating column, need of floating column in multi-story building, issues caused by floating column etc. This chapter also discussed about lateral force like earthquake and wind force which have significant impact of building with floating column and highlight the aims and goals, scope of this research.

Chapter: 2

Gives detailed discussion of previous studies that have been conducted on floating column with different techniques and seismic vulnerability assessment of buildings and this topic has developed great intersects among researches.

Chapter: 3

Distinguish different methods or techniques that are used for the analysis and design of structure in ETABS, enlightens the method being applied to achieve the aims and goals of this research.

Chapter: 4

Shows the results that are obtained during the analysis of the building, compare the result that are achieved during analysis whether that are feasible for structure or not.

Chapter: 5

Concludes the research work by comparing different factors each other by means of excel graphs that will be helpful in future for the analysis of floating column of the building which have similar properties and no: of stories.

Chapter # 02

Literature review

The occurrence of the earthquake in any area is under consideration and many research, journals, books etc. available to understand the effect and vulnerability of the earthquake on different buildings. Many authors present their theory relative to the response of the structure when situated in earthquake area. The brief review of different studies relative to the seismic analysis of structure with floating column are given below.

Avinash Pardhi Shah and Parkash Shah (2016)[5] studied the seismic analysis of multi stories RCC structure building with and without floating column at different location like internal, edge and corner column of the building. They study the behavior of multistory building with floating column in seismic area and identify the critical location of the floating column which cause high deflection and drift force in each story. They take four cases in first case building without floating column. In second case provide floating column 10^{th} to 15^{th} story. In third case provide floating column 5^{th} to 15^{th} story and in fourth case provide floating column 1^{st} to 15^{th} story.

Hardik Bhensdaadia and Siddharth Shah (2017)[6] studied pushover seismic analysis of RCC frame structure with floating column in different earthquake zones. The entire work consists in four models and this models are made to test in zone II for lower seismic area and zone IV for higher seismic area.

Model 1 (when only floating column is provided at particular floor or certain location),

Model 2 (when floating column is provided with 4m story height at particular floor),

Model 3 (when floating column is provided with the heavy load on the slabs at any floor),

Model 4 (when floating column is provided with 4m story height and heavy load on the slabs).

Amit Namdeo Chaudhari, KK Tolani and M.A Patil (2017)[7] study the seismic response of building at different locations of floating column. Research is basically the comparative study of structure with floating column which is support by strut, with the comparison of single floating column and double floating column in X and Y (axes). Analysis is carried out of G+12 building considering the earthquake and wind load on the structure, also check the structure with different load combinations.

T.H. Sadashiva Murthy (2016)[8] study the response of floating column on the behavior of composite Highrise building subjected to seismic force. This research is basically the comparison of the composite structure with and without floating column with different seismic zones and find the critical location of the floating column in structure by using linear static analysis.

Mehmet et al and Emrah Meral (2016)[9] performed the seismic analysis of RC buildings with lack of shear walls but infill walls were provided. They compared the results of two-story, four-story and seven-story buildings and observed that two-story building gave best results under earthquake.

Akshay Gujar (2019)[10] study the performance of RCC structure with floating column in sequential construction analysis which is to check the performance of the structure by applying the loads in stages which is differ from the load applied in single step. Hence, in order to simulate the model structure in ETABs with the actual construction of structure, the model should be properly analyzed at every construction phase taking in to account to check the changes in loads. Sequential construction analysis is non-linear static analysis which take into the basic concept of incremental or additional loading. All loads applied at ones is not valid or resemble the actual construction because building is constructed step by step and dead load acts accordingly.

Mr. Gaurav Pandey and Mr. Sagar jamle (2018)[11] study the ideal position of floating column in high rise building with seismic loading. This paper presents the comparative study of G+14 building in which 5 bays are provided in x direction and 3 bays are provided in z direction for total for total 13 cases with and without floating column at various location within the floor. Analysis under different condition under seismic zone V by response spectrum method with "STAAD Pro V8i". It was examining with the result that floating column in upper floor gave the optimum location of floating column.

Yasamin Rafei Nazari and Murat Saatcioglu (2017)[12] conducted the seismic analysis of buildings(concrete) having shear walls through fragility analysis. In this research incremental dynamic analysis of low rise (two story) and mid-rise (five story) building with four shear walls (two in each direction) was done. They even compared the 1965 and 2010 NBCC seismic vulnerability results and concluded that 2010 NBCC gave satisfactory results.

Shashikumar NS and Dr. Rame Gowda (2018)[13] study the seismic performance of braced framed structure with floating column. The research is carried out to check the performance of structure by removing the column from the structure and placed bracing where column was removed and check the importance of bracing in floating column structure which is subjected to earthquake force. Earthquake analysis is carried out the static and dynamic analysis of structure.

Isra H. Nayel, Shereen Q. Abdulridha and Zahraa M.Kadhum (2018)[14] study the impact of shear wall in RCC multistoried structure with floating column exposed to seismic loads. The research is carried out on different frames with floating column without shear walls and floating column with shear wall at different location by using ETABs 2015 software to determine the displacement, base shear and drift produce in each story. The analysis is based of Response Spectrum Analysis (RSA).

Sharma R.K and Dr. Shelke N.L (2016)[15] this comparative research paper is carried out to find the dynamic analysis of RC frame structure with hanging column in earthquake region, different frames were model with different stories like G+6, G+8, G+10, G+12 and G+14 stories structure with floating column by using Staad Pro V8i software. The structure was model and analyzed so to find the response parameter of the building subjected to earthquake loading and laterally use this parameter while designing the building.

H.Gokdemir, H. Ozbasaran, M. Dogan, E. Unluoglu and U. Albayrak (2013) [16] studied the effects of torsional irregularity. According to results eccentricity between center of rigidity and center of mass were the main cause for torsional degree of torsional moment is function of eccentricity. Therefore, torsional irregularity causes failure in structural system so by decreasing strengths of members in strong zones or by increasing the strength in weak zones can prevent the torsional moment on the structure. It was also recommended that a safe distance must be kept between buildings to counter the effects of torsion on adjacent building during earthquakes.

Ancy Mathew and Priya Prasannan (2017) [17] paper is discussed about the seismic response of RCC floating column reflecting different configurations, the effect of varying the position of the floating column floor wise or within the floor of multi storied RC structure and check the response of the structure by varying the position of floating column by using method of response spectrum analysis in ETABs 2015 software. The main objective is to study the seismic response of the structure with floating and find most suitable configuration for providing floating column. Various parameters such as total base shear, story displacement, story drift, story acceleration are studied with respect to different configuration of floating columns. Also find the critical configuration made it resistant by providing shear wall.

Patil (2013) [18] in this paper G+5 RC structure reveled for the seismic analysis, then three different models are created like simple structure, shear walls and masonry walls structure on ETABs software. The methods used for the analysis correspondent static linear method and time history method. The result of this analysis shows that the shear walls structure gave the maximum strength and better performance of the structure in earthquake loading among the three models.

Naveed Anwar and Mir Shabir Talpur (2017) [19] This research paper discussed about how performance-based structure design (PBD) help to improve the structural performance and floor diaphragms reduce the cost of tall structure. PBD check the response of the building in high seismic area with site seismic data as well as the post yielding response and behavior of the building under seismic period. This case study deal with the high-rise residential building with 57-stories and approximately 192 meters from ground level.

Xilin Lu, Linzhi Chen, Ying Zhou and Zhihua Huang (2009) [20] studied the effect of earthquake by performing shaking table test on truss connected two high-rise buildings with core walls and shear walls. The design showed abnormality in plan as well as elevation of both towers. The results showed that the trusses connecting both towers have capability to resist lateral loads while the lower stories of tower II were damaged during analysis. It was suggested that shear walls need to be strengthened, there is need of more braces whereas connecting trusses must be redesigned for tower II.

F.Hosseinpour and A.E. Abdelnaby (2017) [21] study the nonlinear dynamic behavior of RC structures under frequent earthquakes. They investigated two buildings irregular and regular in heights by using Zeus-NL software. The increase of base shear in irregular structure under selected ground motion was almost twice the regular structure. Longitudinal component of earthquake has minor effect on the total drift, but it increased the number hinges support in columns and concluded that it must be taken into account in the design of structures under frequent earthquakes.

Naveed Anwar, Thaung Htut Aung and Deepak Rayamajhi (2010) [22] This research paper discussed about the case study for performance-based design (PBD) of 50-story building with ductile core wall system. The objective of this study is defining the advantages of the PBD in tall building. The result of case study shows that PBD method ensure the operating of the building under frequent earthquake and measures are taken to remove the total and partial collapse of the building under extreme earthquakes which is exceedingly rare case. Overall response of the building remains elastic means building will remain operational during frequent earthquake.

Chapter # 03

Research Methodology

3.1 Representative Building:

The selected building for this research is high rise Reinforced Concrete Building having Single Basement + G+12 floors whereas the building has regular, and building located at the Hyderabad Pakistan.

3.2 Properties of Building:

It includes all the properties of building that is type of foundation, material properties and section properties. Furthermore, the detail of the zone in which the proposed building lies is also discussed.

3.3 Codes Followed:

The codes followed for the design of building, are ACI-2002 and UBC-1997 Standards.

3.4 Soil Pressure and Ground Water Table:

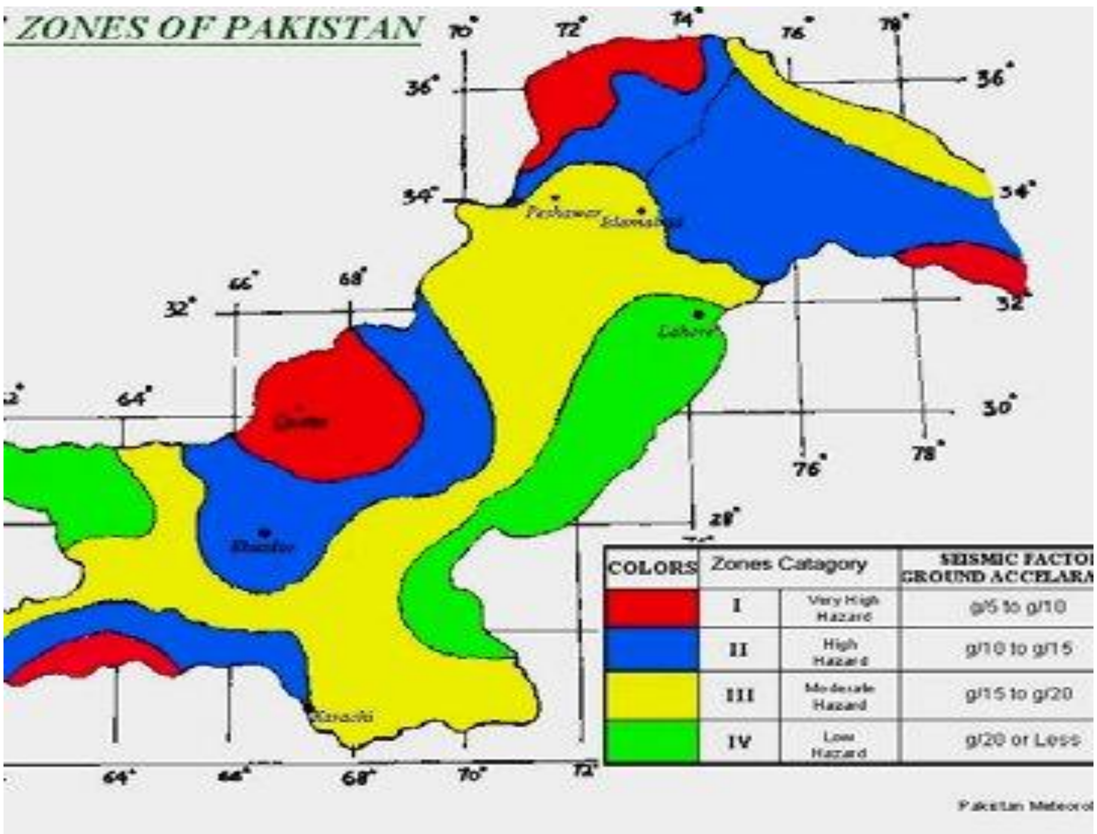
The building is designed at a soil pressure of 2.75 tons/ SFT at 22 ft to 23ft depth from Exit. Road Level. Ground Water Table was taken as 9ft from Exit. Road Level.

3.5 Zones:

Pakistan is divided into five seismic zones. The targeted building lies among the highlighted zones.

SEISMIC ZONE	PEAK GROUND ACCELERATION
1A	0.05g to 0.08g
2A	0.08g to 0.16g
2B	0.16g to 0.24g
3	0.24g to 0.32g
4	>0.32g

Table 3.1 Seismic Zone



Where “g” represents the acceleration due to gravity.

Fig 3.1: Seismic Map Of Pakistan

Tehsil	Seismic Zone	Tehsil	Seismic Zone	Tehsil	Seismic Zone
Sindh					
Badin	2B	Dokri	2A	Shah Bunder	2A
Golarchi	2A	Kambar	2B	Sujawal	2A
Matli	2A	Miro Khan	2A	**Umerkot**	2A
Talhar	2B	Rato Dero	2A	Kunri	2A
Tando Bagho	2B	Shahdadkot	2B	Pithoro	2A
Dadu	2A	Warah	2A	Samaro	2A
Johi	2B	**Malir**	2B		
Khairpur Nathan Shah	2B	**Mirpur Khas**	2A	**FEDERAL AREA**	
Kotri	2A	Digri	2A	Islamabad	2B
Mehar	2A	Kot Ghulam Moh	2A		
Sehwan	2A	**Naushahro Feroze**	2A	**AJ&K**	
Ghotki	2A	Bhiria	2A	Bagh	4
Dharaki	2A	Kandioro	2A	Bhimbar	2B
Khangarh	2A	Moro	2A	Hajira	4
Mirpur Mathelo	2A	**Nawab Shah**	2A	Kotli	3
Ubauro	2A	Daulatpur	2A	Muzaffarabad	4
Hyderabad City	2A	Skrand	2A	New Mirpur	2B
Hala	2A	**Sanghar**	2A	Palandri	3
Hyderabad	2A	Jam Nawaz Ali	2A	Rawalakot	3
Latifabad	2A	Khipro	2A		
Matiari	2A	Shahdadpur	2A		
Qasimabad	2A	Sinjhoro	2A		
Tando Allahyar	2A	Tando Adam	2A	**NORTHERN AREAS**	
Tando Mohammad Khan	2A	**Shikarpur**	2A	Chilas	3
Jacobabad	2A	Garhi Yasin	2A	Dasu	3
Garhi Khairo	2A	Khanpur	2A	Gakuch	3
Kandhkot	2A	Lakhi	2A	Gilgit	3
Kashmor	2A	**Sukkur**	2A	Ishkuman	2B
Thul	2A	Pano Aqil	2A	Skardu	3
Karachi Central	2B	Rohri	2A	Yasin	3
Karachi East	2B	Salehpat	2A		
Karachi South	2B	**Tharparkar**/Chachro	2A		
Karachi West	2B	Diplo	3		
Khairpur	2A	Mithi	2B		
Faiz Ganj	2A	Nagar Parkar	2B		
Gambat	2A	**Thatta**	2A		
Kingri	2A	Ghorabari	2A		
Kot Diji	2A	Jati	2A		
Mirwah	2A	Keti Bunder	2A		
Nara	2A	Kharo Chan	2A		
Sobhodero	2A	Mirpur Bathoro	2A		
Larkana	2A	Mirpur Sakro	2A		

Table 3.2 Seismic Zone of Tehsil Pakistan

The zone of Hyderabad city is 2A where the proposed building is located. Therefore, design of building is carried out as per this zone.

3.6 Foundation:

The foundation for the purposed building is Raft Foundation. This type of foundation is provided for the Structures that contains large number of columns and beams.

3.7 Slabs:

The slab provided for the basement is 7” thick while the remaining floors have 6” thick slab.

3.8 Walls:

The types of walls provided are Reinforced Cement Concrete walls. To overcome seismic loads the building has 3 shear walls (with different cross sections) having concrete ratio of 1:1:2.The Shear Wall is provided through the entire height of the building except the retaining wall and the shear wall strength is 5000 psi.

Shear Wall	Thickness
SW1	9’’
SW2	12’’
SW3	10’’

Table 3.3: Shear Wall Thickness

COLUMNS LENGTH				
Storey	Basement – 1st Floor	1st – 2nd Floor	2nd - 3rd Floor	4th – 12th Floor
Column Length (ft)	11	10	13	10'6"

Table 3.4 Columns Length

CONCRETE STRENGTH	
Foundation	4ksi
Slabs	4ksi
Beams	4ksi
Columns	5ksi
Shear Walls	5ksi
STEEL STRENGTH	
Steel Bars	60ksi
Code	ASTM-A615A

Table 3.5 Concrete and Steel Strength

CONCRETE COVER	
Foundation	3in
Columns and Beams	1 - $^{1}/_{2}$ in
Slab	$^{3}/_{4}$ in
Shear Wall	1 - $^{1}/_{2}$ in
Water Tank Top Slab	1 - $^{1}/_{2}$ in
Water Tank Bottom and Side Slab	1 in

Table 3.6 Concrete Cover

3.9 Type of Cement:

The type of cement used is foundation is Sulphate Resisting Cement (SRC). It is provided when the soil contains more sulphates, and in superstructure cement used is Ordinary Portland Cement (OPC).

3.10 Seismic Analysis:

In order to perform the seismic analysis of high rise building with floating column ETABS software is used.

3.11 Methods of Analysis:

There are basically two methods of analysis is used which are given below.

- Equivalent Static Force Analysis Method
- Dynamic Analysis Method

Equivalent Static Force Analysis:

The equivalent lateral earth force is distinctive concept in the Seismic Engineering. The concept is unique, because it converts dynamic analysis into partial dynamic analysis and partial static analysis to find the highest displacement produce by the earthquake in structure. This equivalence is limited only to a single vibration form of a structure and following are the assumption of this method.

1. Assume the structure is rigid.
2. Ensure the perfect fixity of the structure with the foundation.
3. During the ground motion, each point of the structure undergoes the same acceleration.

Dynamic Analysis:

The dynamic analysis is to be carried out in order to obtain structural seismic effect and its distribution at different heights adjacent to the building heights. This method is further divided in to linear and non-linear dynamic analysis.

1. Time History Method: The time history method is a non-linear dynamic analysis. This is analysis method which evaluated the structural response is non-linear. The time history method performed in step by step in which initially the dynamic response of the structure with the specified loads which are varying with the time. In which we predicted earthquake effect at the base of the building.

2. Response Spectrum Method: The response spectrum analysis method that calculate every physical form of vibration to the highest seismic response of an elastic structure. The response spectrum is a graph between the maximum amplitude of acceleration versus time for linear oscillator with the single degree freedom to generate the components of the earths motion. This graph is used for evaluation of buildings peak response to an earthquake. In seismic prone area, most structure use this value to determine the force that the building design. The response spectrum analysis is based on the assumption of linear elastic behavior of the structure [23].

3.12 ETABS:

ETABS is one of the most sophisticated and advanced tools for the modeling, analysis and design of building. ETABS is considered as multitasking software and has the following functions:

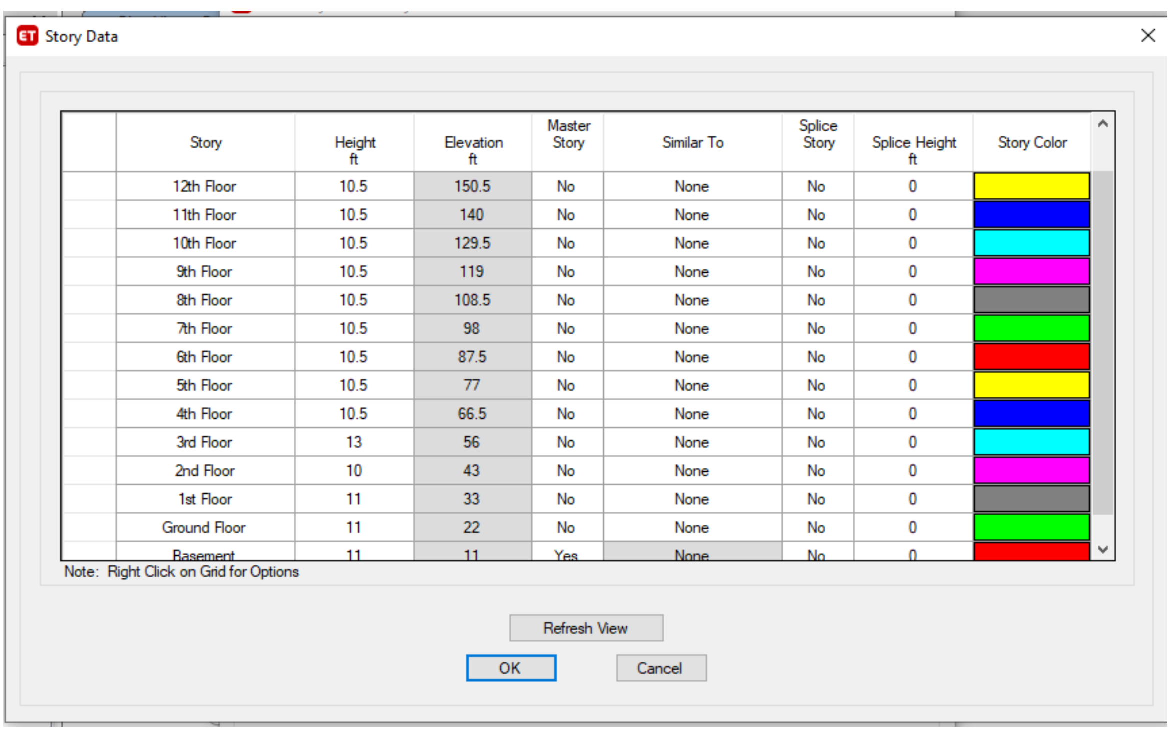
- Cartesian, Cylindrical and free-form grids.
- Modeling of any building either it is a single-story building or multi tower high rise building.
- Frame elements are defined that is slab, beams (straight or curved) and columns along with section properties (concrete and steel).
- Different types of walls can be modeled i.e., RCC walls, Shear walls, Retaining walls etc.
- Loads are defined i.e., Live loads, Dead Loads, Wind Loads, Earthquake Loads.
- A wide range of codes to be followed is given with different systems.
- Provides linear (static and dynamic) analysis as well as non-linear (static and dynamic) analysis.
- Provides plan and elevation view of building at same time and is helpful in modeling irregular buildings.
- ETABS provide the Bending Moment and Shear Force Diagrams of different structural components.

- Application of shell forces and reaction diagrams.
- ETABS provides video animations and a number of display options.
- Helpful in generation of reports.

3.13 ETABS Analysis Procedure:

<u>Step1: Define Units, Grids and Story Data:</u>

First of all, define the set of units or codes that you will use while designing the structure, then the grid data added relative to the position of column in (x and y axes). In addition to this, also the number of stories and relative height of each floor is defined, all stories at single time or a master story at once can be selected and the other stories are then added.



Story	Height ft	Elevation ft	Master Story	Similar To	Splice Story	Splice Height ft	Story Color
12th Floor	10.5	150.5	No	None	No	0	
11th Floor	10.5	140	No	None	No	0	
10th Floor	10.5	129.5	No	None	No	0	
9th Floor	10.5	119	No	None	No	0	
8th Floor	10.5	108.5	No	None	No	0	
7th Floor	10.5	98	No	None	No	0	
6th Floor	10.5	87.5	No	None	No	0	
5th Floor	10.5	77	No	None	No	0	
4th Floor	10.5	66.5	No	None	No	0	
3rd Floor	13	56	No	None	No	0	
2nd Floor	10	43	No	None	No	0	
1st Floor	11	33	No	None	No	0	
Ground Floor	11	22	No	None	No	0	
Basement	11	11	Yes	None	No	0	

Fig 3.2: Grid Story Data

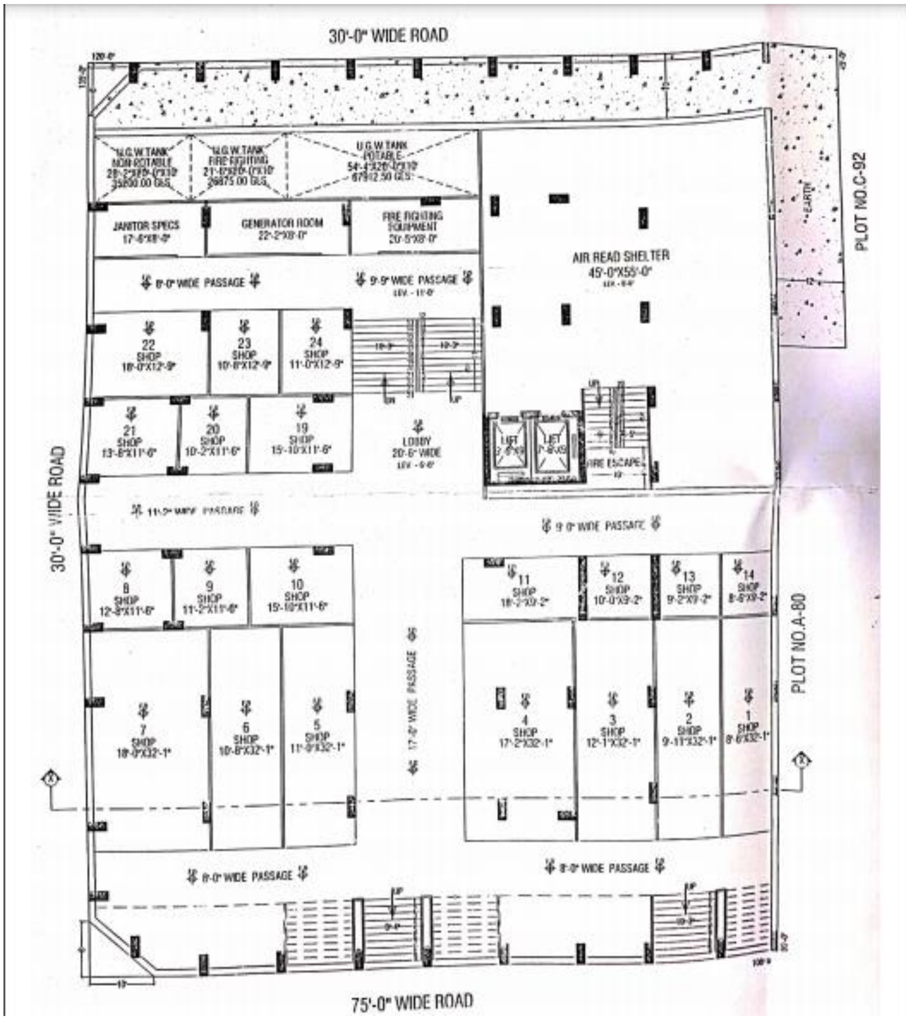


Fig 3.3: Site Plan of Existing Building

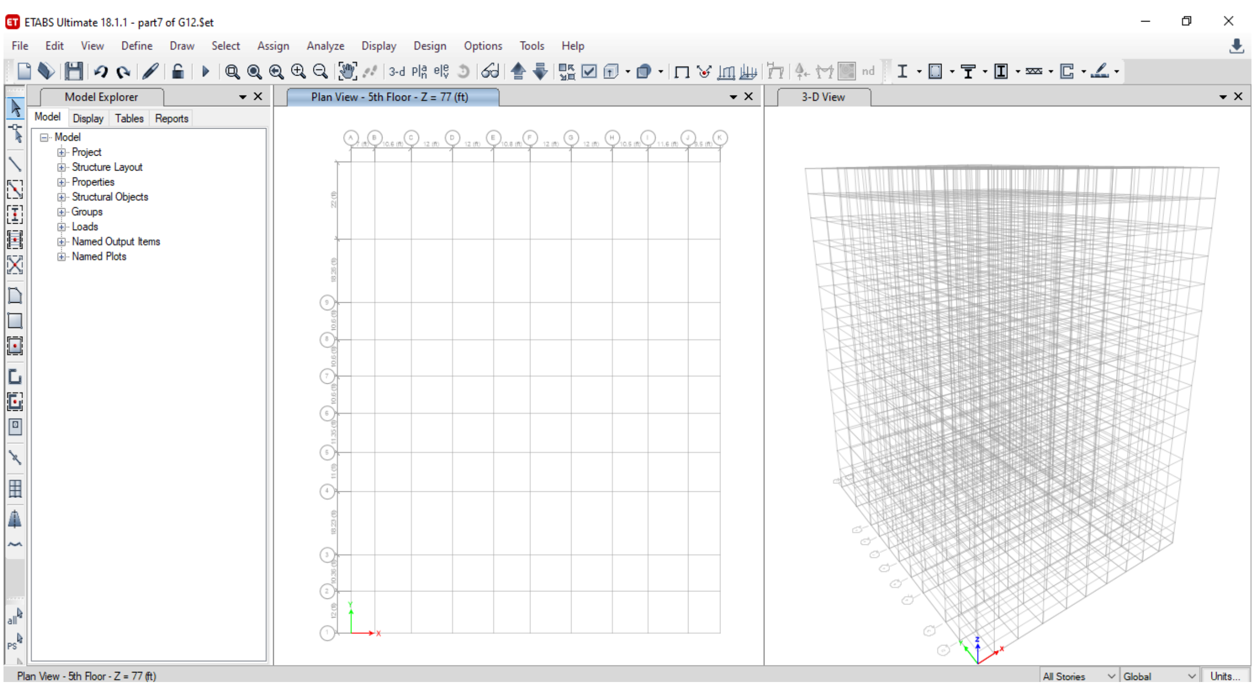


Fig: 3.4 Site Plan of Existing Building by ETABS

Step2: Define Material Properties:

After the grids and number of stories being assigned, the strength of steel, concrete and shear walls is defined for all frame elements.

Step3: Define and Assign Beams:

1. The dimension of the beams is defined in ETABs e.g., go to the Define menu > Frame Sections > Add new property > Define the section of the Beam used in this building.

2. As this structural drawing is initiative of the design so define the one dimension for all beams, here beam dimension is 12”x24”.

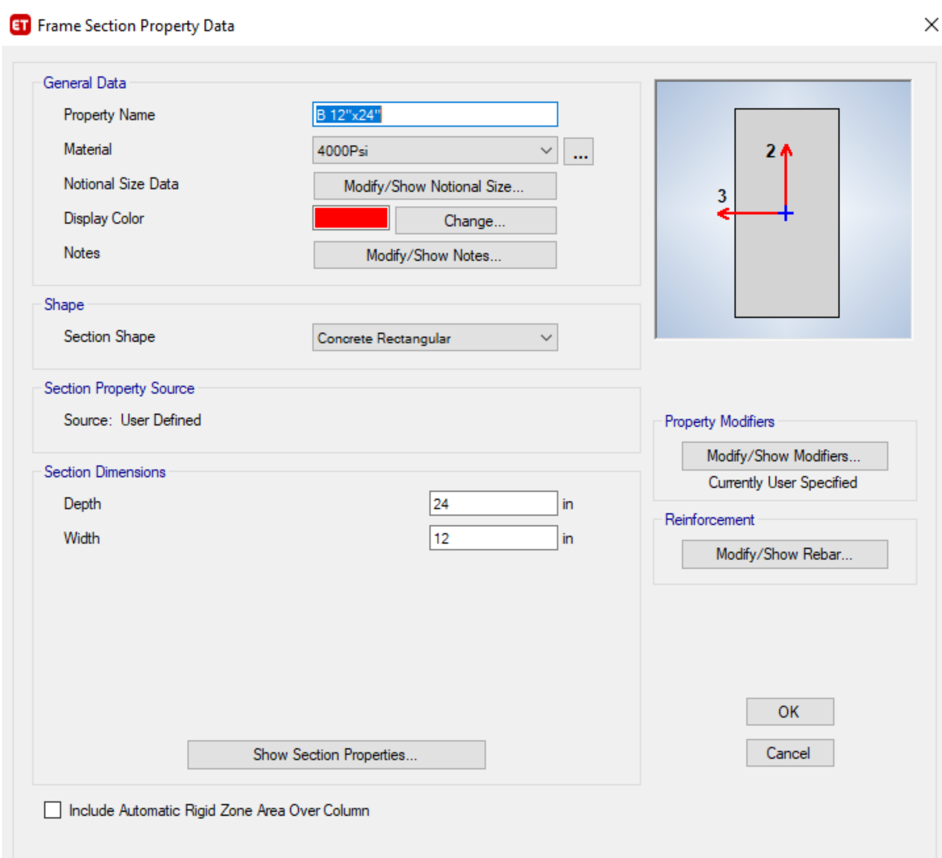


Fig: 3.5 Beam Section Property

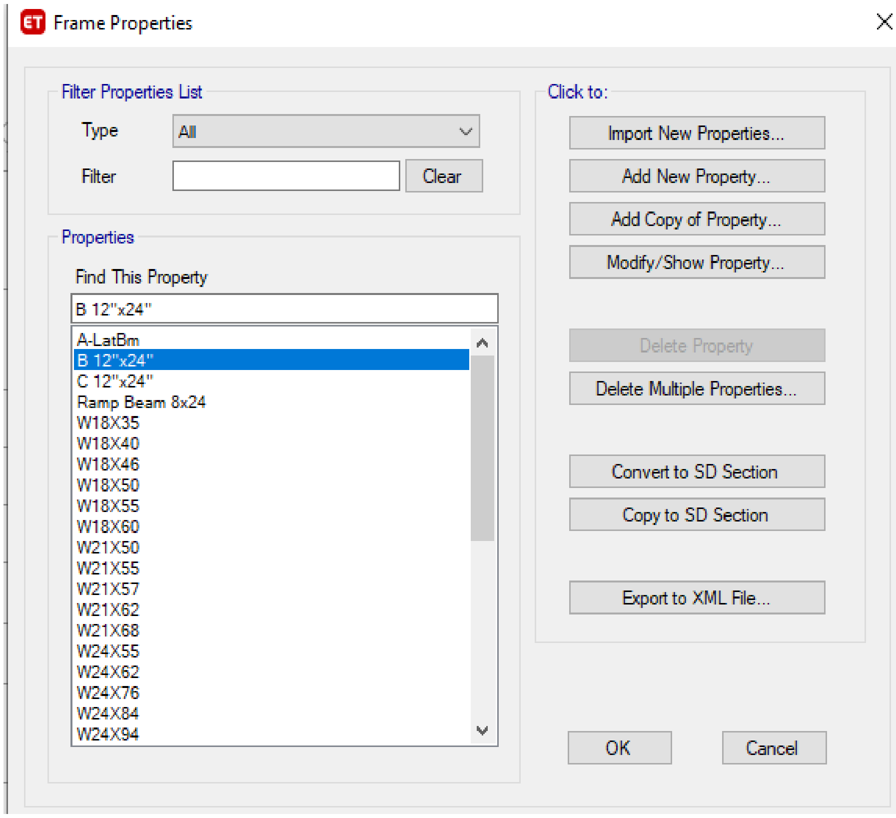


Fig 3.6 Section Properties of beams

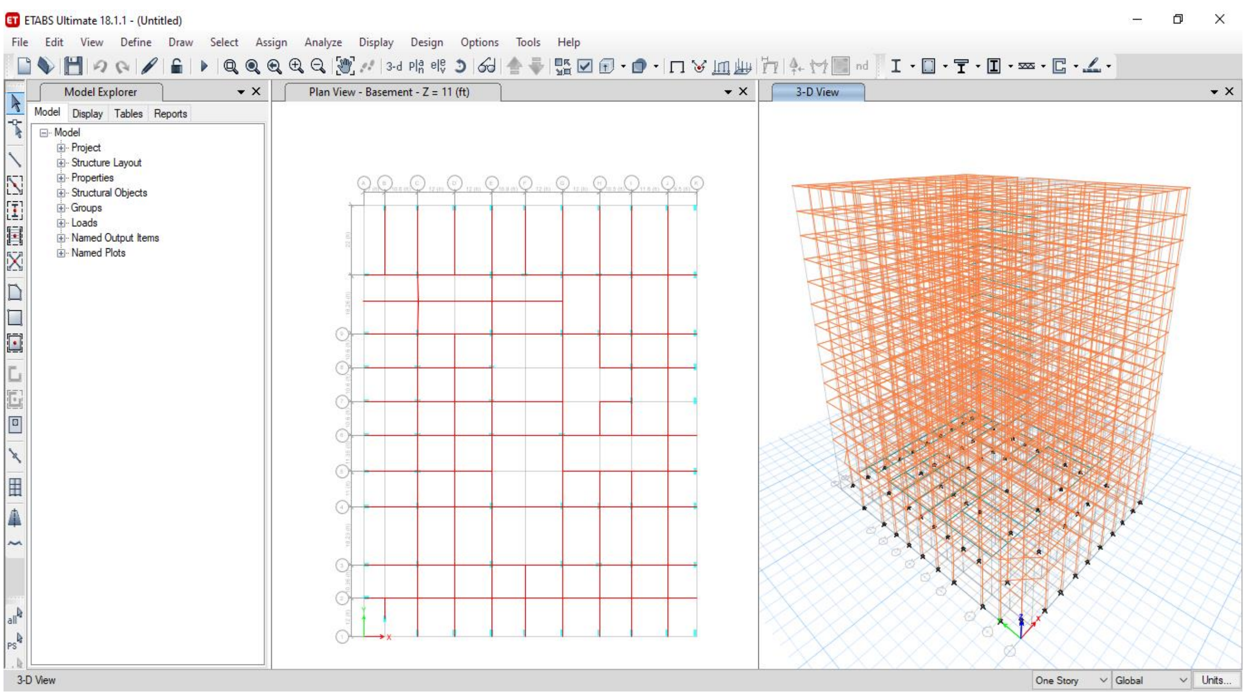


Fig 3.7 Plan view and 3d view of Beams

Step4: Define and Assign Columns:

1. The dimensions of columns are defined (i.e., 67 number of columns) using the same pattern and then they are assigned according to their orientation similar as proposed building.

2. As this structural drawing is initiative of the design so define the one dimension for all columns, here column dimension is 12”x24”.

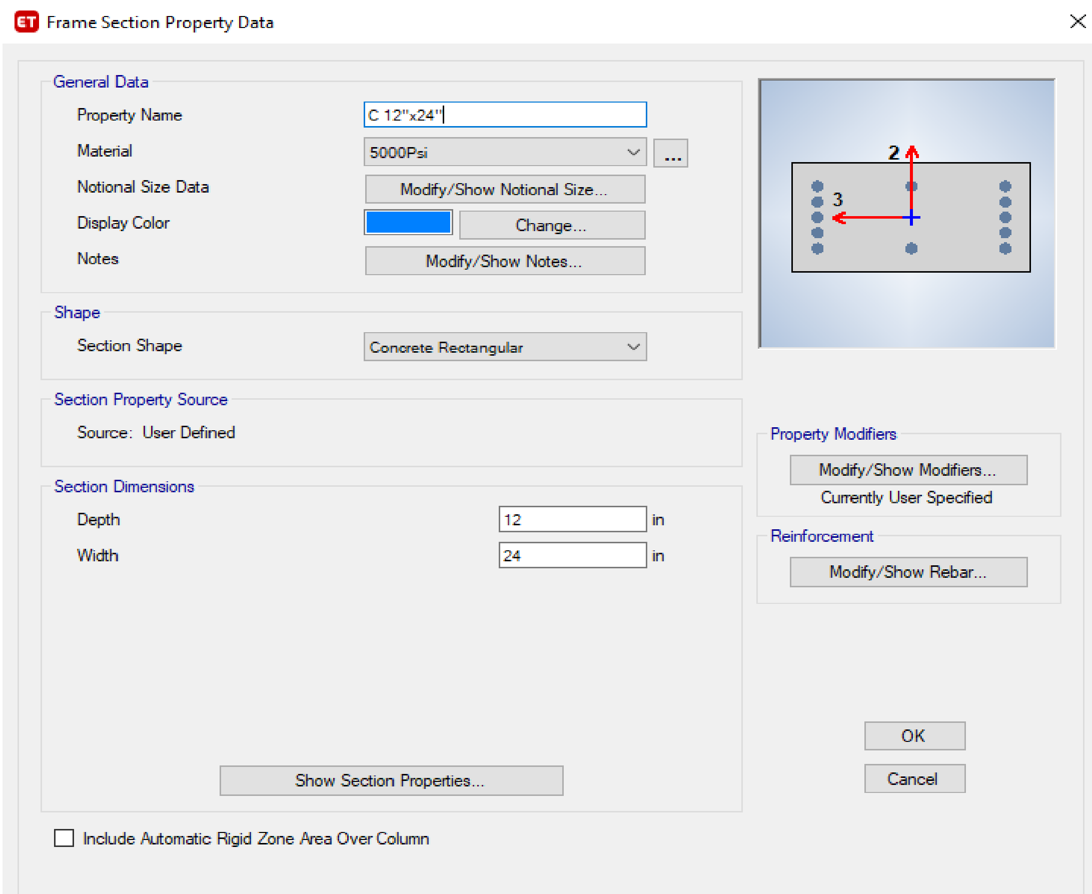


Fig 3.8 Column Section Property

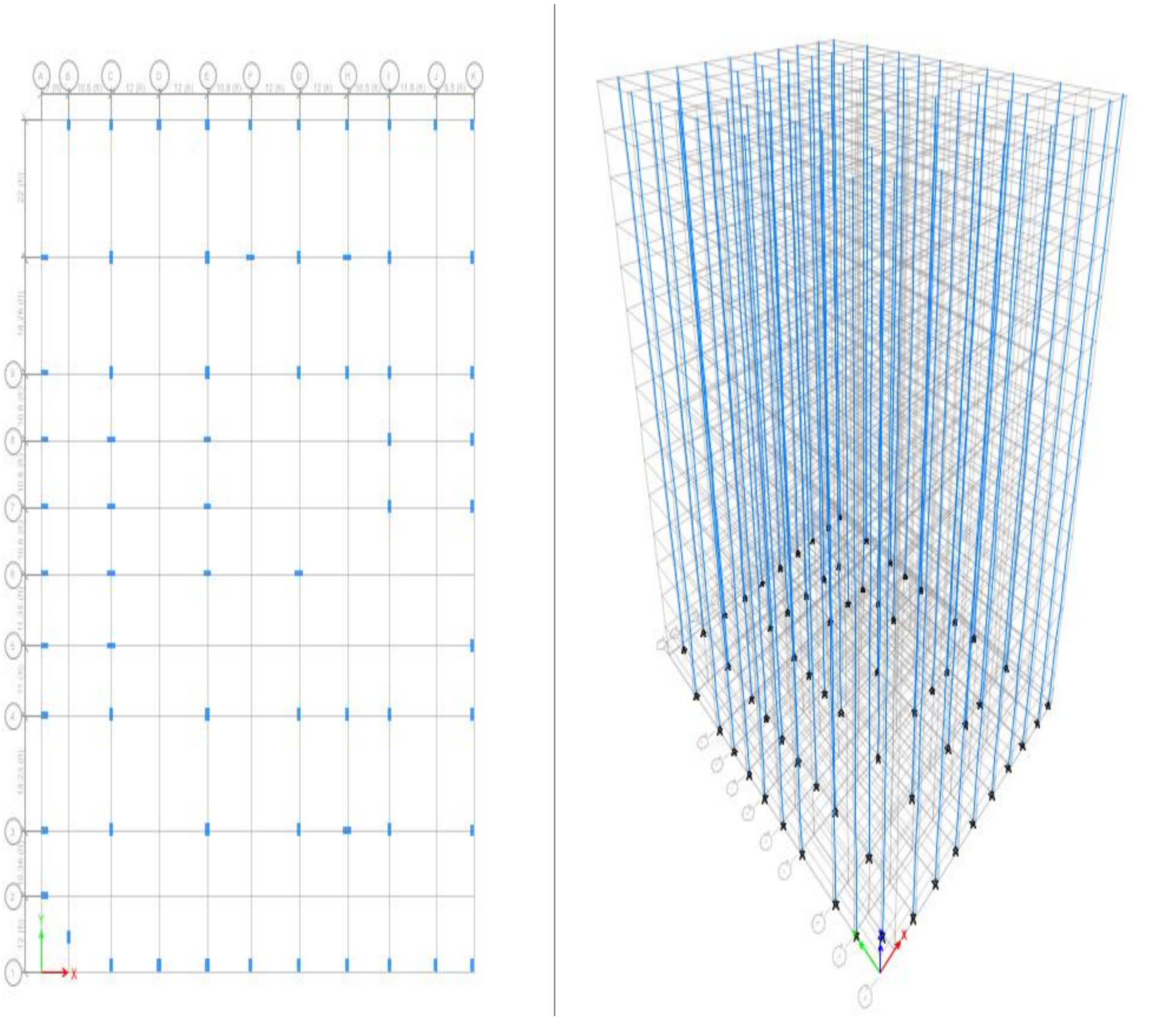


Fig 3.9 Plan view and 3d view of Columns

Step5: Define and Assign Retaining Walls:

The RCC retaining wall is provide the throughout the perimeter of the building in basement and ground floor, the thickness of retaining wall is 9in and strength is 5000psi.

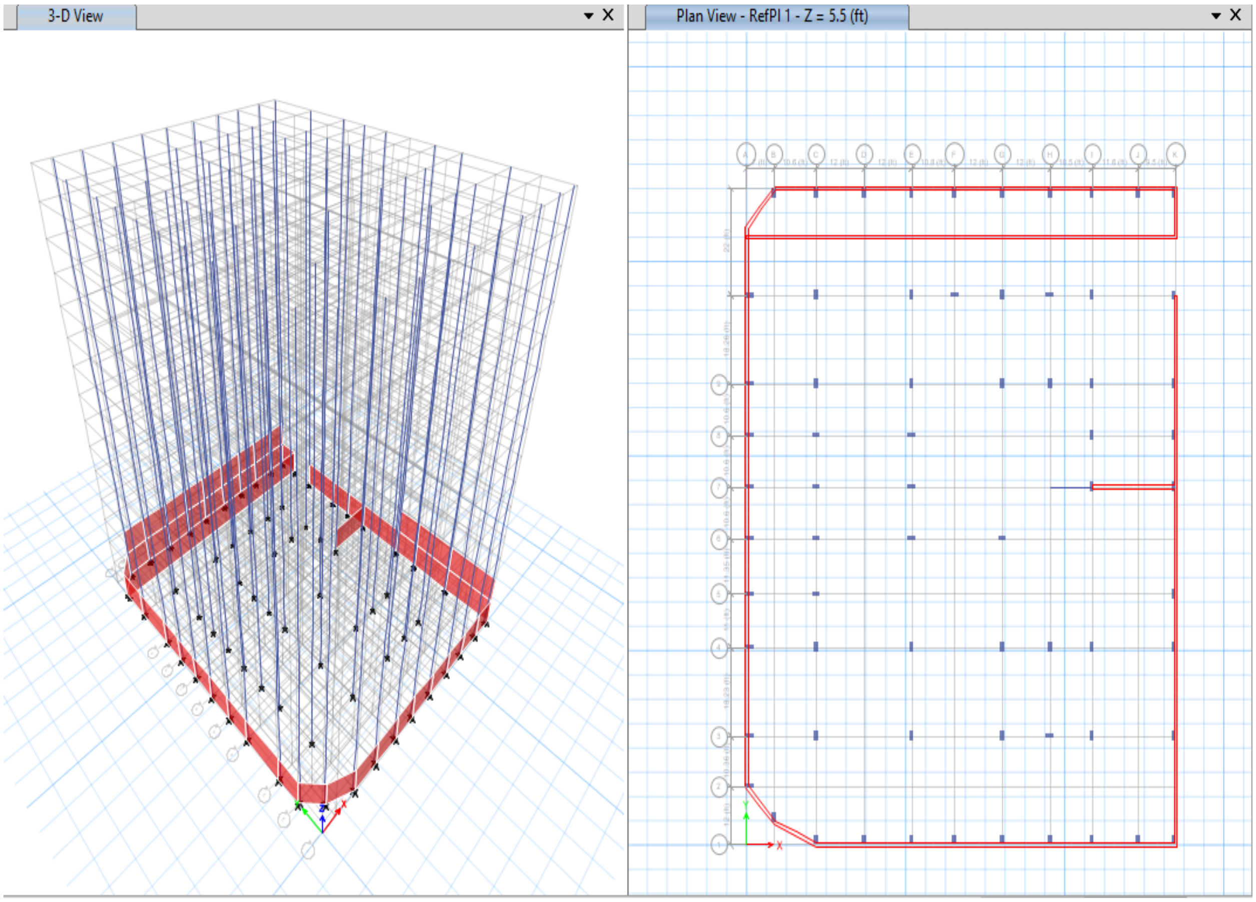


Fig 3.10 Plan view and 3d view of Retaining walls

Step6: Define and Assign Shear Walls:

The shear walls are then defined in detail because it has main influence on the building during seismic excitations. In this case, the building will be modeled with 2 shear walls at different positions and with different sections. In this building, the shear wall is provided through the entire height of the building.

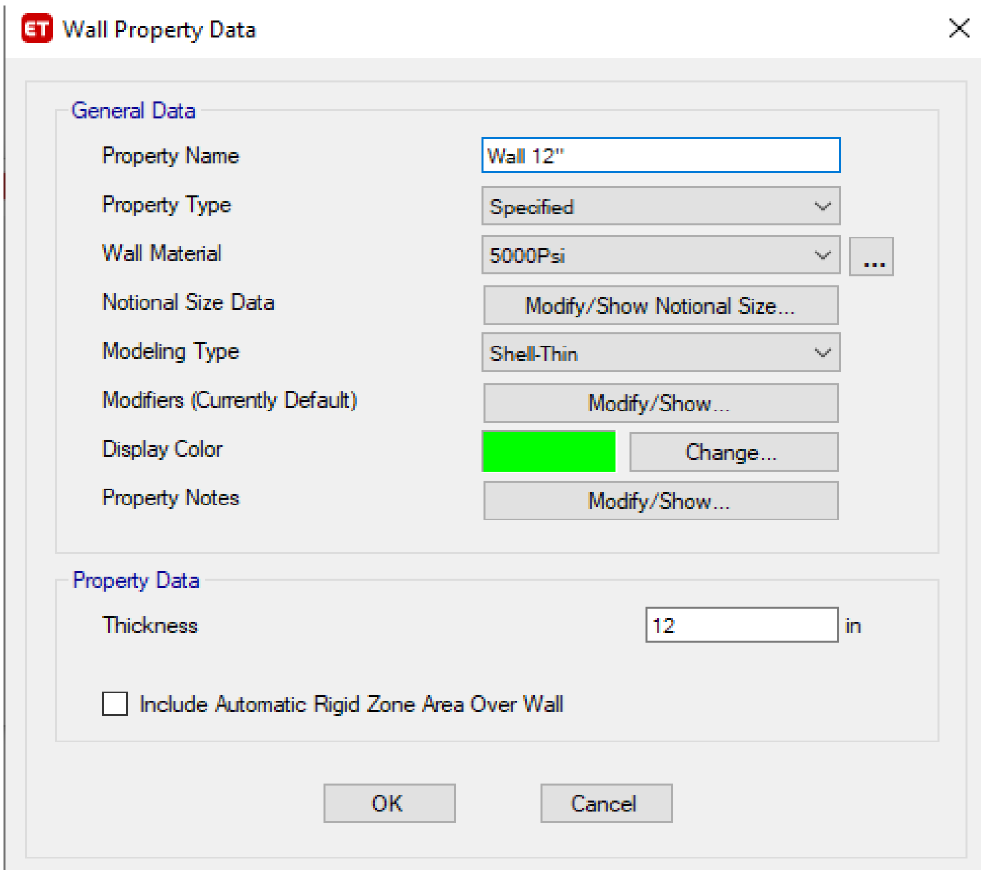


Fig 3.11 Shear Wall Property Data

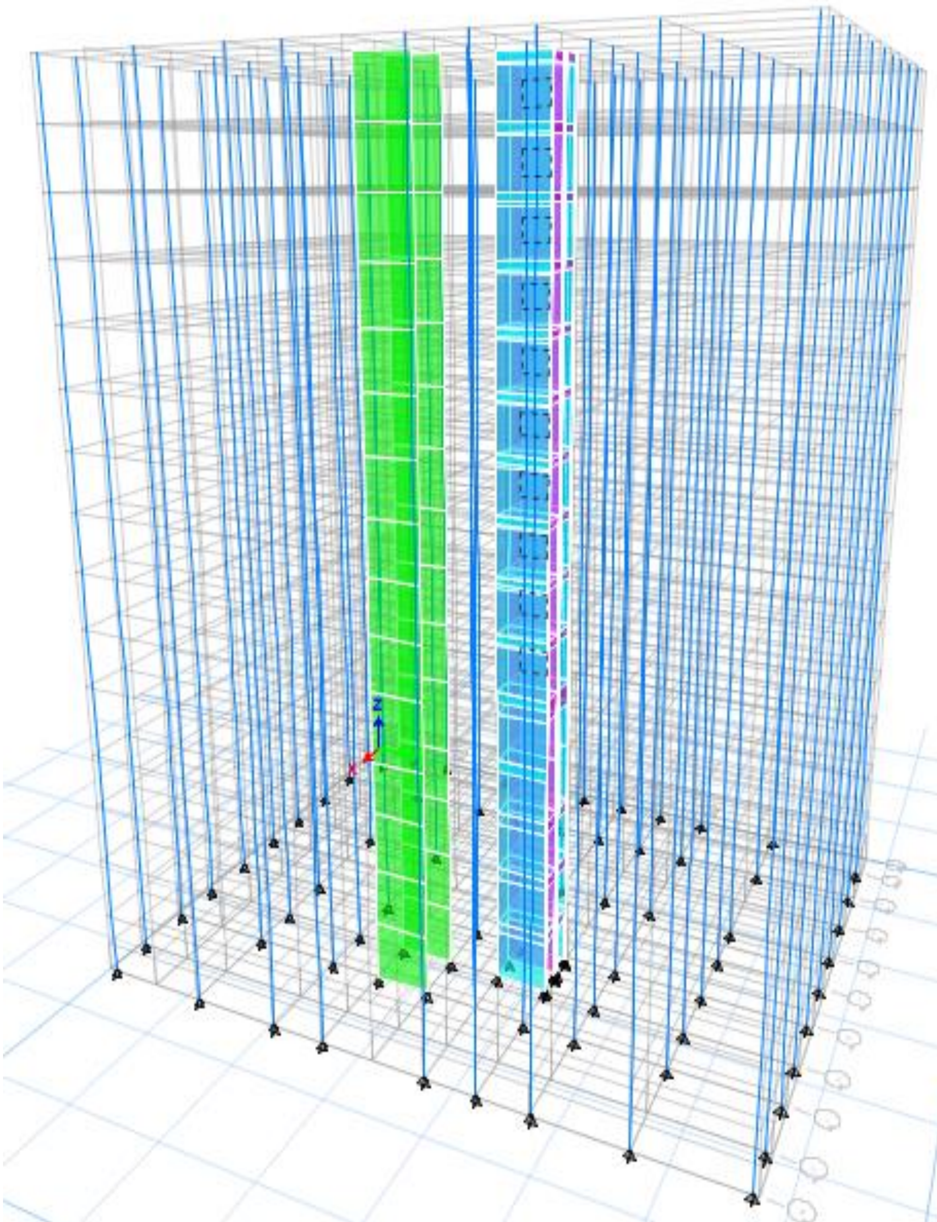


Fig: 3.12 3d view of 2 Different Section Shear Wall

Step7: Define and Assign Frame Element:

The ramp and stairs are then defined and assigned on stories where they are located in Architectural Plan.

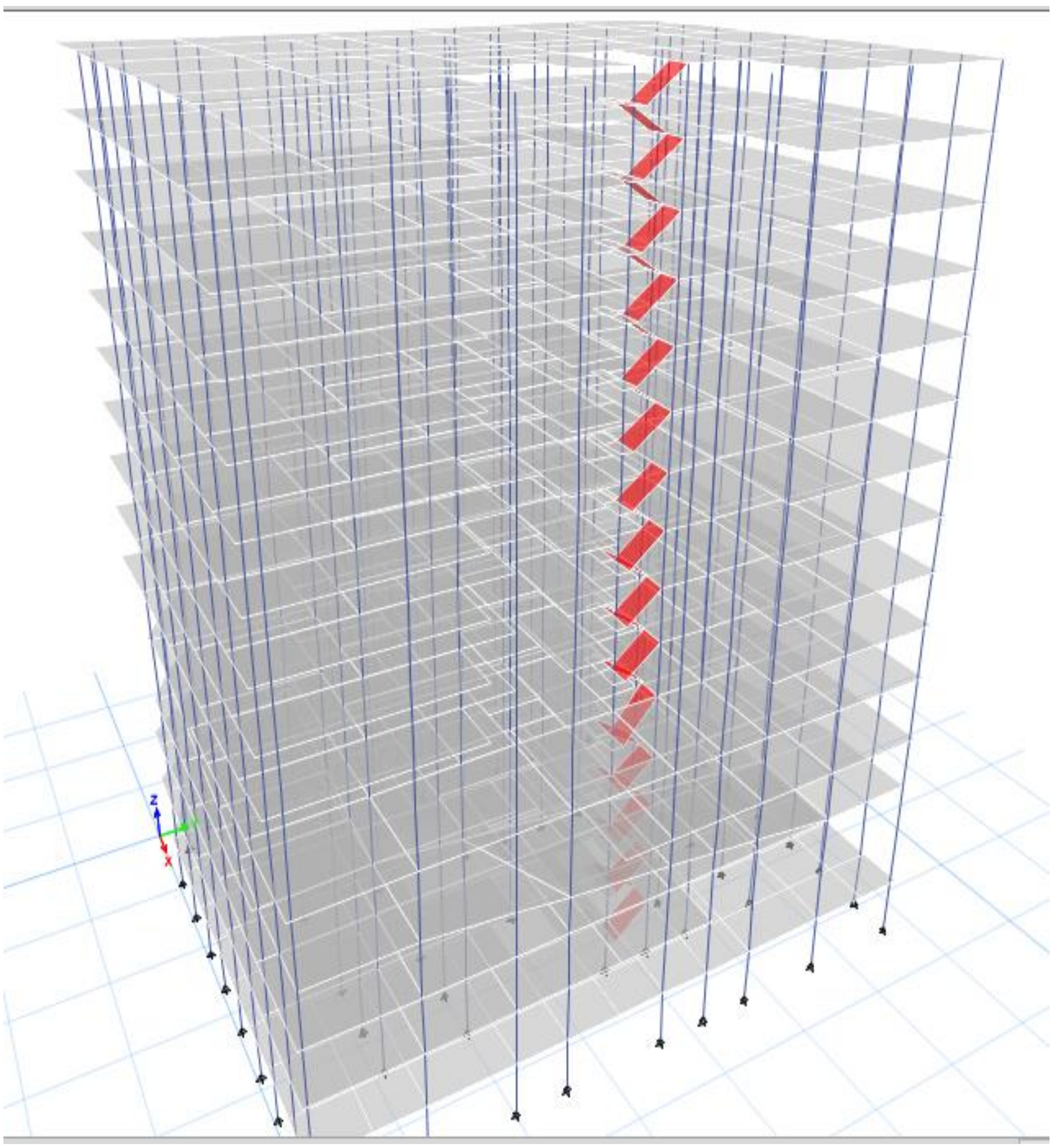


Fig: 3.13 3d view of Staircase

Step8: Define and Assign Slabs:

Use the Define Menu > Select Sections Properties > Slab Sections and then assign slabs i.e., 7’’ thick slab for the basement, while remaining floors have 6’’ thick slab.

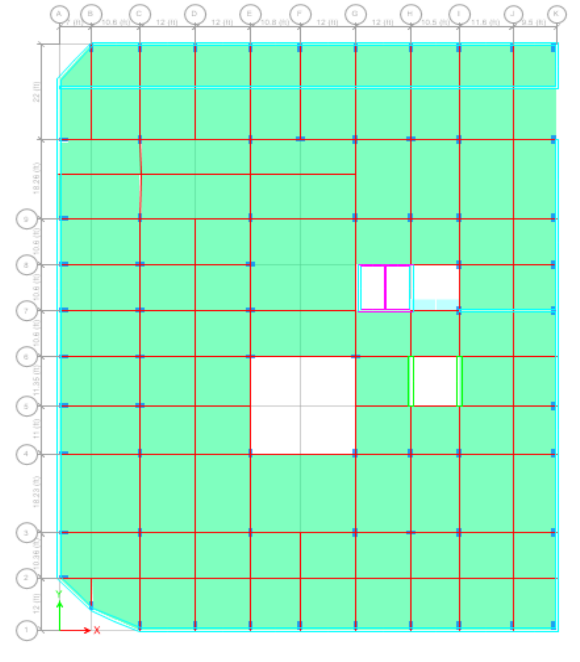


Fig:3.14 Slab Plan of Basement Floor

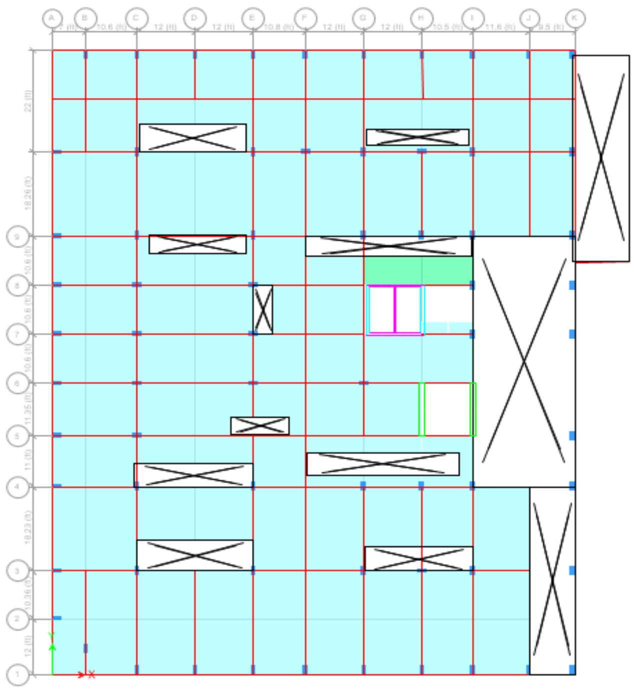


Fig: 3.15 Slab Plan of 5th Floor

Step9: Provision of Floating Column:

The location of floating column in this structure is basement as we have the number of shops is needed, and floating column take many spaces, so increase the economy of the structure it is preferred to provide floating column in the basement.

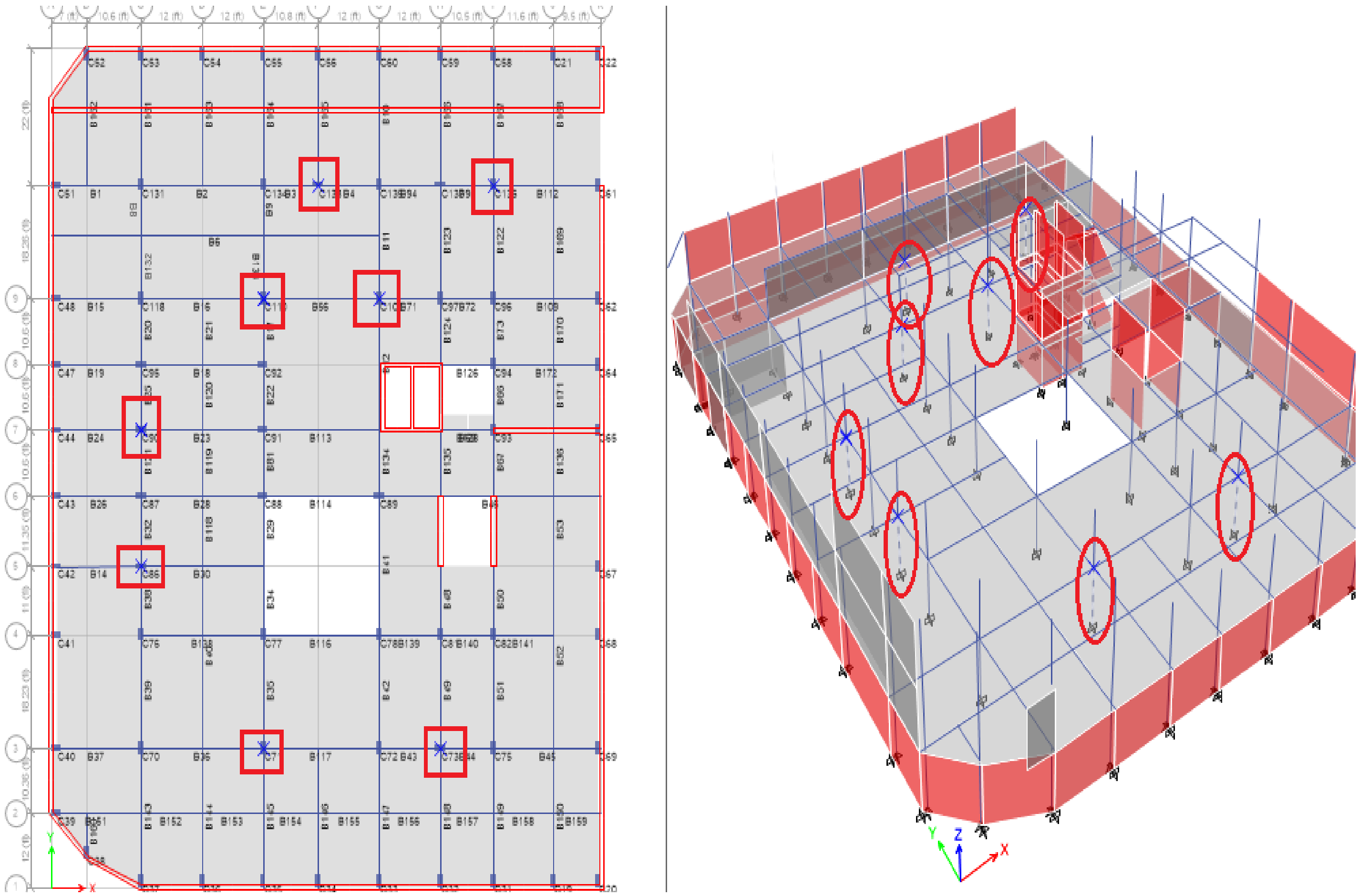


Fig:3.16 Location of Floating Column

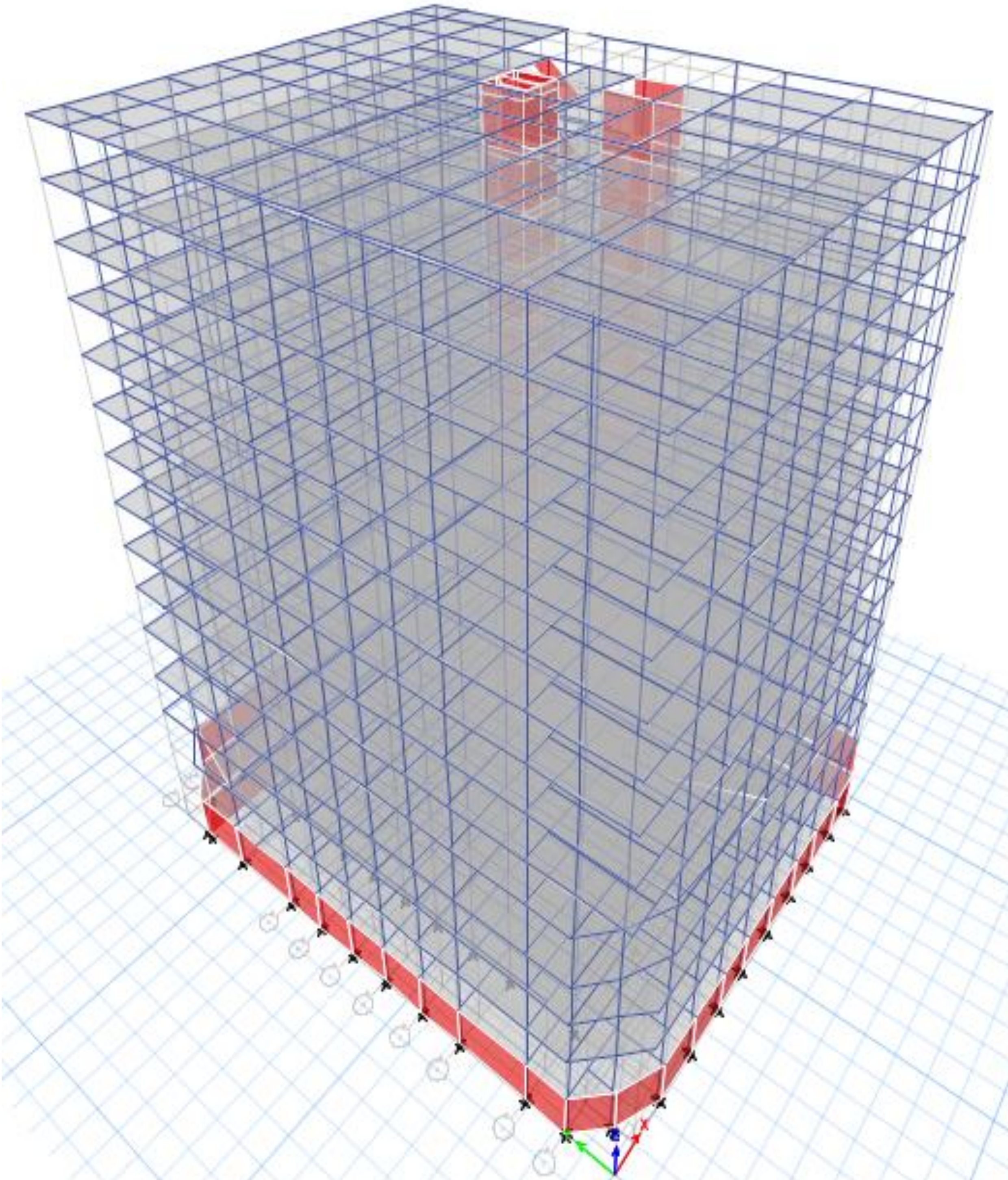


Fig:3.17 ETABS Model of the Building

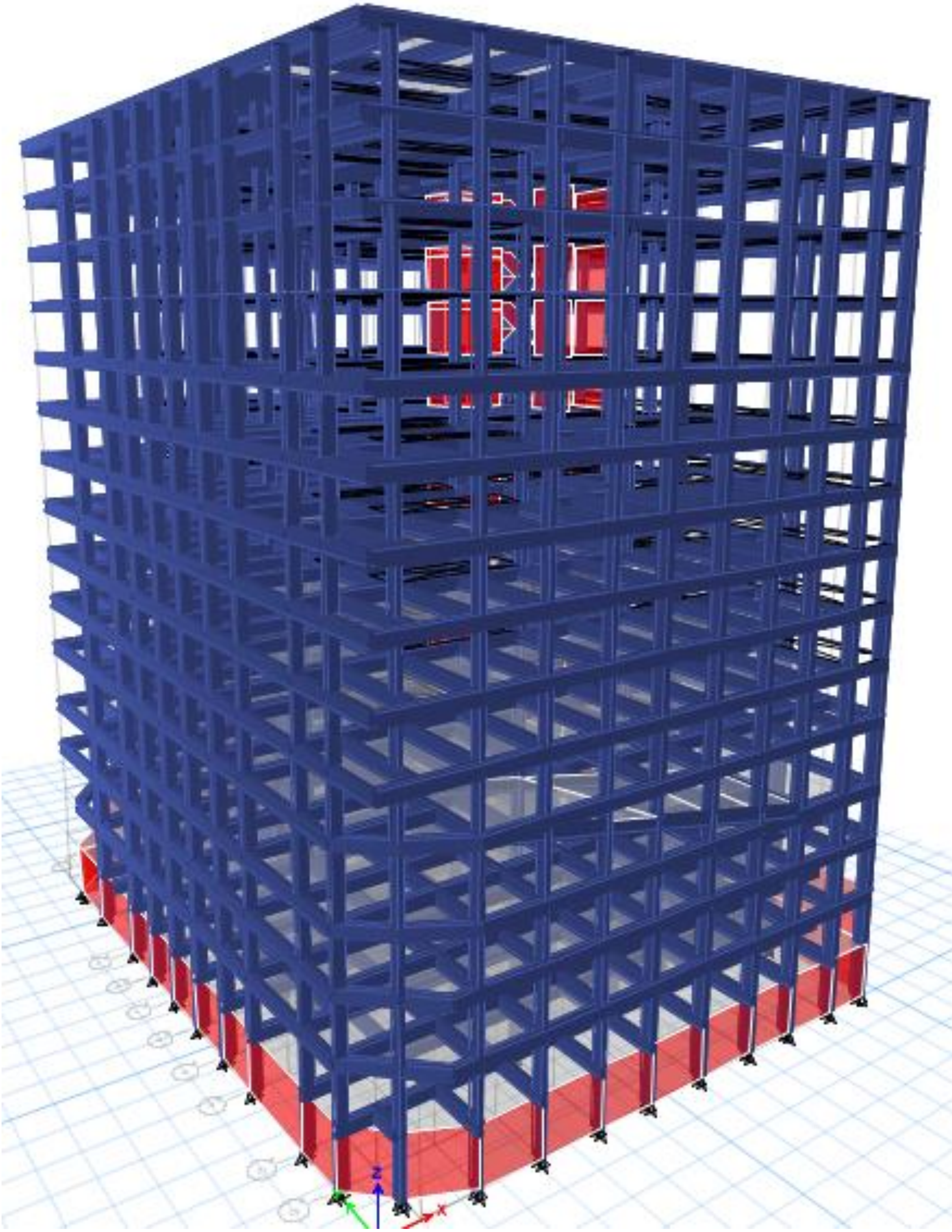


Fig: 3.18 Extruded view of Building

Step 10: Define and Assign Loads

Once the Building is being modeled, the next step is to define and assign the different structural loads. For the seismic analysis of building, the non-linear static analysis would be conducted. The loads will be defined that is Dead loads, Live loads, Wind loads, Earthquake loads by following the building codes.

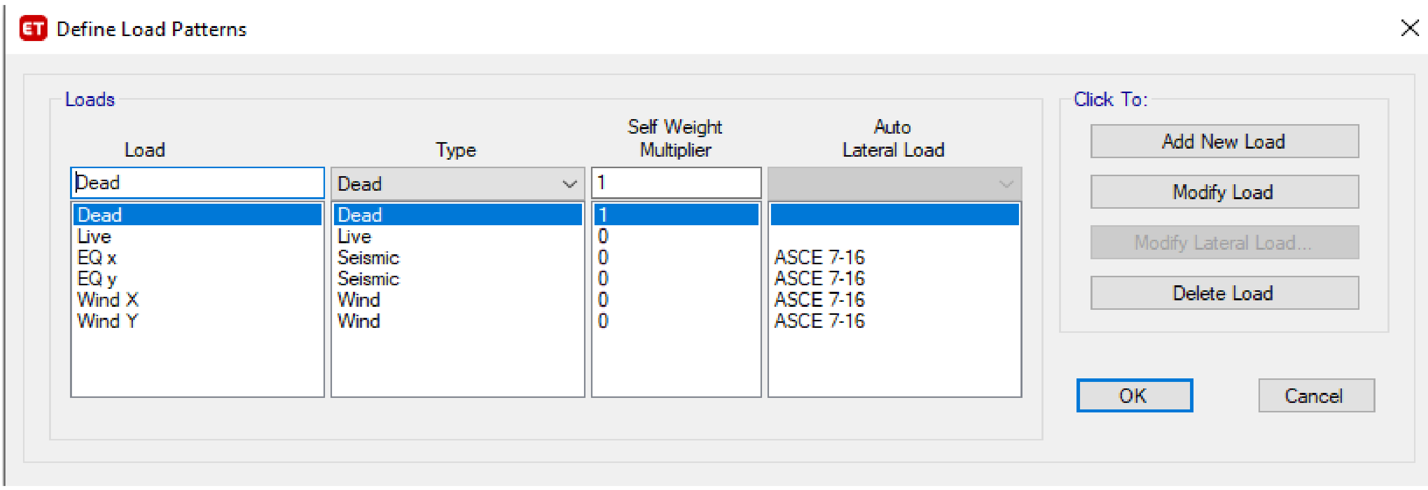


Fig:3.19 Define Load Pattern

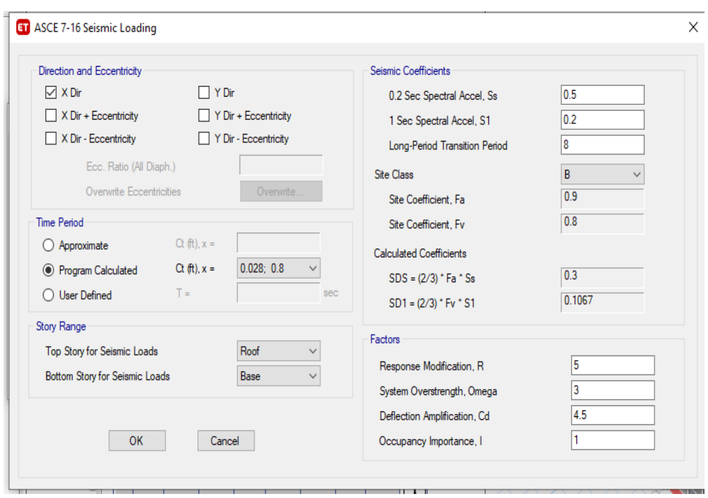


Fig:3.20 Seismic Loading

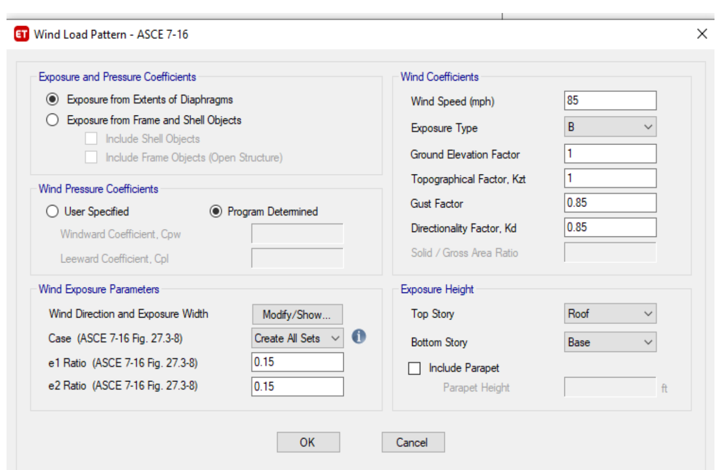


Fig:3.21 Wind Loading

We have assigned all the loads that the structure carries. Furthermore, the wind and the earthquake loads are modified in detail.

3.14 DEFINING WIND LOADS:

The wind load consists of different factors i.e., Wind speed, Exposure type, Importance Factor and Pressure Coefficient. These factors can be obtained from Building Code of Pakistan.

3.14.1 Wind Speed:

According to the Building code of Pakistan, for any building having a height of 33 ft or greater, the wind speed should not be less than 75 mph, The building selected for this research has a total height of 120 ft therefore we will use wind speed as 85 mph.

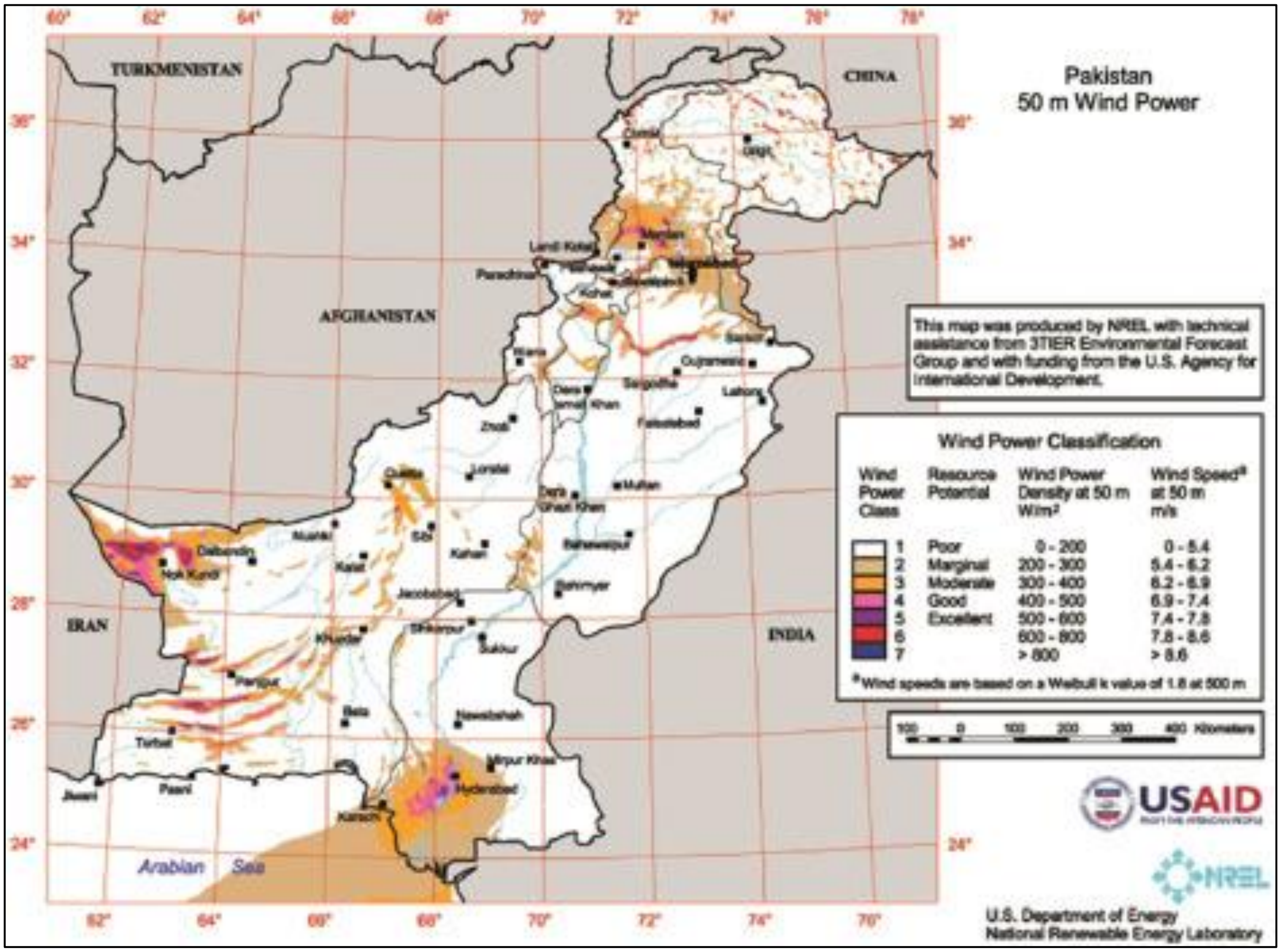


Fig:3.22 Wind Speed Map of Pakistan

3.14.2 Exposure Type:

There are generally 3 types of exposure use in ETABS, according to site and location where the building locates.

Exposure 'D' is the largest multiplier when converting wind velocity to wind pressure which represents coastal areas and the 'smoothness' of water relative to wind. Noncoastal areas have exposure categories B and C with greater roughness coefficients. For this project we choose the exposure type B because building located at densely populated area.

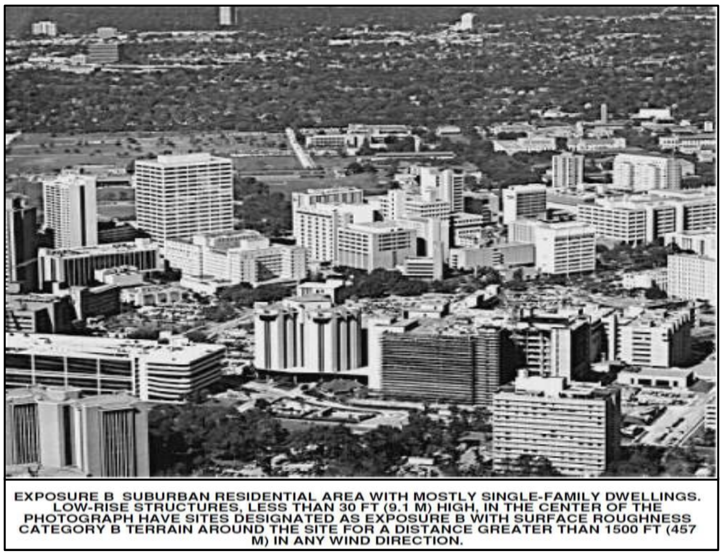


Fig:3.23 Example of Exposure B

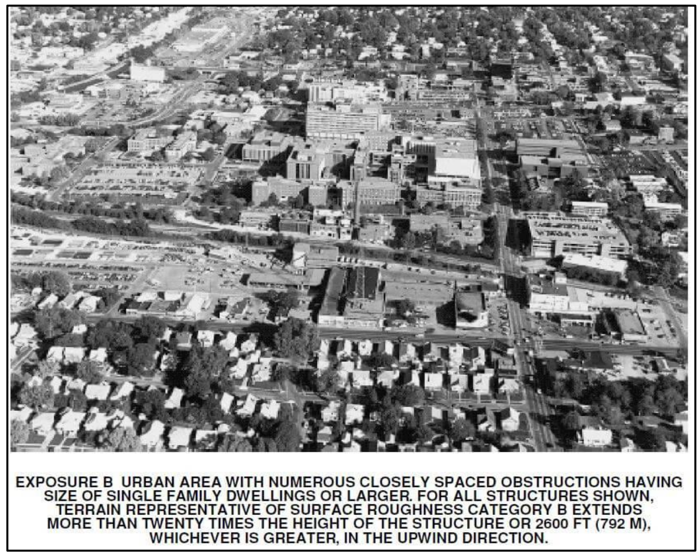


Fig:3.24 Example of Exposure B

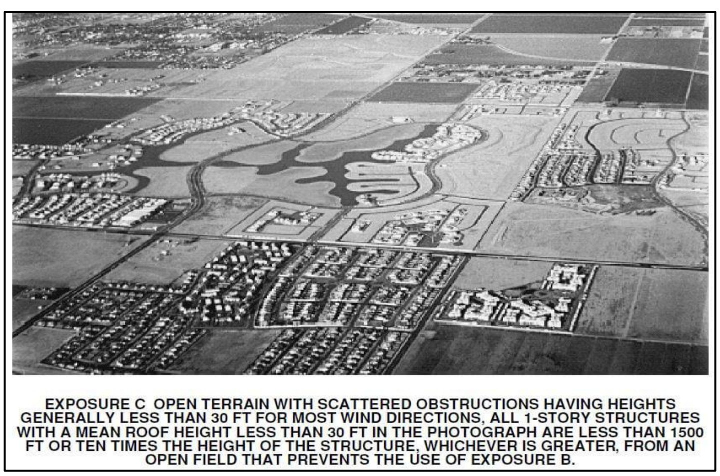


Fig:3.25 Example of Exposure C

Fig:3.26 Example of Exposure D

3.14.3 Ground Elevation Factor:

Table 26.9-1 Ground Elevation Factor, K_e

Ground Elevation above Sea Level ft	m	Ground Elevation Factor K_e
<0	<0	See note 2
0	0	1.00
1,000	305	0.96
2,000	610	0.93
3,000	914	0.90
4,000	1,219	0.86
5,000	1,524	0.83
6,000	1,829	0.80
>6,000	>1,829	See note 2

Notes

1. The conservative approximation $K_e = 1.00$ is permitted in all cases.
2. The factor K_e shall be determined from the above table using interpolation or from the following formula for all elevations:
   $K_e = e^{-0.0000362 z_g}$ (z_g = ground elevation above sea level in ft).
   $K_e = e^{-0.000119 z_g}$ (z_g = ground elevation above sea level in m).
3. K_e is permitted to be take as 1.00 in all cases.

Fig:3.27 Ground Elevation Factor

3.14.4 Topographical Factor:

26.8.2 Topographic Factor. The wind speed-up effect shall be included in the calculation of design wind loads by using the factor K_{zt}:

$$K_{zt} = (1 + K_1 K_2 K_3)^2 \qquad (26.8\text{-}1)$$

where K_1, K_2, and K_3 are given in Fig. 26.8-1.

If site conditions and locations of buildings and other structures do not meet all the conditions specified in Section 26.8.1, then $\boxed{K_{zt} = 1.0.}$

Fig:3.28 Topographic Factor

3.14.5 Gust Factor:

26.11 GUST EFFECTS

26.11.1 Gust-Effect Factor. The gust-effect factor for a rigid building or other structure is permitted to be taken as $\boxed{0.85}$.

Fig:3.29 Gust Factor

3.14.6 Directionality Factor:

factors were drawn by Jung and Masters (2013). The relation between wind speed averaging times for extratropical winds in any terrain exposure is given in Section 11.2.4.2 of Simiu (2011).

In using local data, it should be emphasized that sampling errors can lead to large uncertainties in specification of the wind speed. Sampling errors are the errors associated with the limited size of the climatological data samples (e.g., years of record of extreme speeds). It is possible to have a 20-mi/h (8.9-m/s) error in the estimated extreme wind speed at an individual station with a record length of 30 years. When short local records are used to estimate extreme wind speeds, care and conservatism should be exercised in their use.

If meteorological data are used to justify a wind speed lower than the basic wind speed from Figs. 26.5-1 and 26.5-2, an analysis of sampling error is required. This can be accomplished by showing that the difference between the estimated speed and the basic wind speed from Figs. 26.5-1 and 26.5-2 is at least two to three times the standard deviation of the sampling error (Simiu and Scanlan 1996).

C26.6 WIND DIRECTIONALITY

The wind load factor 1.3 in ASCE 7-95 included a "wind directionality factor" with a nominal value of 0.85 (Ellingwood 1981; Ellingwood et al. 1982). This factor accounts for two effects: (1) The reduced probability of maximum winds coming from any given direction, and (2) the reduced probability of the maximum pressure coefficient occurring for any given wind direction. The nominal wind directionality factor (denoted by K_d in the standard) is tabulated in Table 26.6-1 for different structure types. As new research becomes available, this factor can be directly modified. Nominal values for the factor were established from references in the literature and collective committee judgment. A value of $\boxed{0.85}$ might be more appropriate if a triangular trussed frame is shrouded in a round cover. A value of 0.95 might be more appropriate for a round structure that has a nonaxisymmetrical lateral load resistance system.

C26.7 EXPOSURE

The descriptions of the surface roughness categories and exposure categories in Section 26.7 have been expressed as far as possible in easily understood verbal terms that are sufficiently precise for most practical applications. Upwind surface roughness conditions required for Exposures B and D are shown schematically in Figs. C26.7-1 and C26.7-2, respectively. Aerial photographs showing examples of Exposures B, C, and D are shown in Figs. C26.7-5 through C26.7-7. For cases where the designer wishes to make a more detailed assessment of the surface roughness category and exposure category, the following more-mathematical description is offered for guidance (Irwin 2006). The ground surface roughness is best measured in terms of a roughness length parameter called z_0. Each of the surface roughness categories B through D corresponds to a range of values of this parameter, as does the even-rougher category A used in older versions of the standard in heavily built-up urban areas but removed

Fig:3.30 Wind Direction Coefficient

3.14.7 Wind Direction Angle:

- For wind in x axis, the angle is set as 0 degree.
- For wind in y axis, the angle is set as 90 degrees.

3.14.8 Pressure Coefficient Cq:

Structure or Part Thereof	Description	C_q Factor
1. Primary frames and systems	**Method 1** (Normal force method)	
	Walls:	
	Windward wall	0.8 inward
	Leeward wall	0.5 outward
	Roofs[1]:	
	Wind perpendicular to ridge	
	Leeward roof or flat roof	0.7 outward
	Windward roof	
	Less than 2:12 (16.7%)	0.7 outward
	Slope 2:12 (16.7%) to less than 9:12 (75%)	0.9 outward or 0.3 inward
	Slope 9:12 (75%) to 12:12 (100%)	0.4 inward
	Slope > 12:12 (100%)	0.7 inward
	Wind parallel to ridge and flat roofs	0.7 outward
	Method 2 (Projected area method)	
	On vertical projected area	
	Structures 12 192 mm (40 feet) or less in height	1.3 horizontal any direction
	Structures over 12 192 mm (40 feet) in height	1.4 horizontal any direction
	On horizontal projected area[1]	0.7 upward
2. Elements and components not in areas of discontinuity[2]	Wall elements	
	All structures	1.2 inward
	Enclosed and unenclosed structures	1.2 outward
	Partially enclosed structures	1.6 outward
	Parapets walls	1.3 inward or outward
	Roof elements[3]	
	Enclosed and unenclosed structures	
	Slope < 7:12 (58.3%)	1.3 outward
	Slope 7:12 (58.3%) to 12:12 (100%)	1.3 outward or inward
	Partially enclosed structures	
	Slope < 2:12 (16.7%)	1.7 outward
	Slope 2:12 (16.7%) to 7:12 (58.3%)	1.6 outward or 0.8 inward
	Slope > 7:12 (58.3%) to 12:12 (100%)	1.7 outward or inward
3. Elements and components in areas of discontinuities[2,4,5]	Wall corners[6]	1.5 outward or 1.2 inward
	Roof eaves, rakes or ridges without overhangs[6]	
	Slope < 2:12 (16.7%)	2.3 upward
	Slope 2:12 (16.7%) to 7:12 (58.3%)	2.6 outward
	Slope > 7:12 (58.3%) to 12:12 (100%)	1.6 outward
	For slopes less than 2:12 (16.7%)	
	Overhangs at roof eaves, rakes or ridges, and canopies	0.5 added to values above
4. Chimneys, tanks and solid towers	Square or rectangular	1.4 any direction
	Hexagonal or octagonal	1.1 any direction
	Round or elliptical	0.8 any direction
5. Open-frame towers[7,8]	Square and rectangular	
	Diagonal	4.0
	Normal	3.6
	Triangular	3.2
6. Tower accessories (such as ladders, conduit, lights and elevators)	Cylindrical members	
	51 mm (2 inches) or less in diameter	1.0
	Over 51 mm (2 inches) in diameter	0.8
	Flat or angular members	1.3
7. Signs, flagpoles, light poles, minor structures[8]		1.4 any direction

Fig:3.31 Pressure Coefficient

3.14.9 Wind Load on Structure:

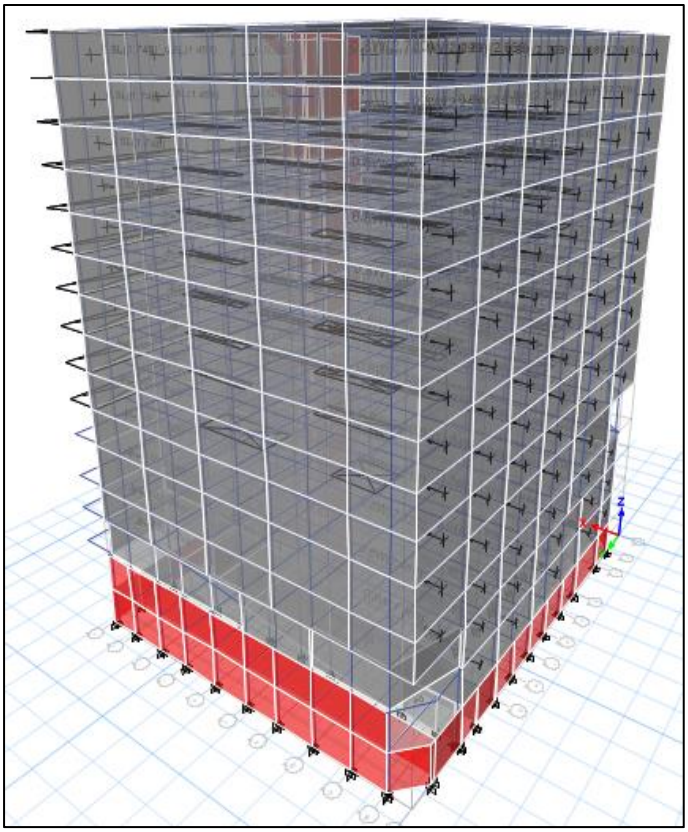


Fig:3.32 Wind Pressure at Windward wall

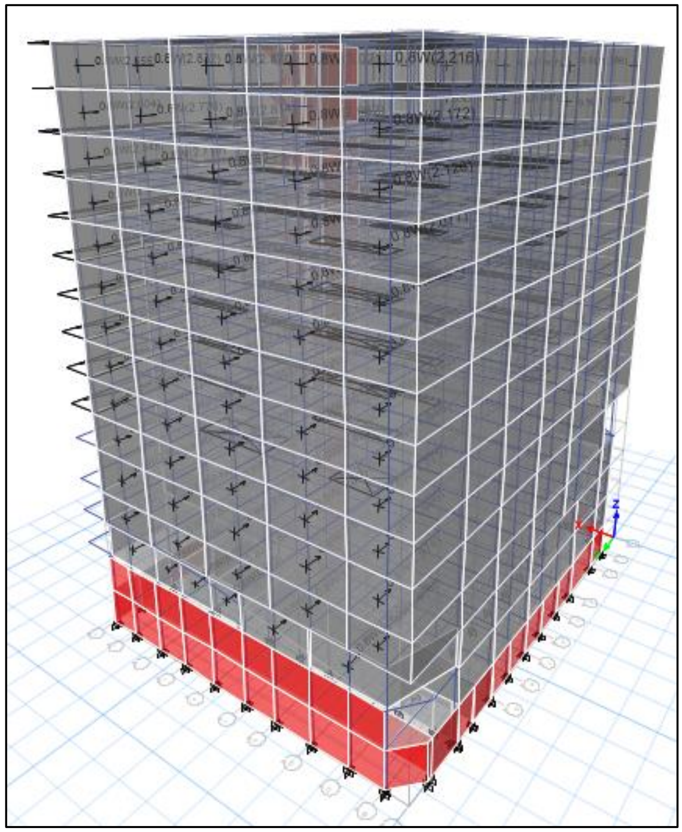


Fig:3.33 Wind Pressure at Leeward wall

3.15 DEFINING SEISMIC LOADS:

There are several factors on which the seismic load depends those are given below.

3.15.1 Seismic Zone:

Zone	1	2A	2B	3	4
Z	0.075	0.15	0.20	0.30	0.40

Fig:3.34 Seismic Zone

3.15.2 Site Class:

The building located at site on which generally rocky material are present, that's why we select the site class "B".

Find site coefficient F_a and F_v for site class B and Spectral response reduction factor for short period and 1 sec period, S_s=0.5 and S_1= 0.2

Table 11.4-1 Short-Period Site Coefficient, F_a

Site Class	Mapped Risk-Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameter at Short Period					
	$S_S \leq 0.25$	$S_S = 0.5$	$S_S = 0.75$	$S_S = 1.0$	$S_S = 1.25$	$S_S \geq 1.5$
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.9	0.9	0.9	0.9	0.9	0.9
C	1.3	1.3	1.2	1.2	1.2	1.2
D	1.6	1.4	1.2	1.1	1.0	1.0
E	2.4	1.7	1.3	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8
F	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8

Note: Use straight-line interpolation for intermediate values of S_s.

Fig:3.35 Site Coefficient F_a

Table 11.4-2 Long-Period Site Coefficient, F_v

Site Class	Mapped Risk-Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameter at 1-s Period					
	$S_1 \leq 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 = 0.5$	$S_1 \geq 0.6$
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.8	0.8	0.8	0.8	0.8	0.8
C	1.5	1.5	1.5	1.5	1.5	1.4
D	2.4	2.2^a	2.0^a	1.9^a	1.8^a	1.7^a
E	4.2	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8
F	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8

Note: Use straight-line interpolation for intermediate values of S_1.
[a]Also, see requirements for site-specific ground motions in Section 11.4.8.

Fig:3.36 Site Coefficient F_v

3.15.3 Response Modification Factor:

18. Ordinary reinforced masonry shear walls	14.4	2	2½	2	NL	160	NP	NP	NP
19. Detailed plain masonry shear walls	14.4	2	2½	2	NL	NP	NP	NP	NP
20. Ordinary plain masonry shear walls	14.4	1½	2½	1¼	NL	NP	NP	NP	NP
21. Prestressed masonry shear walls	14.4	1½	2½	1¾	NL	NP	NP	NP	NP
22. Light-frame (wood) walls sheathed with wood structural panels rated for shear resistance	14.5	7	2½	4½	NL	NL	65	65	65
23. Light-frame (cold-formed steel) walls sheathed with wood structural panels rated for shear resistance or steel sheets	14.1	7	2½	4½	NL	NL	65	65	65
24. Light-frame walls with shear panels of all other materials	14.1 and 14.5	2½	2½	2½	NL	NL	35	NP	NP
25. Steel buckling-restrained braced frames	14.1	8	2½	5	NL	NL	160	160	100
26. Steel special plate shear walls	14.1	7	2	6	NL	NL	160	160	100
C. MOMENT-RESISTING FRAME SYSTEMS									
1. Steel special moment frames	14.1 and 12.2.5.5	8	3	5½	NL	NL	NL	NL	NL
2. Steel special truss moment frames	14.1	7	3	5½	NL	NL	160	100	NP
3. Steel intermediate moment frames	12.2.5.7 and 14.1	4½	3	4	NL	NL	35[d]	NP[d]	NP[d]
4. Steel ordinary moment frames	12.2.5.6 and 14.1	3½	3	3	NL	NL	NP[e]	NP[e]	NP[e]
5. Special reinforced concrete moment frames[m]	12.2.5.5 and 14.2	8	3	5½	NL	NL	NL	NL	NL
6. Intermediate reinforced concrete moment frames	14.2	5	3	4½	NL	NL	NP	NP	NP
7. Ordinary reinforced concrete moment frames	14.2	3	3	2½	NL	NP	NP	NP	NP
8. Steel and concrete composite special moment frames	12.2.5.5 and 14.3	8	3	5½	NL	NL	NL	NL	NL
9. Steel and concrete composite intermediate moment frames	14.3	5	3	4½	NL	NL	NP	NP	NP
10. Steel and concrete composite partially restrained moment frames	14.3	6	3	5½	160	160	100	NP	NP
11. Steel and concrete composite ordinary moment frames	14.3	3	3	2½	NL	NP	NP	NP	NP
12. Cold-formed steel—special bolted moment frame[n]	14.1	3½	3[o]	3½	35	35	35	35	35
D. DUAL SYSTEMS WITH SPECIAL MOMENT FRAMES CAPABLE OF RESISTING AT LEAST 25% OF PRESCRIBED SEISMIC FORCES	12.2.5.1								
1. Steel eccentrically braced frames	14.1	8	2½	4	NL	NL	NL	NL	NL
2. Steel special concentrically braced frames	14.1	7	2½	5½	NL	NL	NL	NL	NL
3. Special reinforced concrete shear walls[g,h]	14.2	7	2½	5½	NL	NL	NL	NL	NL
4. Ordinary reinforced concrete shear walls[g]	14.2	6	2½	5	NL	NL	NP	NP	NP
5. Steel and concrete composite eccentrically braced frames	14.3	8	2½	4	NL	NL	NL	NL	NL
6. Steel and concrete composite special concentrically braced frames	14.3	6	2½	5	NL	NL	NL	NL	NL
7. Steel and concrete composite plate shear walls	14.3	7½	2½	6	NL	NL	NL	NL	NL
8. Steel and concrete composite special shear walls	14.3	7	2½	6	NL	NL	NL	NL	NL
9. Steel and concrete composite ordinary shear walls	14.3	6	2½	5	NL	NL	NP	NP	NP
10. Special reinforced masonry shear walls	14.4	5½	3	5	NL	NL	NL	NL	NL
11. Intermediate reinforced masonry shear walls	14.4	4	3	3½	NL	NL	NP	NP	NP
12. Steel buckling-restrained braced frames	14.1	8	2½	5	NL	NL	NL	NL	NL
13. Steel special plate shear walls	14.1	8	2½	6½	NL	NL	NL	NL	NL
E. DUAL SYSTEMS WITH INTERMEDIATE MOMENT FRAMES CAPABLE OF RESISTING AT LEAST 25% OF PRESCRIBED SEISMIC FORCES	12.2.5.1								
1. Steel special concentrically braced frames[f]	14.1	6	2½	5	NL	NL	35	NP	NP
2. Special reinforced concrete shear walls[g,h]	14.2	6½	2½	5	NL	NL	160	100	100
3. Ordinary reinforced masonry shear walls	14.4	3	3	2½	NL	160	NP	NP	NP
4. Intermediate reinforced masonry shear walls	14.4	3½	3	3	NL	NL	NP	NP	NP

Fig:3.37 Response Modification factor and Deflection

3.15.4 Seismic Loading:

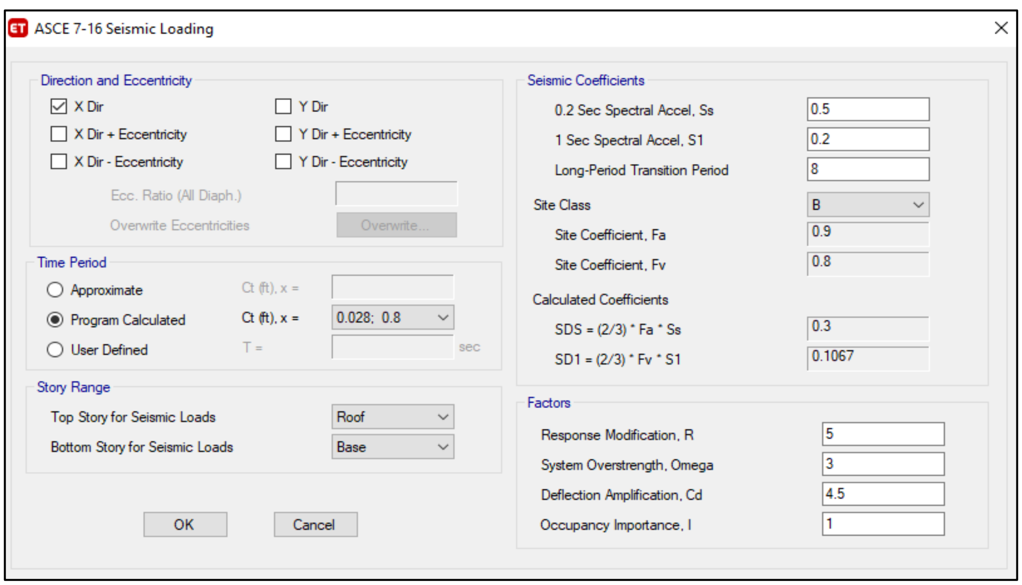


Fig:3.38 Seismic loading dependences factor

3.16 ASSIGNING LOADS

The software has the advantage that it will assign all the dead, live, wind and earthquakes load automatically. Furthermore, the live load is assigned i.e., for any residential building its selected as 50psf and for the shopping mall it's selected as 100psf. In this case, the building is a commercial as well as residential building, therefore the live load is selected as 60psf.

3.16.1 Superimposed Dead Load:

The self-weight of the building is calculated and added in dead load by itself in ETABS, but for superimposed load we refer code book and apply accordingly the superimposed dead load like finishes on the floor, refer ASCE 7-16. The cement finish of 25mm has dead load of 1.53 kN/m^2, and 1.53/0.047 = 32.55 ≈ 33 lb/ft^2.

Table C3.1-1b Minimum Design Dead Loads (kN/m²)[a]

Component	Load (kN/m²)
CEILINGS	
Acoustical fiberboard	0.05
Gypsum board (per mm thickness)	0.008
Mechanical duct allowance	0.19
Plaster on tile or concrete	0.24
Plaster on wood lath	0.38
Suspended steel channel system	0.10
Suspended metal lath and cement plaster	0.72
Suspended metal lath and gypsum plaster	0.48
Wood furring suspension system	0.12
COVERINGS, ROOF, AND WALL	
Asbestos-cement shingles	0.19
Asphalt shingles	0.10
Cement tile	0.77
Clay tile (for mortar add 0.48 kN/m²)	
Book tile, 51 mm	0.57
Book tile, 76 mm	0.96
Ludowici	0.48
Roman	0.57
Spanish	0.91
Composition:	
Three-ply ready roofing	0.05
Four-ply felt and gravel	0.26
Five-ply felt and gravel	0.29
Copper or tin	0.05
Corrugated asbestos-cement roofing	0.19
Deck, metal, 20 gauge	0.12
Deck, metal, 18 gauge	0.14
Decking, 51-mm wood (Douglas fir)	0.24
Decking, 76-mm wood (Douglas fir)	0.38
Fiberboard, 13 mm	0.04
Gypsum sheathing, 13 mm	0.10
Insulation, roof boards (per mm thickness)	
Cellular glass	0.0013
Fibrous glass	0.0021
Fiberboard	0.0028
Perlite	0.0015
Polystyrene foam	0.0004
Urethane foam with skin	0.0009
Plywood (per mm thickness)	0.006
Rigid insulation, 13 mm	0.04
Skylight, metal frame, 10-mm wire glass	0.38
Slate, 5 mm	0.34
Slate, 6 mm	0.48
Waterproofing membranes:	
Bituminous, gravel-covered	0.26
Bituminous, smooth surface	0.07
Liquid applied	0.05
Single-ply, sheet	0.03
Wood sheathing (per mm thickness)	
Plywood	0.0057
Oriented strand board	0.0062
Wood shingles	0.14
FLOOR FILL	
Cinder concrete, per mm	0.017
Lightweight concrete, per mm	0.015
Sand, per mm	0.015
Stone concrete, per mm	0.023
FLOORS AND FLOOR FINISHES	
Asphalt block (51 mm), 13-mm mortar	1.44
Cement finish (25 mm) on stone-concrete fill	1.53
Ceramic or quarry tile (19 mm) on 13-mm mortar bed	0.77
Ceramic or quarry tile (19 mm) on 25-mm mortar bed	1.10

Fig:3.39 Floor Finish

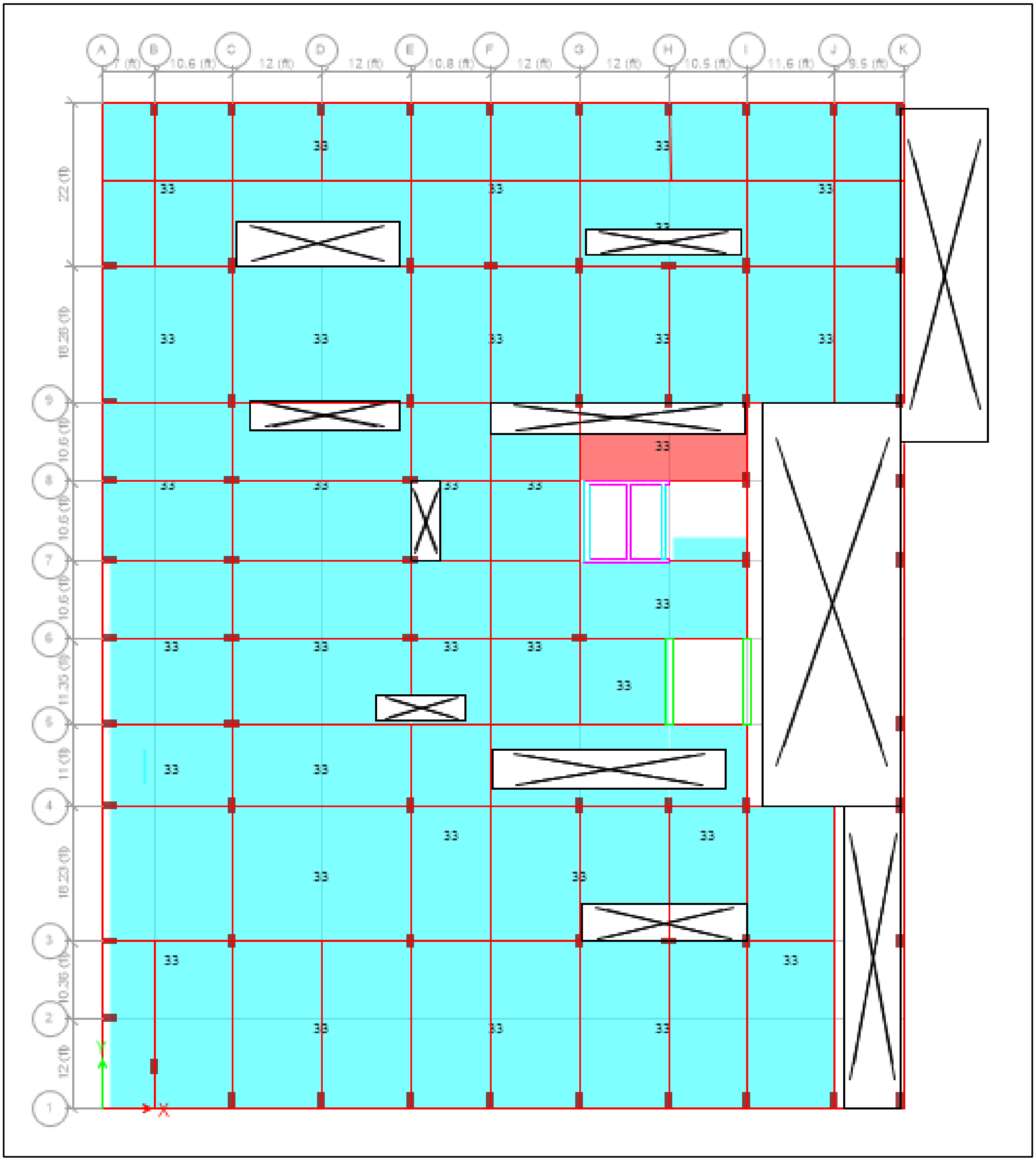


Fig:3.40 Superimposed Dead Load on Structure

3.16.2 Staircase Dead Load:

CALCULATION OF STEPS LOAD ON INCLINED SLAB					
First Flight			Second Flight		
Rise (*ft*)	0.5		Rise (*ft*)	0.83
Tread (*ft*)	0.75		Tread (*ft*)	0.75
Width of staircase (*ft*)	2.6		Width of staircase (*ft*)	2.6
Steps Area (Triangle) ($\boldsymbol{ft^2}$)	0.1875		Steps Area (Triangle) ft^2)	0.31125
Volume ($\boldsymbol{ft^3}$)	0.4875		Volume (ft^3)	0.80925
Density of Brick (lb/$\boldsymbol{ft^3}$)	120		Density of Brick (lb/ft^3)	120
Total No: steps	12		Total No: steps	7
Total load on steps (lbs)	702		Total load on steps (lbs)	679.77
Area of inclined slab (From ETABS) ($\boldsymbol{ft^2}$)	52.92		Area of inclined slab (From ETABS) (ft^2)	22.45
Load on Inclined Slab (lb/$\boldsymbol{ft^2}$)	13.26531		Load on Inclined Slab (lb/ft^2)	30.27929

Table 3.7: Calculation of Dead Load on Staircase

3.16.3 Live Load:

The live load act on the building as per ASCE 7-16 is 40psf for normal building, but our building is with balconies, which cause increases the live load value and we use the 60psf.

Table 5.1 – Uniform and Concentrated Loads

Use Or Occupancy		Uniform Load[1]		Concentrated Load	
Category	Description	kN/m²	psf	kN	lbs
1. Access floor system	Office use	2.4	50	9.0	2,002[2]
	Computer use	4.8	100	9.0	2,000[2]
2. Armories		7.2	150	0	0
3. Assembly areas[3] and auditoriums and balconies therewith	Fixed seating areas	2.4	50	0	0
	Movable seating and other areas	4.8	100	0	0
	Stage areas and enclosed platforms	6.0	125	0	0
4. Cornices and marquees		2.9	60[4]	0	0
5. Exit facilities[5]		4.8	100	0	0[6]
6. Garages	General storage and/or repair	4.8	100		[7]
	Private or pleasure-type motor vehicle storage	2.4	50		[7]
7. Hospitals	Wards and rooms	1.9	40	4.5	1,000[2]
8. Libraries	Reading rooms	2.9	60	4.5	1,000[2]
	Stack room	6.0	125	6.7	1,500[2]
9. Manufacturing	Light	3.6	75	9.0	2,000[2]
	Heavy	6.0	125	13.5	3,000[2]
10. Offices		2.4	50	9.0	2,000[2]
11. Printing plants	Press rooms	7.2	150	11.2	2,500[2]
	Composing and linotype rooms	4.8	100	9.0	2,000[2]
12. Residential[8]	Basic floor area	1.9	40	0	0[6]
	Exterior balconies	2.9	60[4]	0	0
	Decks	1.9	40[4]	0	0
	Storage	1.9	40	0	0
13. Restrooms[9]					
14. Reviewing stands, grandstands, bleachers, and folding and		4.8	100	0	0

Fig:3.41 Live load for different structure

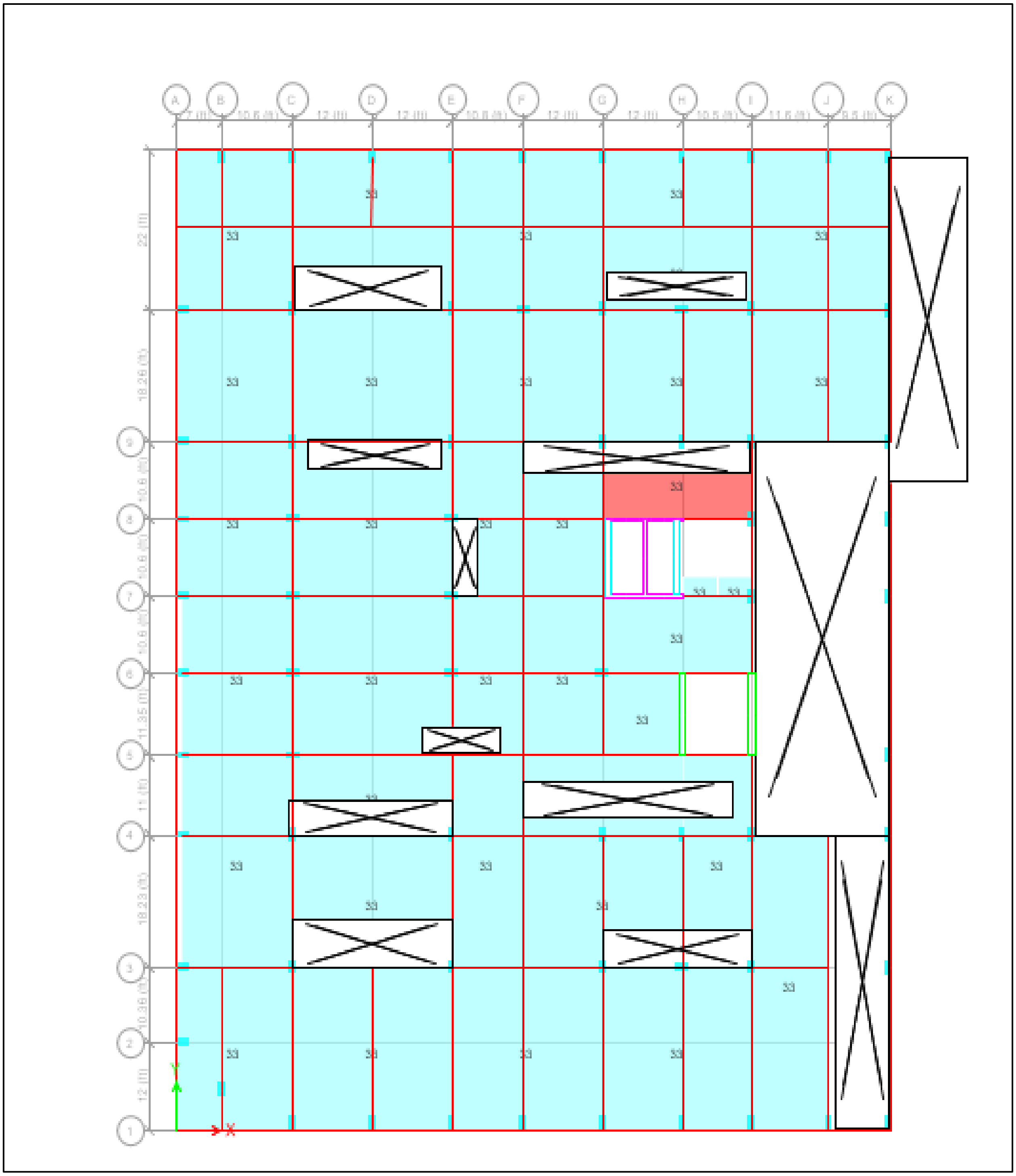


Fig:3.42 Live Load on Structure

3.16.4 Wall Load:

The wall load on the structure is calculated separately for interior wall and exterior wall, because the exterior wall is thicker than the interior wall.

Exterior wall load = 10.5ft x 0.75ft x 0.145 kips/ft^3 = 1.142 kips/ft

Height of Wall | Thickness of Wall | PCC Wall Density

Interior wall load = 10.5ft x 0.6ft x 0.145 kips/ft^3 = 0.913 kips/ft

Height of Wall | Thickness of Wall | PCC Wall Density

As the wall load act on the beams so, select all the outer beams of the structure and applied exterior wall load which is 1.142 kips/ft and for all interior beam applied interior wall load which is 0.913 kips/ft.

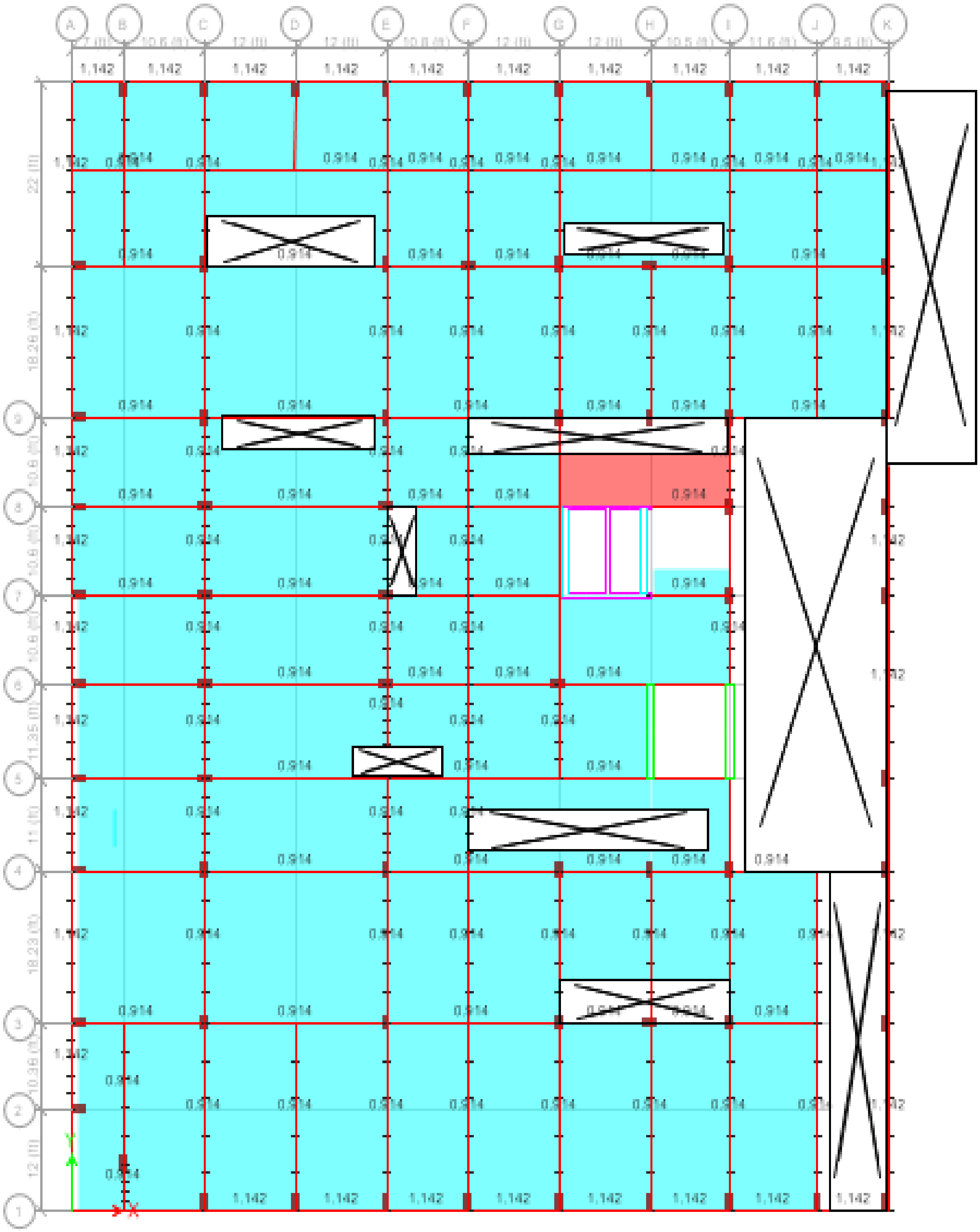


Fig:3.43 Wall Load on Structure

After assigning the loads, one can check the applied load by selecting any slab and then right click to check.

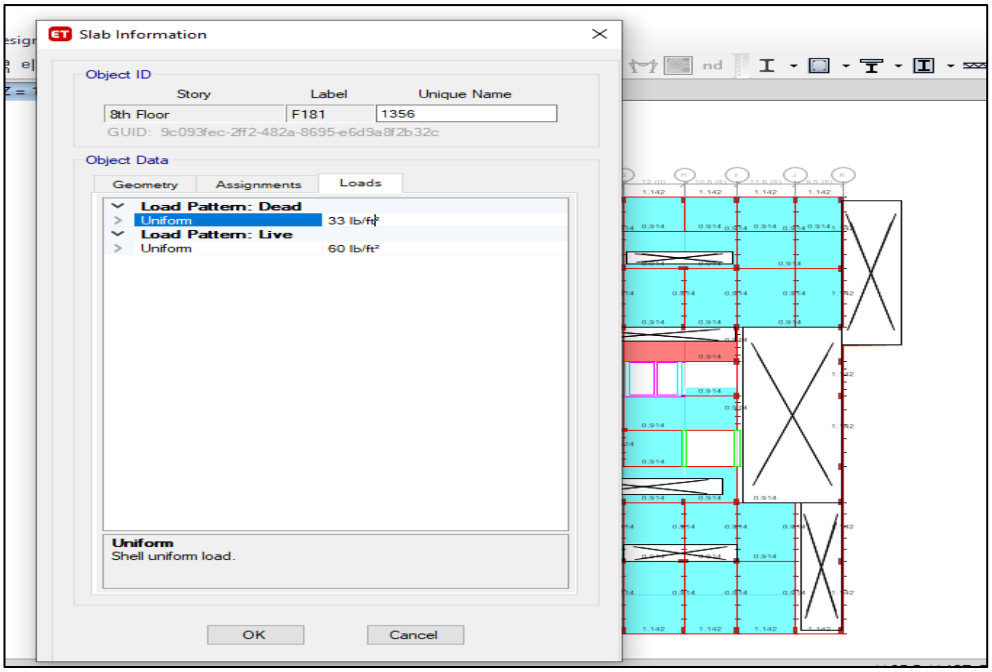


Fig:3.44 Check for Applied Loads

3.17 MASS SOURCE:

The Mass source is essential term while calculating the base shear, according to the ASCE 7-16 Sec- 12.7.2 we take the live load as 25%.

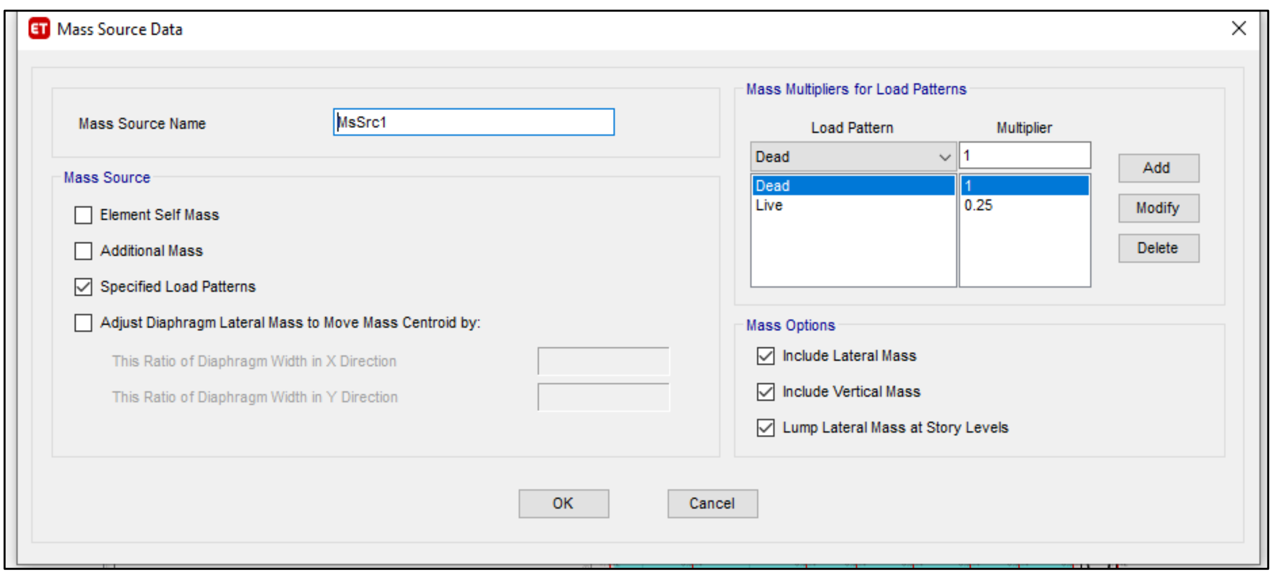


Fig:3.45 Mass Source

3.18 DIAPHRAGM:

For our building we select the rigid diaphragm because span to depth ratio for our structure is less than 2.

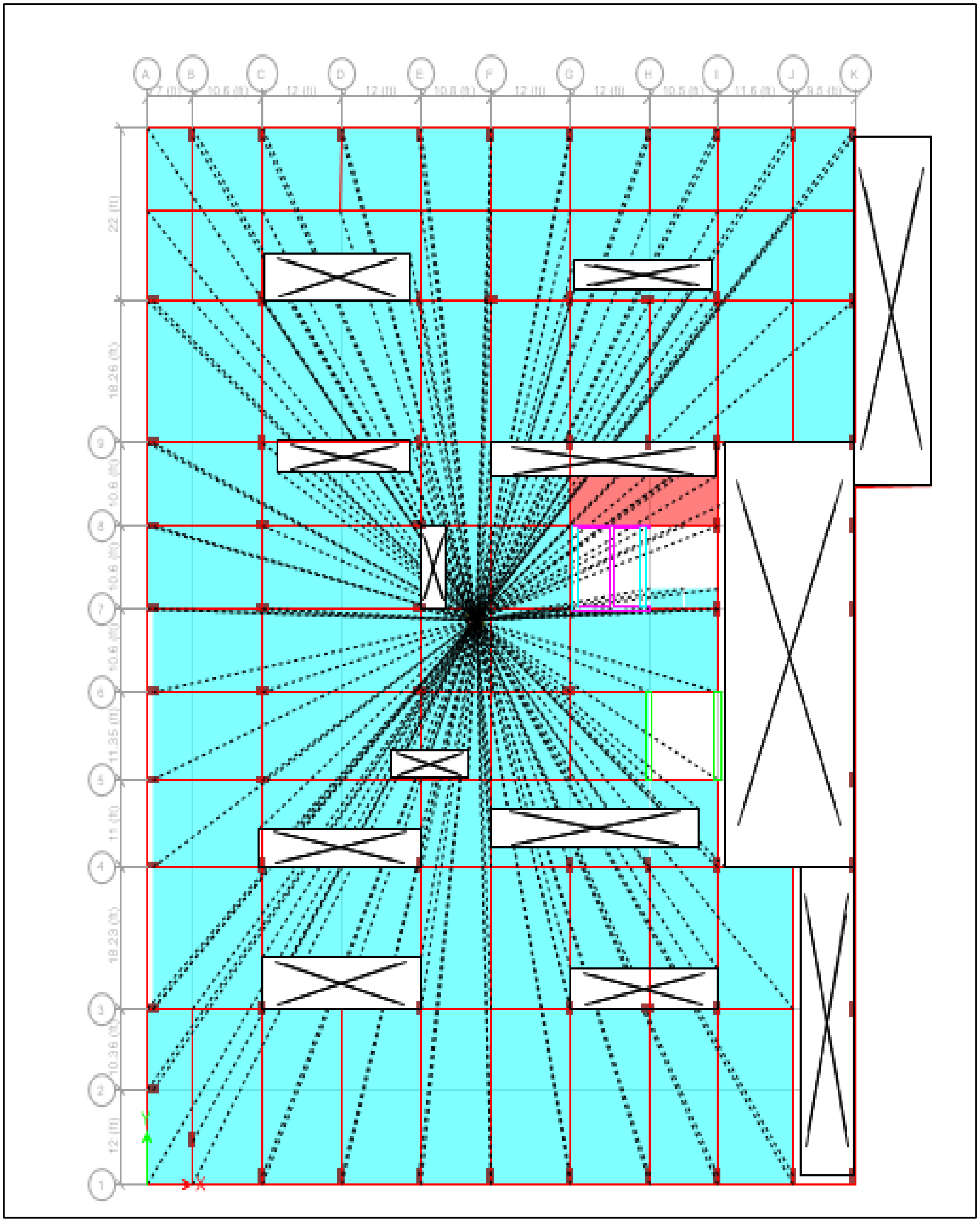


Fig:3.46 Diaphragm on Structure

3.19 LOAD COMBINATION:

According to ASCE 7-16 for concrete frame structure we have some basic load combination which are shown in figure.

2.3 LOAD COMBINATIONS FOR STRENGTH DESIGN

2.3.1 Basic Combinations. Structures, components, and foundations shall be designed so that their design strength equals or exceeds the effects of the factored loads in the following combinations. Effects of one or more loads not acting shall be considered. Seismic load effects shall be combined loads in accordance with Section 2.3.6. Wind and seismic loads need not be considered to act simultaneously. Refer to Sections 1.4, 2.3.6, 12.4, and 12.14.3 for the specific definition of the earthquake load effect E. Each relevant strength limit state shall be investigated.

1. $1.4D$
2. $1.2D + 1.6L + 0.5(L_r \text{ or } S \text{ or } R)$
3. $1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (L \text{ or } 0.5W)$
4. $1.2D + 1.0W + L + 0.5(L_r \text{ or } S \text{ or } R)$
5. $0.9D + 1.0W$

Fig:3.47 Load Combination as per ASCE 7-16

In ETABS we can define the call this load combination or use the default load combination for concrete frame design so, all this combination by default adds in the library.

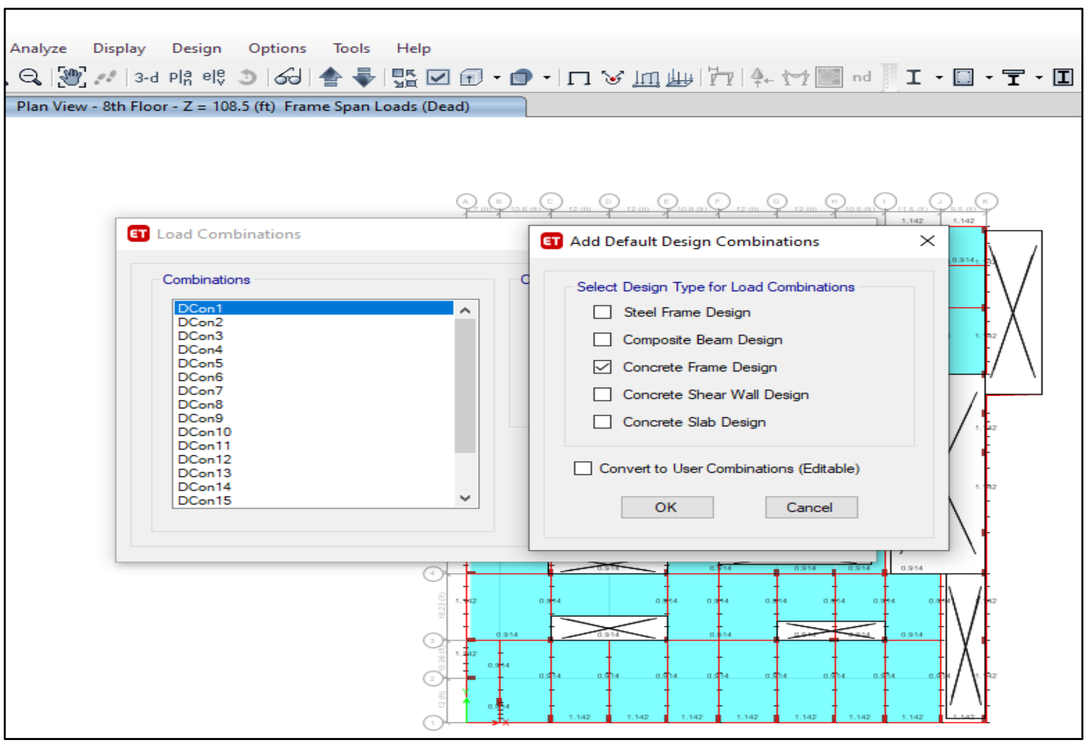


Fig:3.48 Add Default Load Combination

3.19 MESHING OF FLOORS:

Meshing of floor is done to distribute the whole load on the slab into number of small blocks, so it can easily and efficiently transfer the load from one slab to another slab.

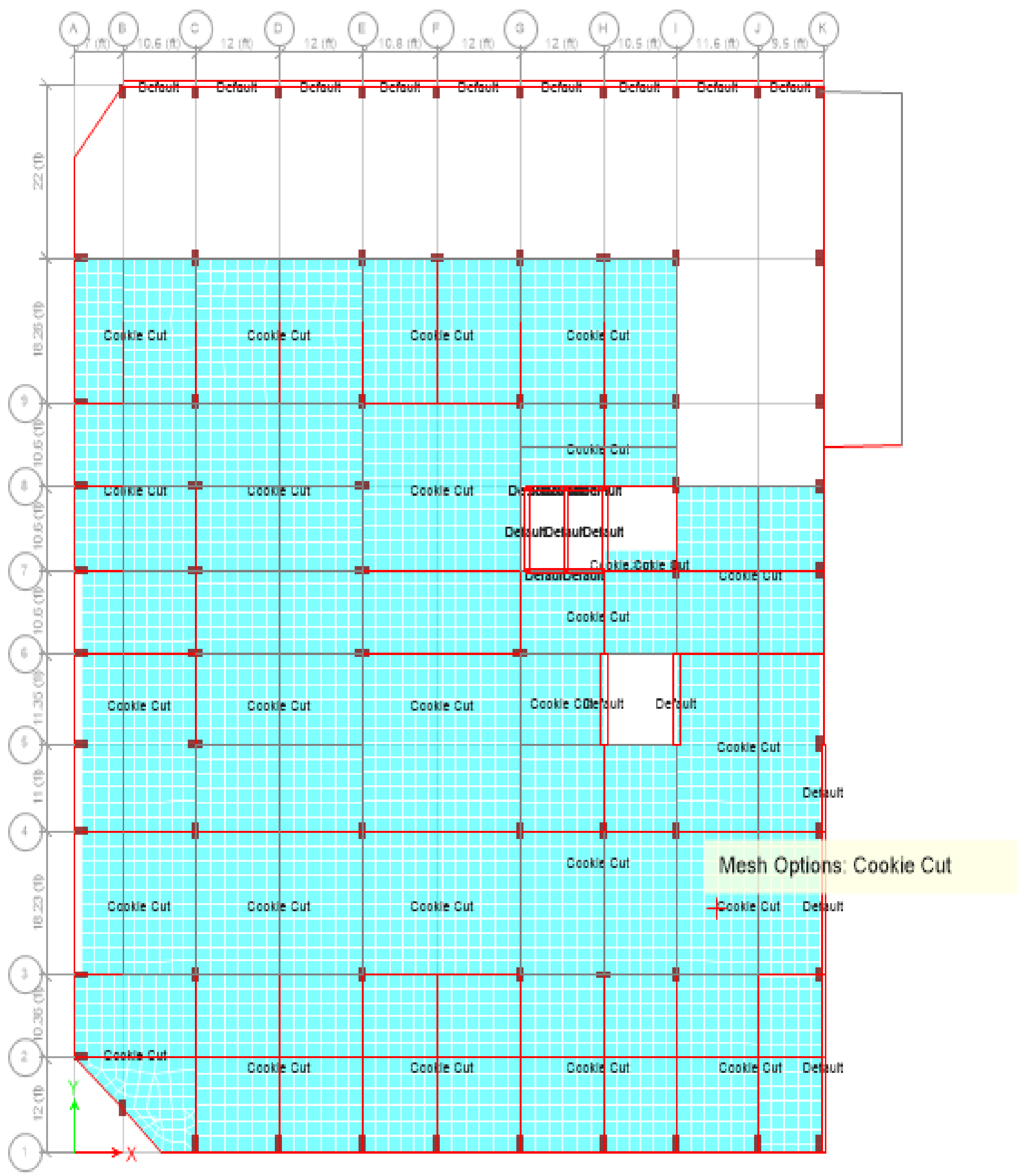


Fig:3.49 Meshing of Floor

Once the building is modeled and all the loads are assigned the next step is run analysis, a run analysis would be conducted that would clearly show the various Bending moment diagrams, Shear force diagrams of the building and the performance of building under seismic excitations.

3.20 RUN ANALYSIS:

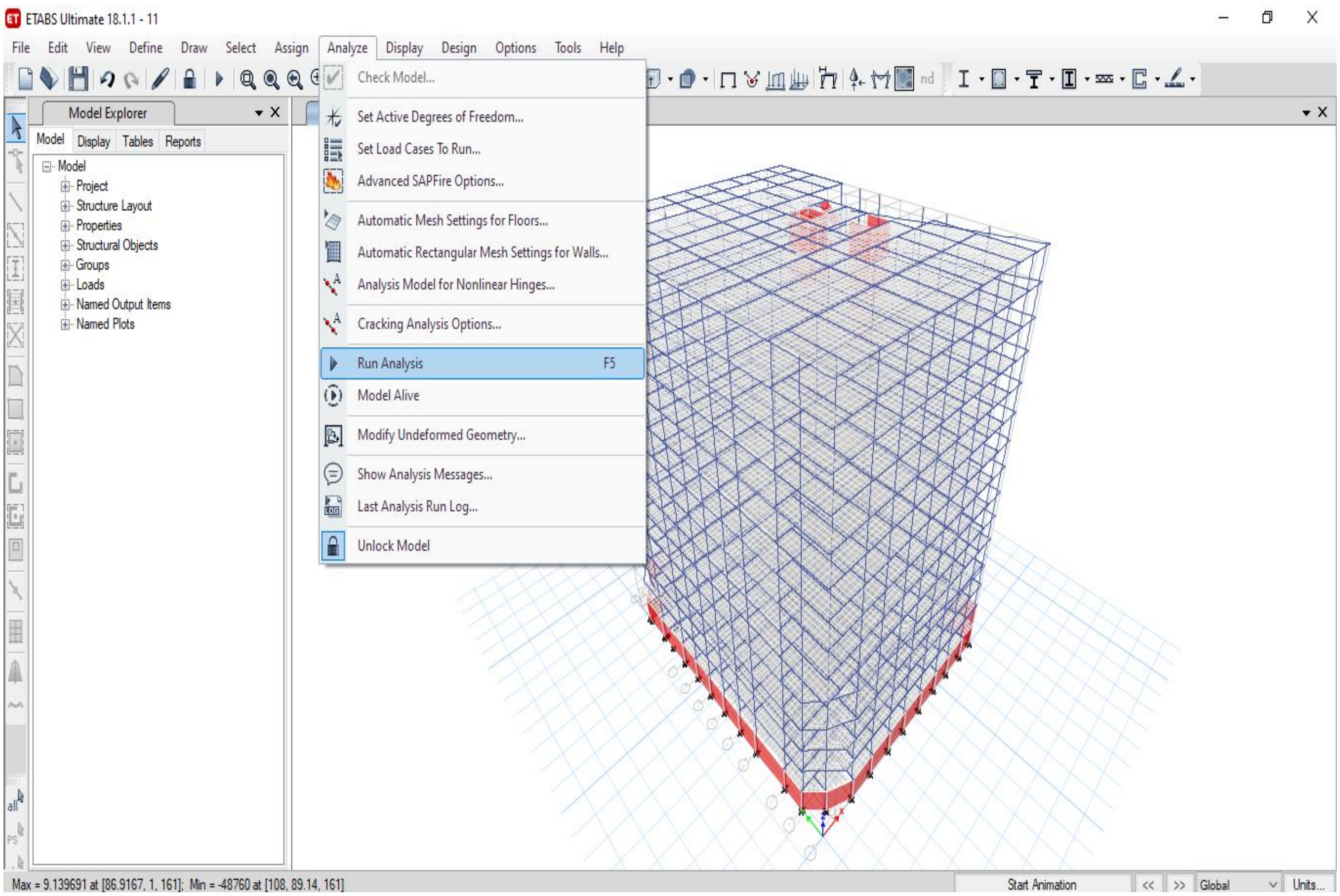


Fig:3.50 Run Analysis

CHAPTER 4

RESULTS AND DISCUSSIONS

Once the building is modeled and all the loads are assigned the next step is run analysis, a run analysis would be conducted that would clearly show the various outcomes i.e., Bending moment diagrams, Shear force diagrams of the building and the performance of building under seismic excitations. For this go to Analyze > Run analysis.

4.1 ANALYSIS OF THE STRUCTURE:

4.1.1 Meshing of Slabs

The meshing is done automatically after the Run analysis. ETABS mesh the shells into parts that helps in distributing the loads to each beam girder by a suitable method. This is actually a finite element technique.

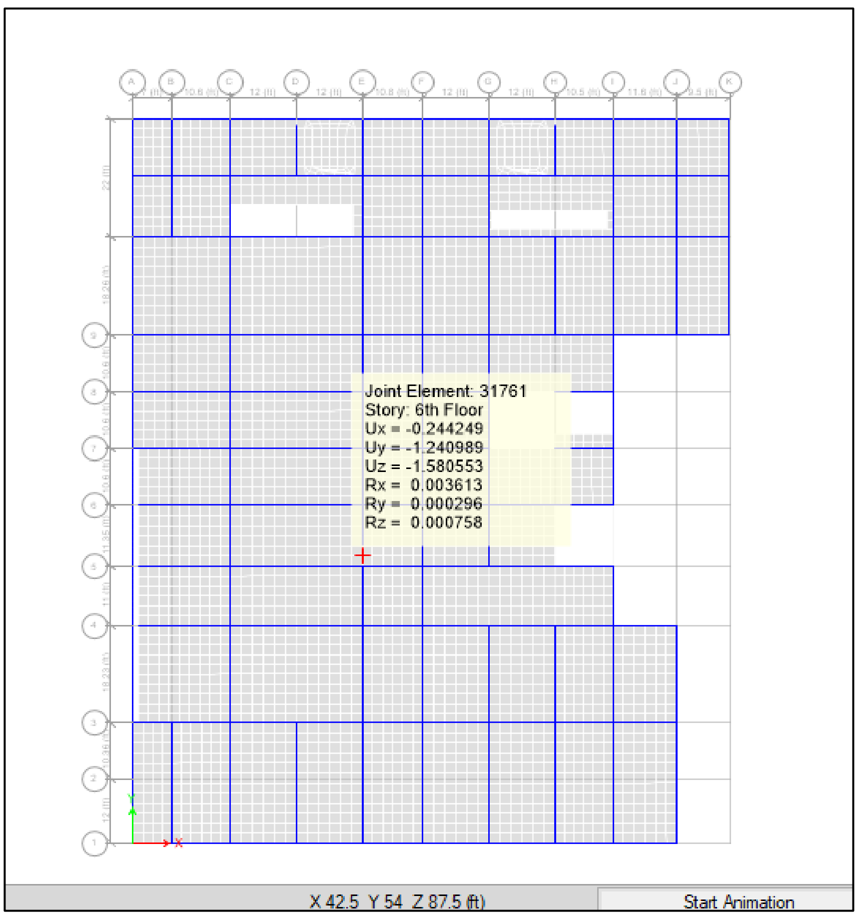


Fig:4.1 Meshing of Slab

4.1.2 Frame and Shell Member Before and After Analysis

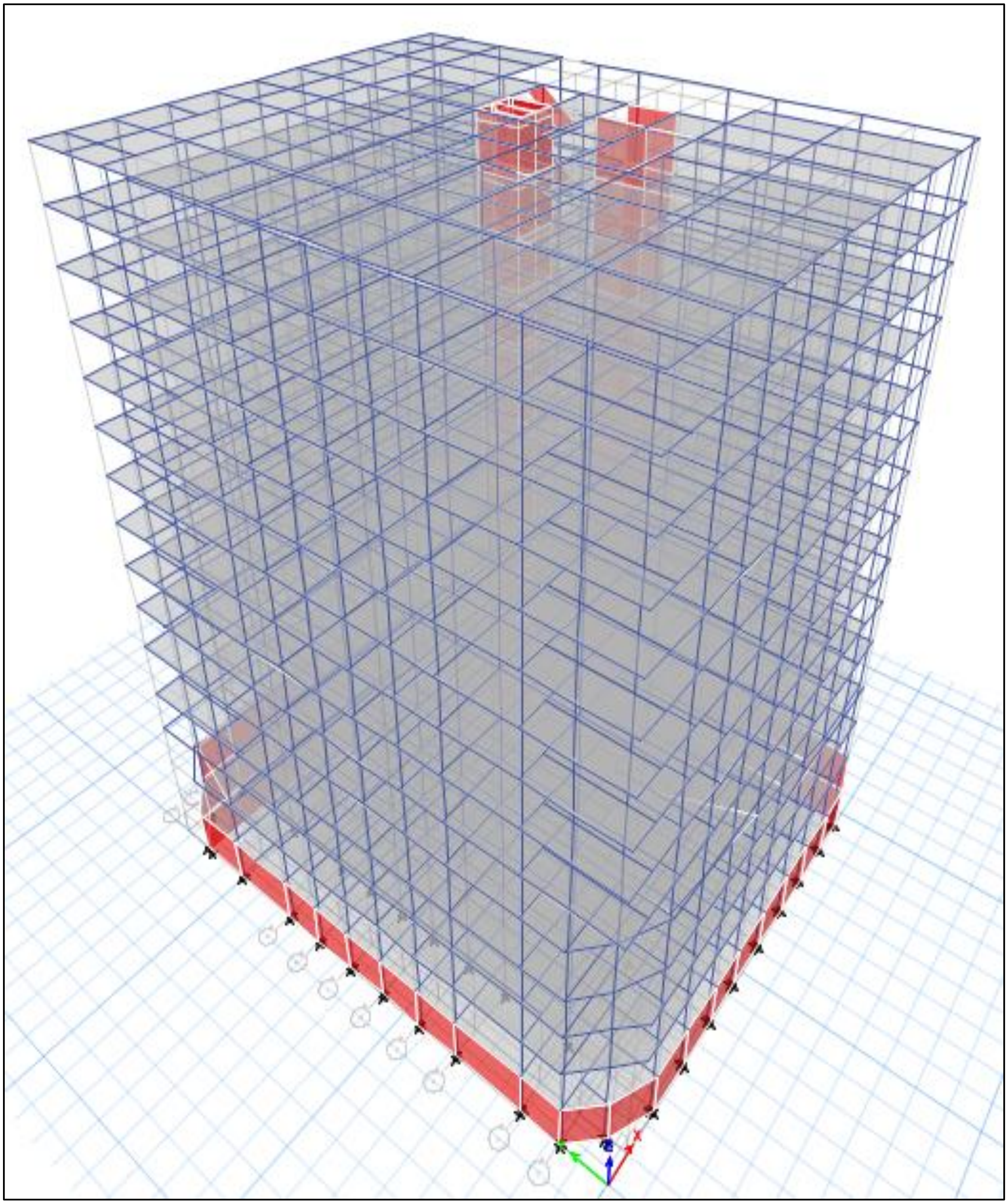


Fig:4.2 Frame and Shell Member Before Analysis

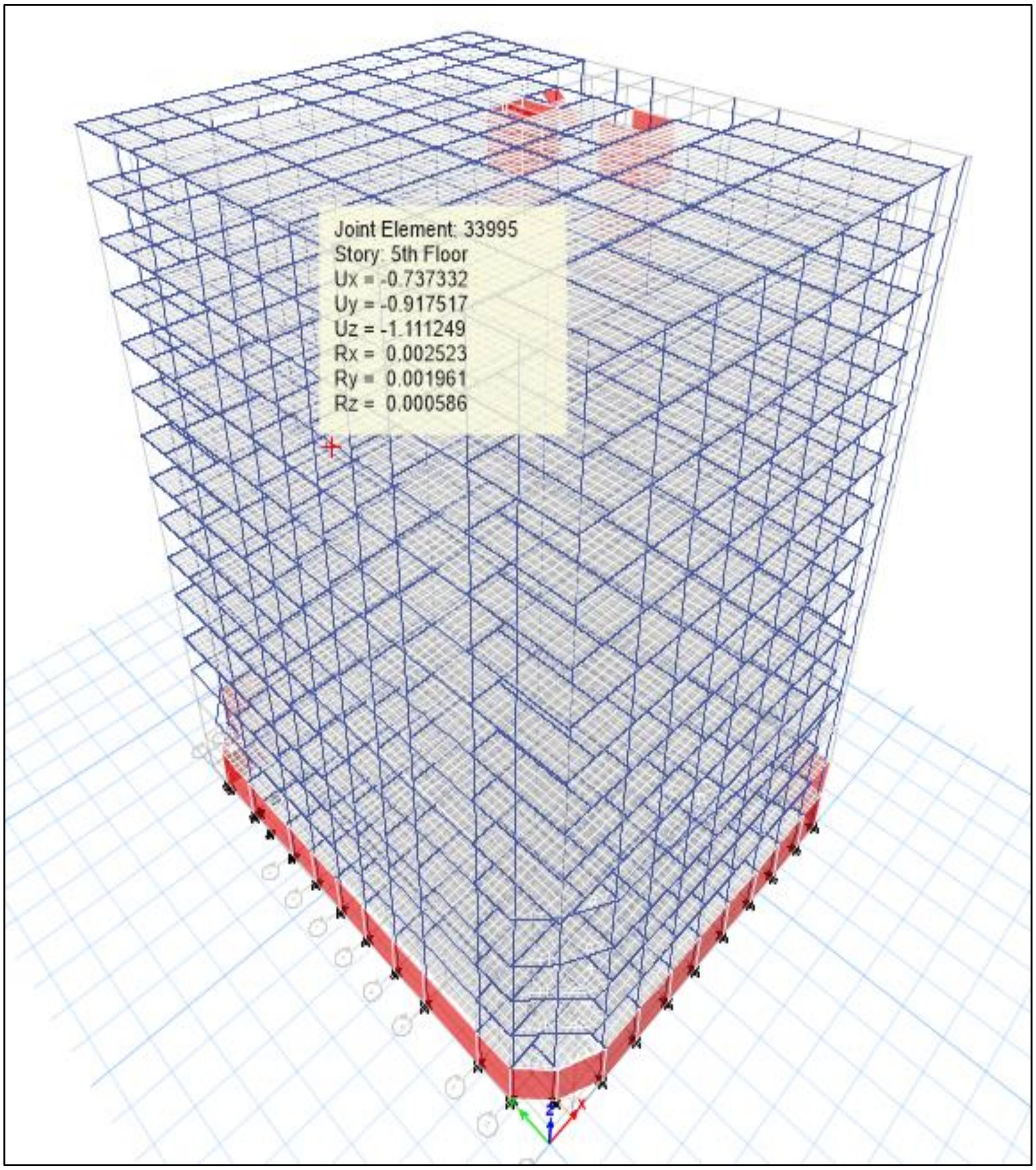


Fig:4.3 Frame and Shell Member After Analysis

4.1.3 Story Displacements and Drift for Different Loading:

To check the displacement, occur in any floor go to the "display" menu and "story response plot".

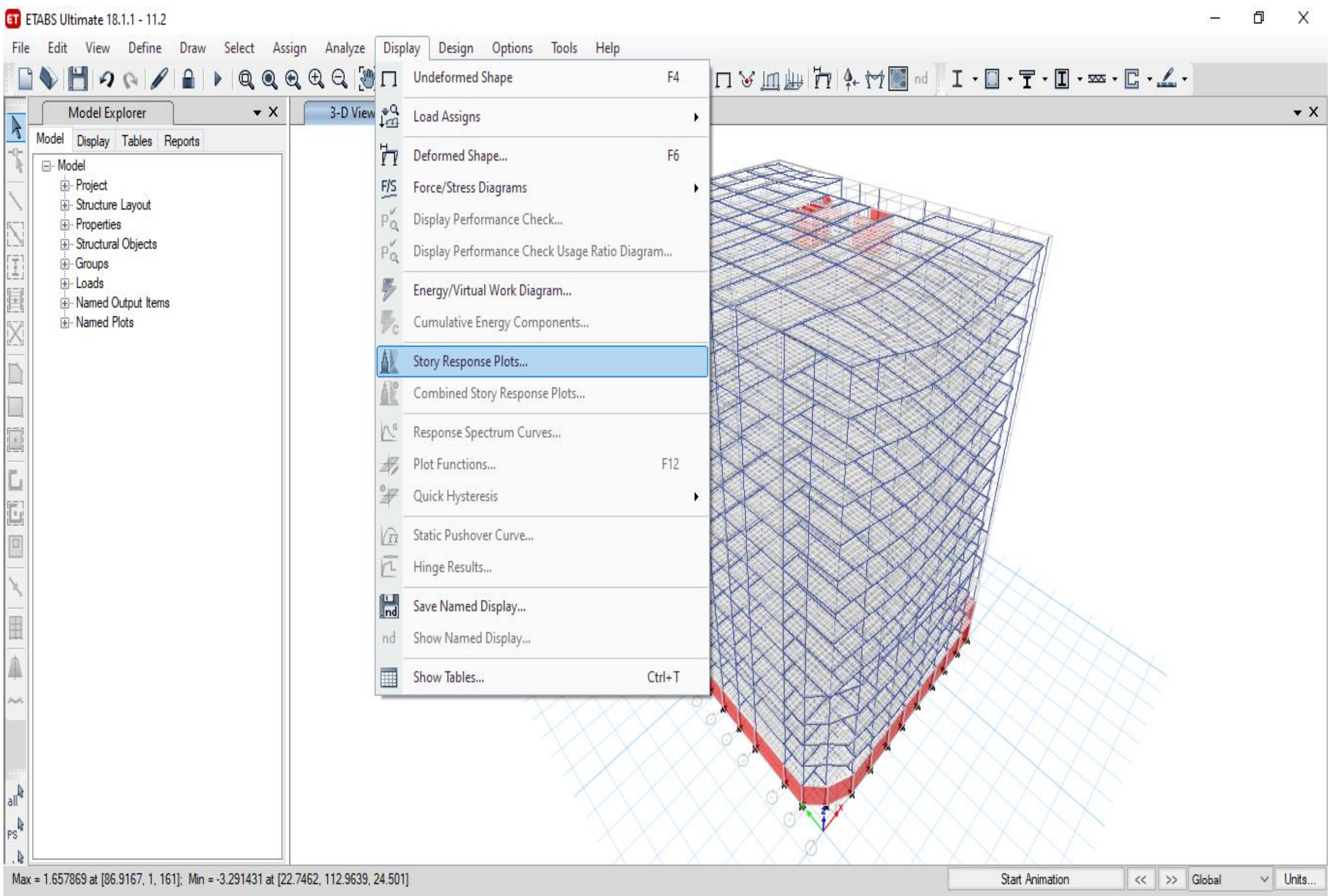


Fig:4.4 Drift and Displacement

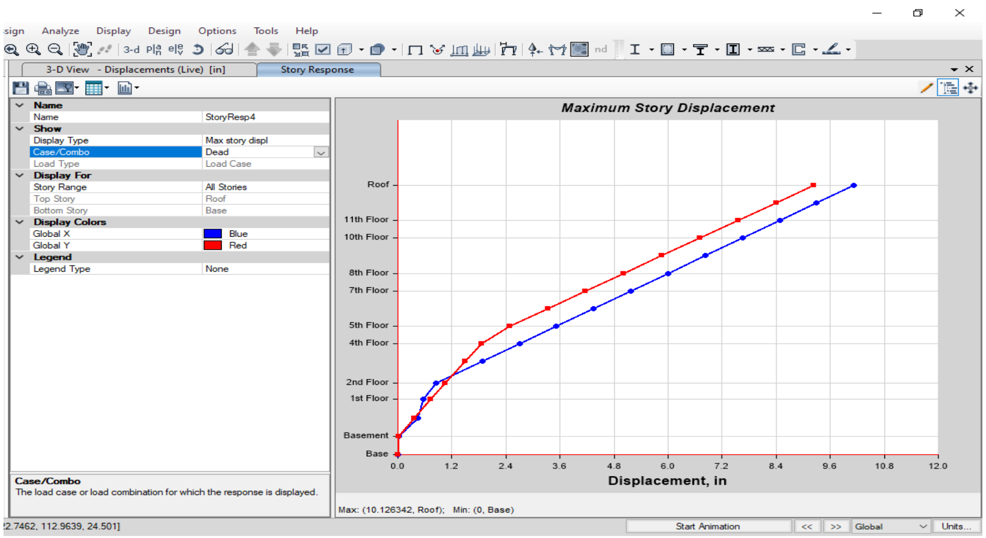


Fig:4.5 Drift and Displacement due to Dead Load

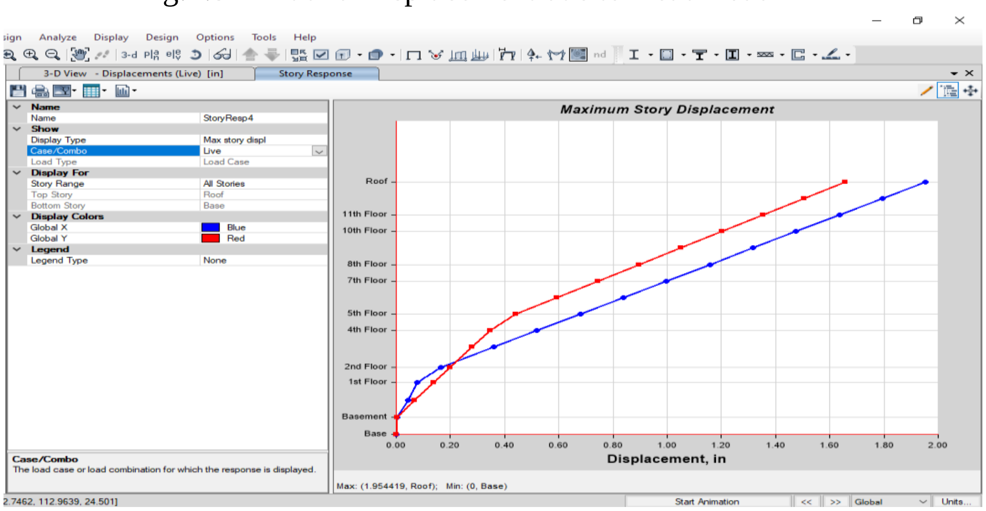


Fig:4.6 Drift and Displacement due to Live Load

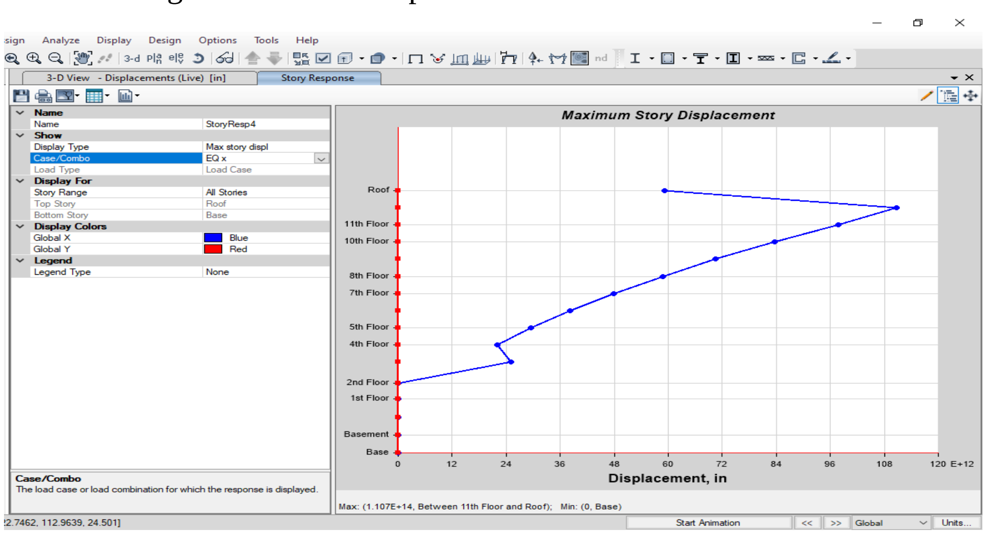


Fig:4.7 Drift and Displacement due to EQx

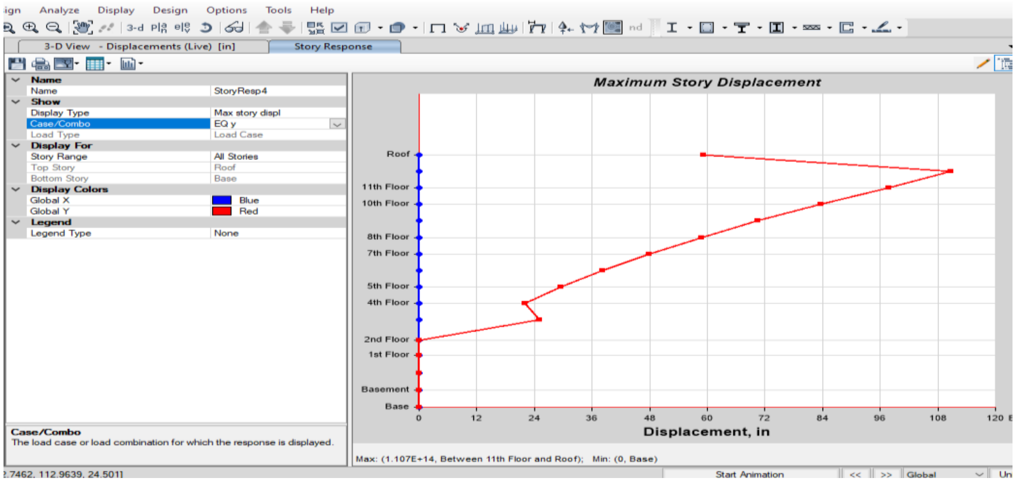


Fig:4.8 Drift and Displacement due to EQy

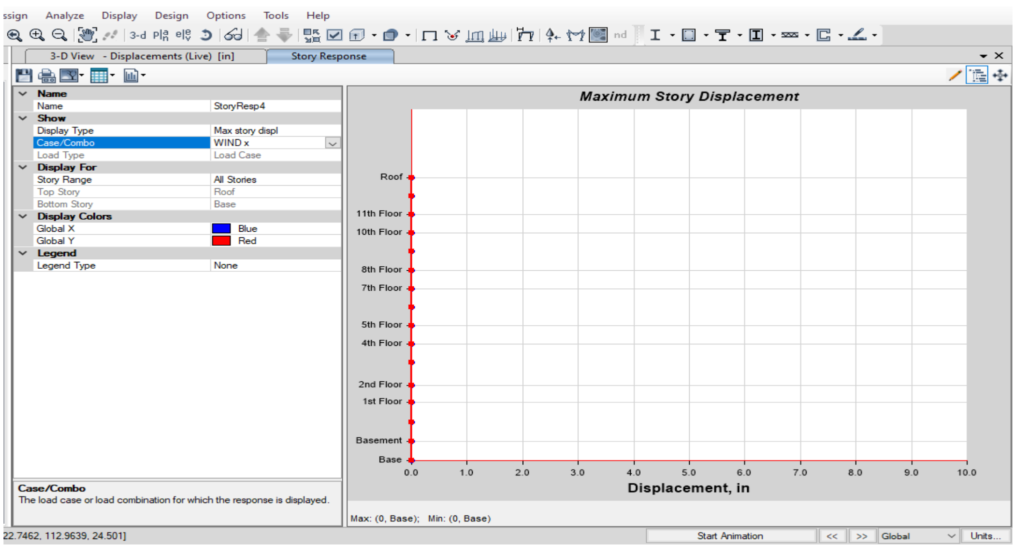


Fig:4.9 Drift and Displacement due to Wind X

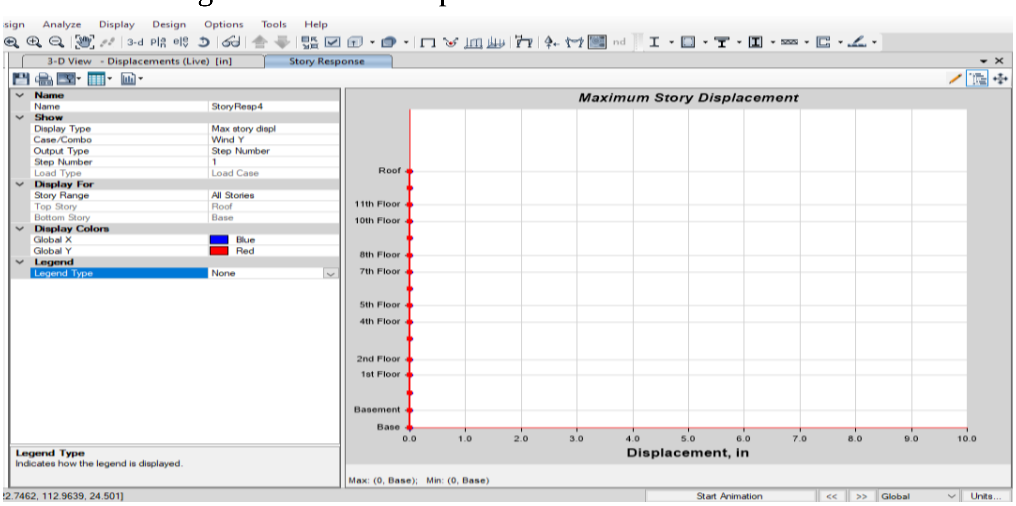


Fig:4.10 Drift and Displacement due to Wind Y

4.1.4 Axial Force Diagram:

Axial force diagram due to dead load is given below at different elevations.

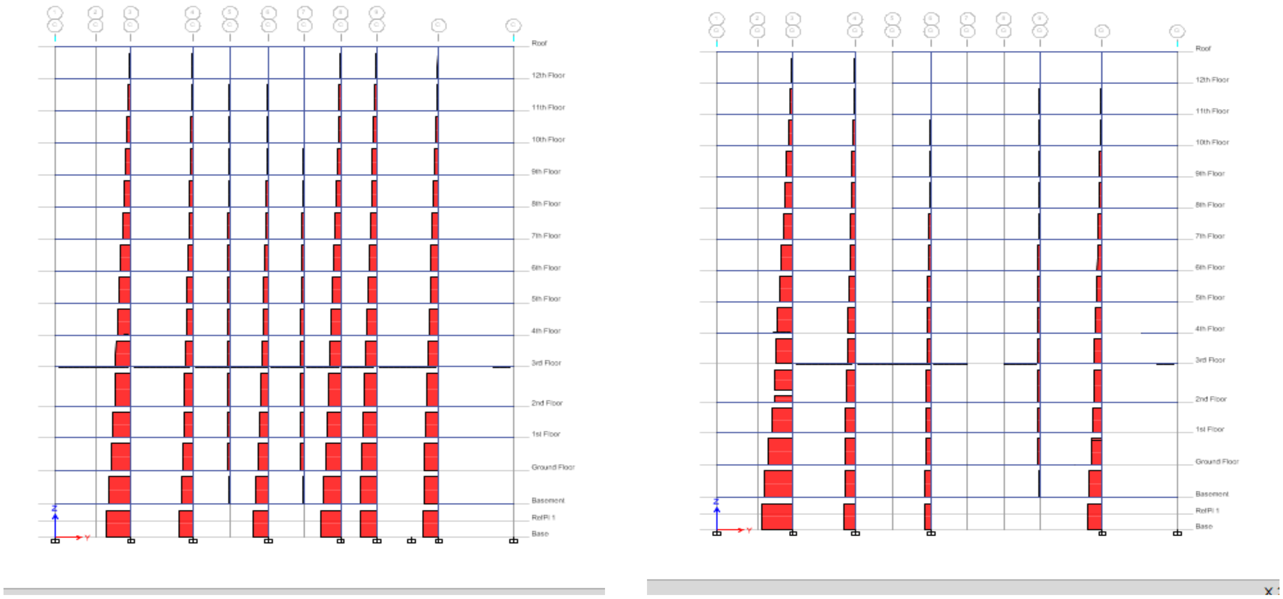


Fig:4.11 Axial Load at C and G Elevation

Axial force diagram due to live load is given below at different elevations.

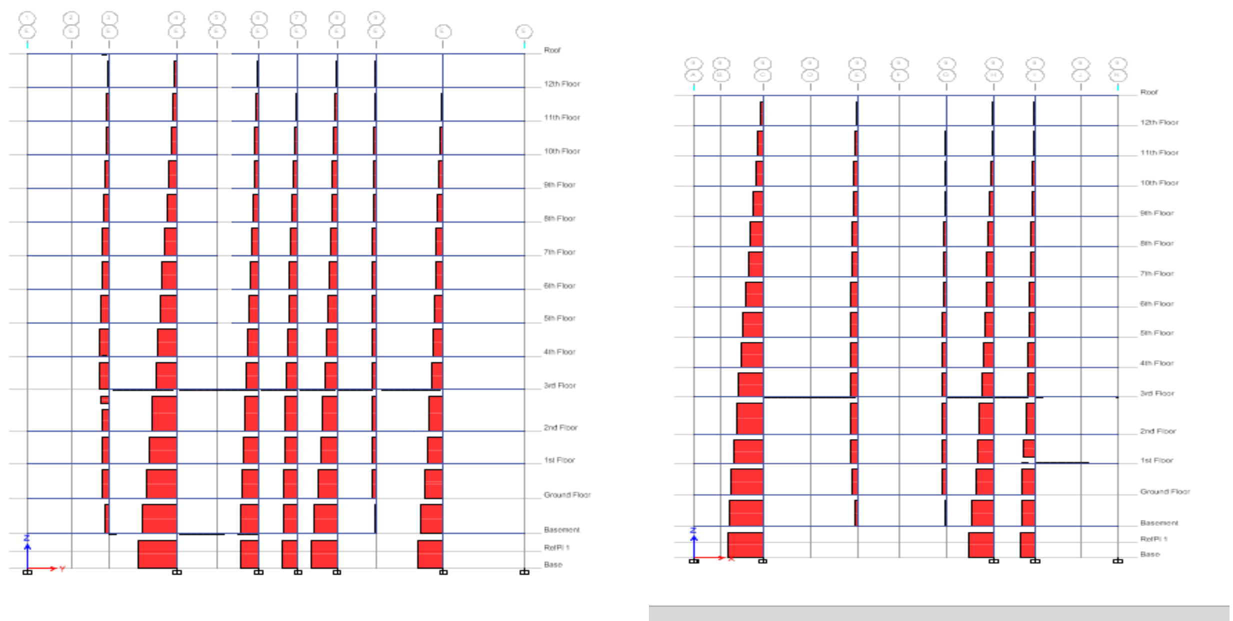


Fig:4.12 Axial Load at 3 and 7 Elevation

4.1.5 Shear Force Diagram Due to Dead Load:

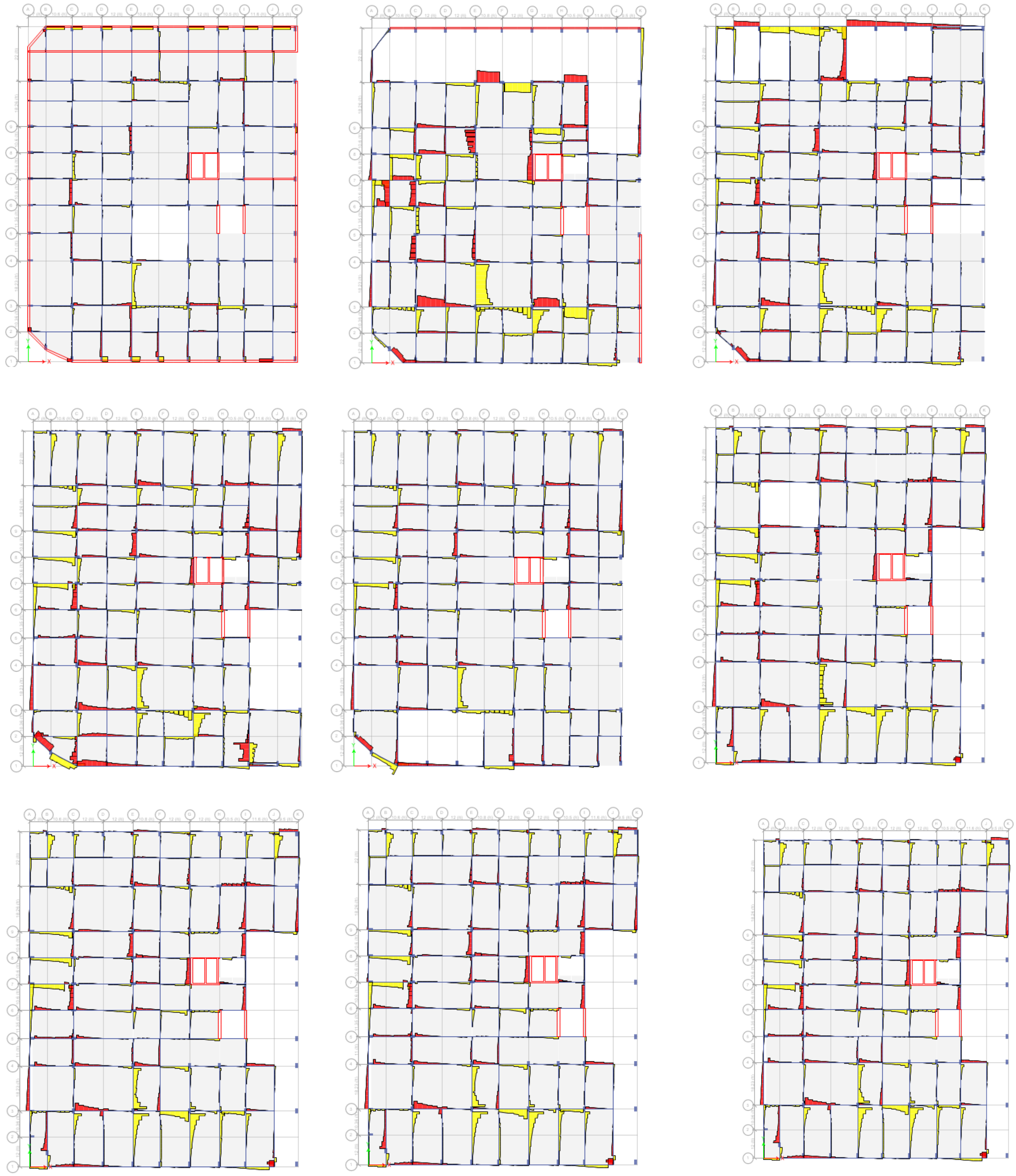


Fig:4.13 SFD due to DL from Basement to 7th Floor

4.1.6 Shear Force Diagram Due to Live Load:

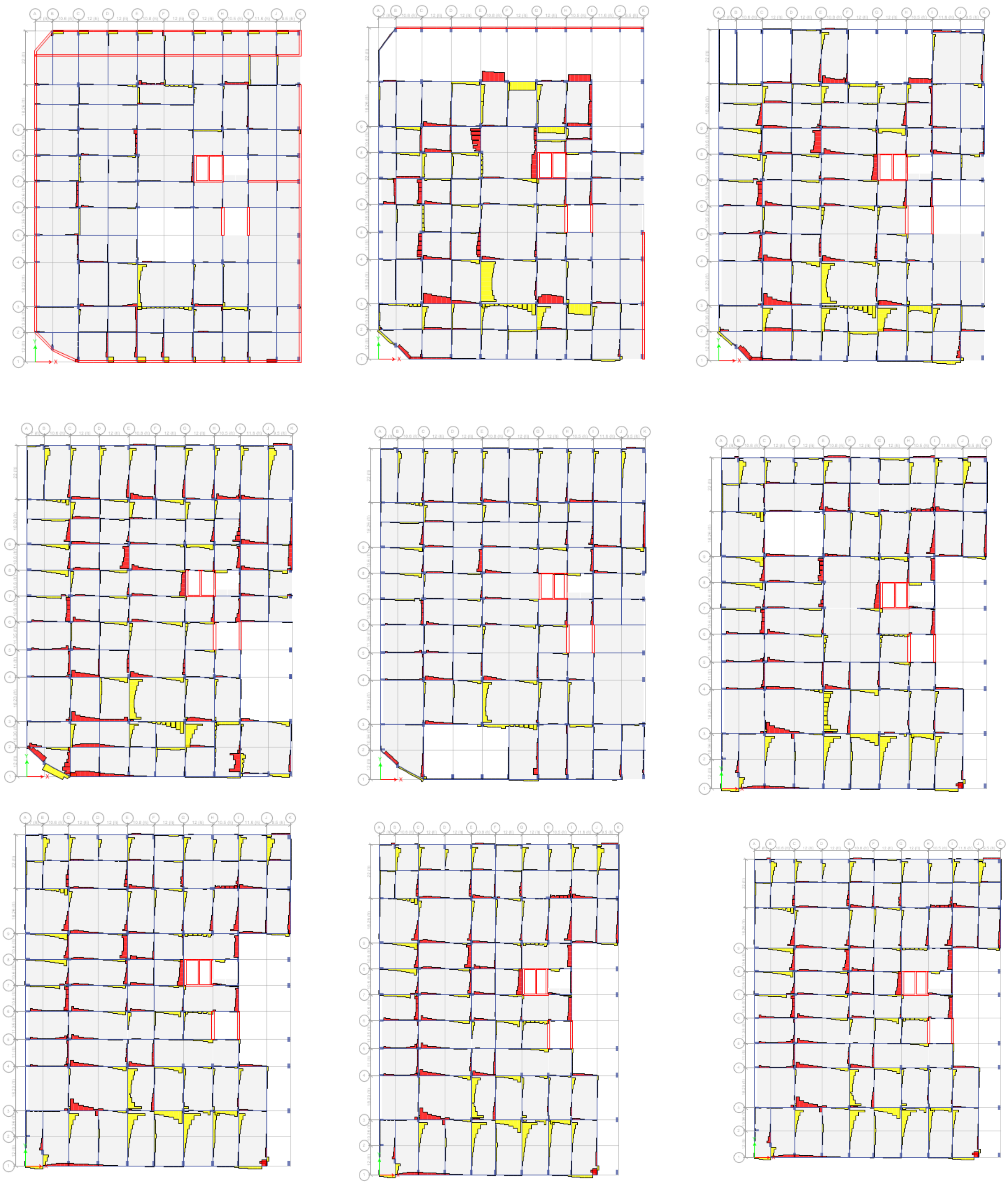


Fig:4.14 SFD due to LL from Basement to 7th Floor

4.1.7 Moment Force Diagram Due to Dead Load:

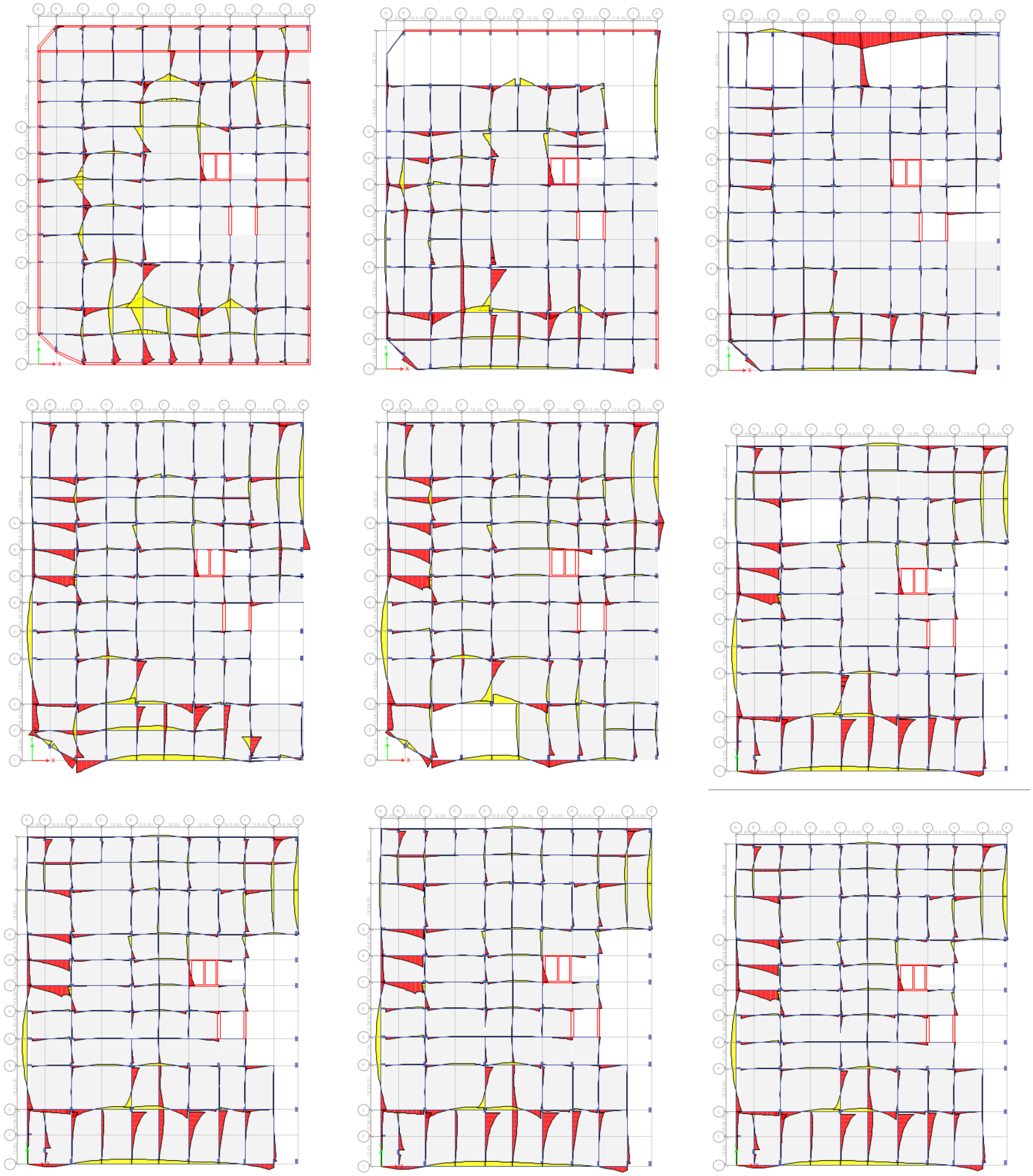


Fig:4.15 MFD due to DL from Basement to 7th Floor

4.1.8 Moment Force Diagram Due to Live Load:

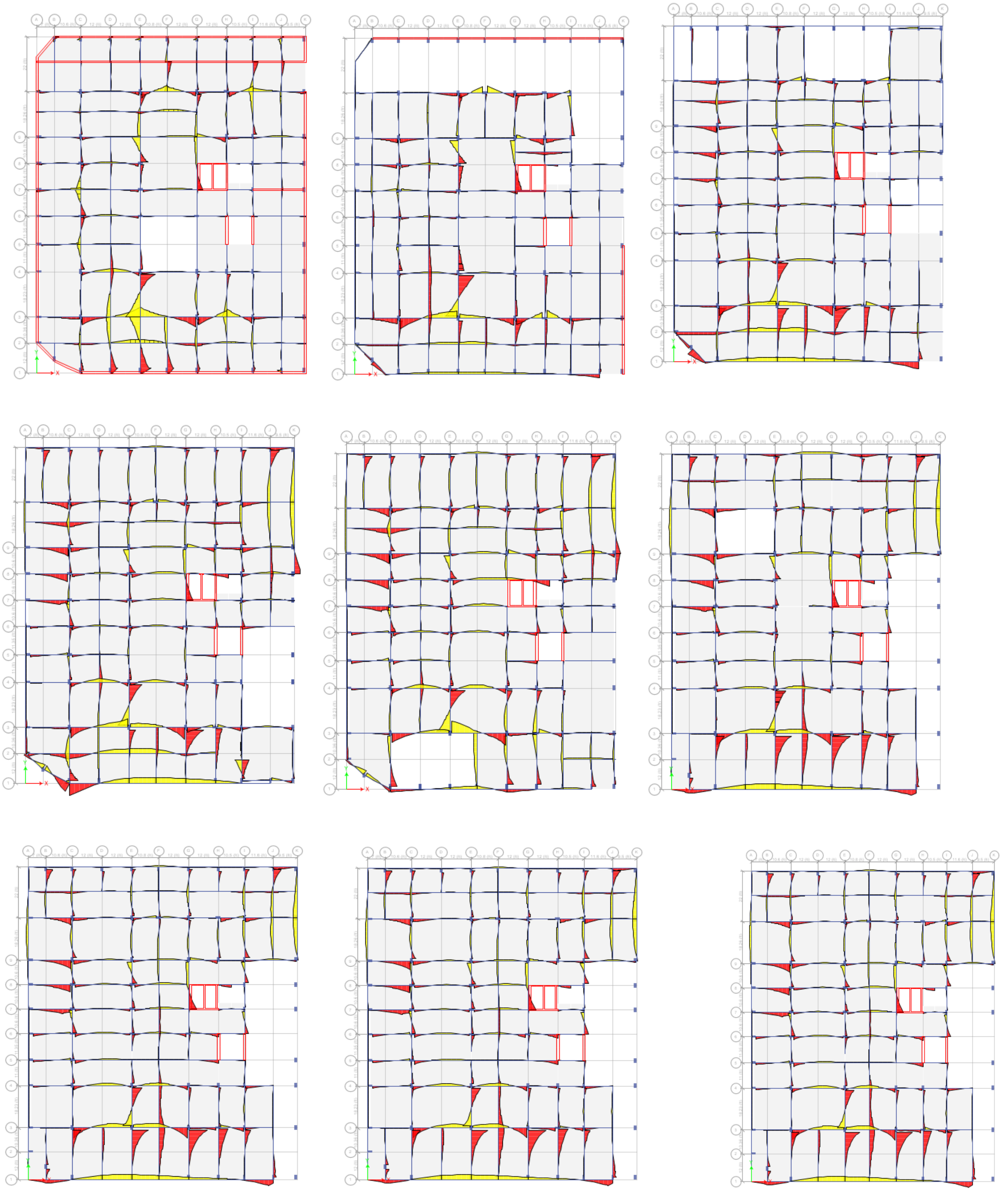


Fig:4.16 MFD due to LL from Basement to 7^{th} Floor

4.1.9 Shell Stress Distribution of Fmax and Mmax due to Dead Load:

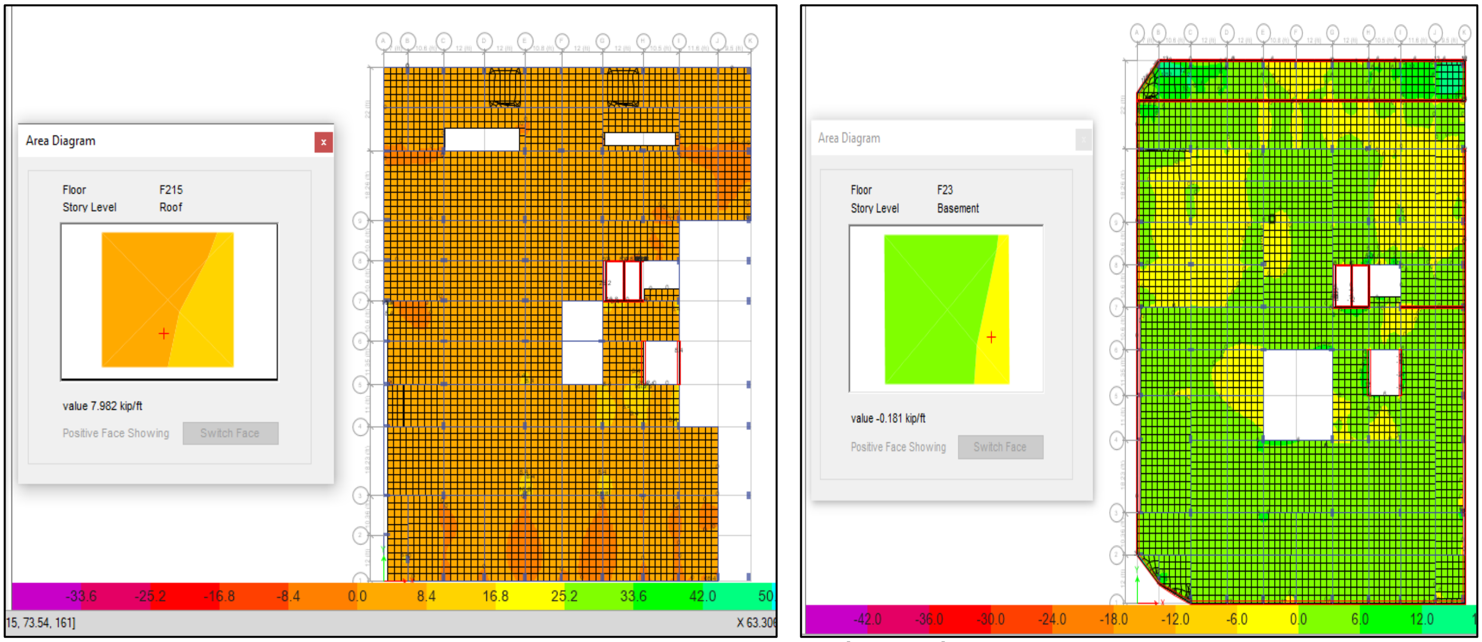


Fig:4.17 Fmax due to DL on 5th and 6th Floor

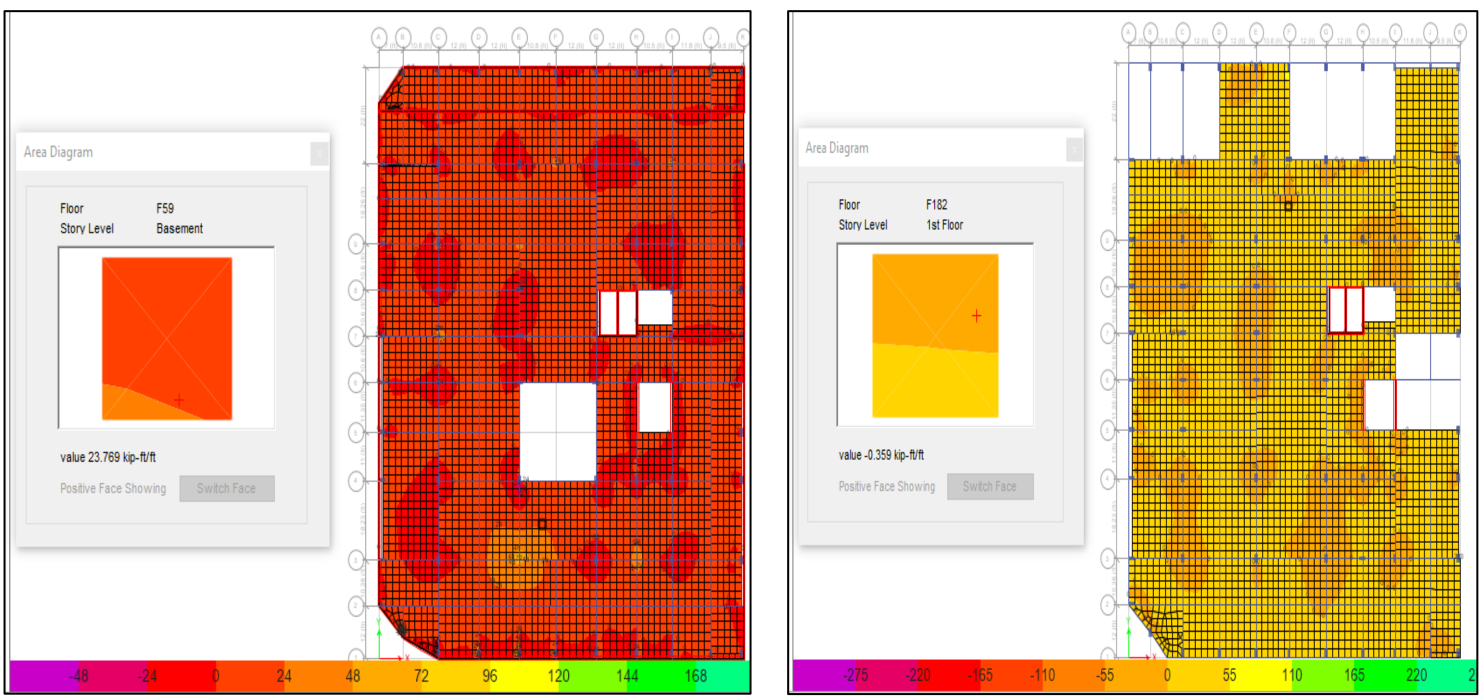


Fig:4.18 Mmax due to DL on 6th and 7th Floor

4.1.10 Shell Stress Distribution of Vmax and Mmax due to Live Load:

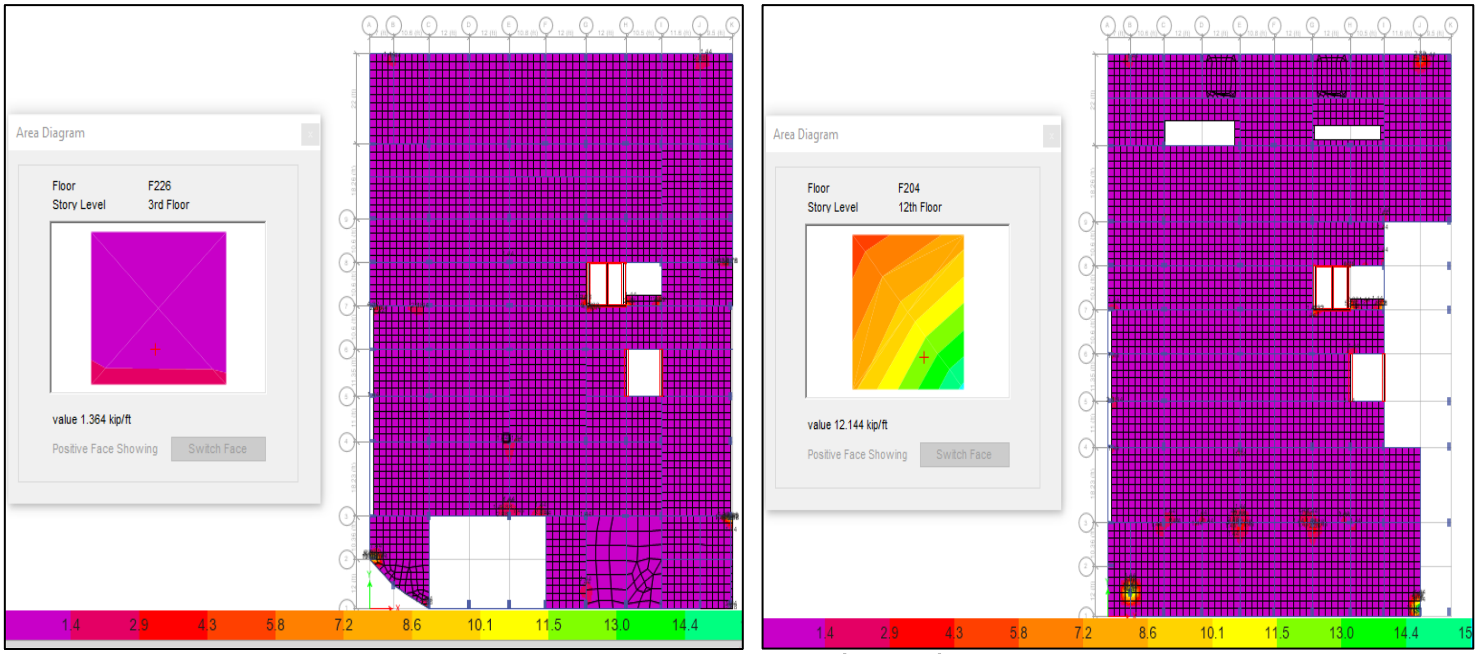


Fig:4.19 Vmax due to LL on 4th and 5th Floor

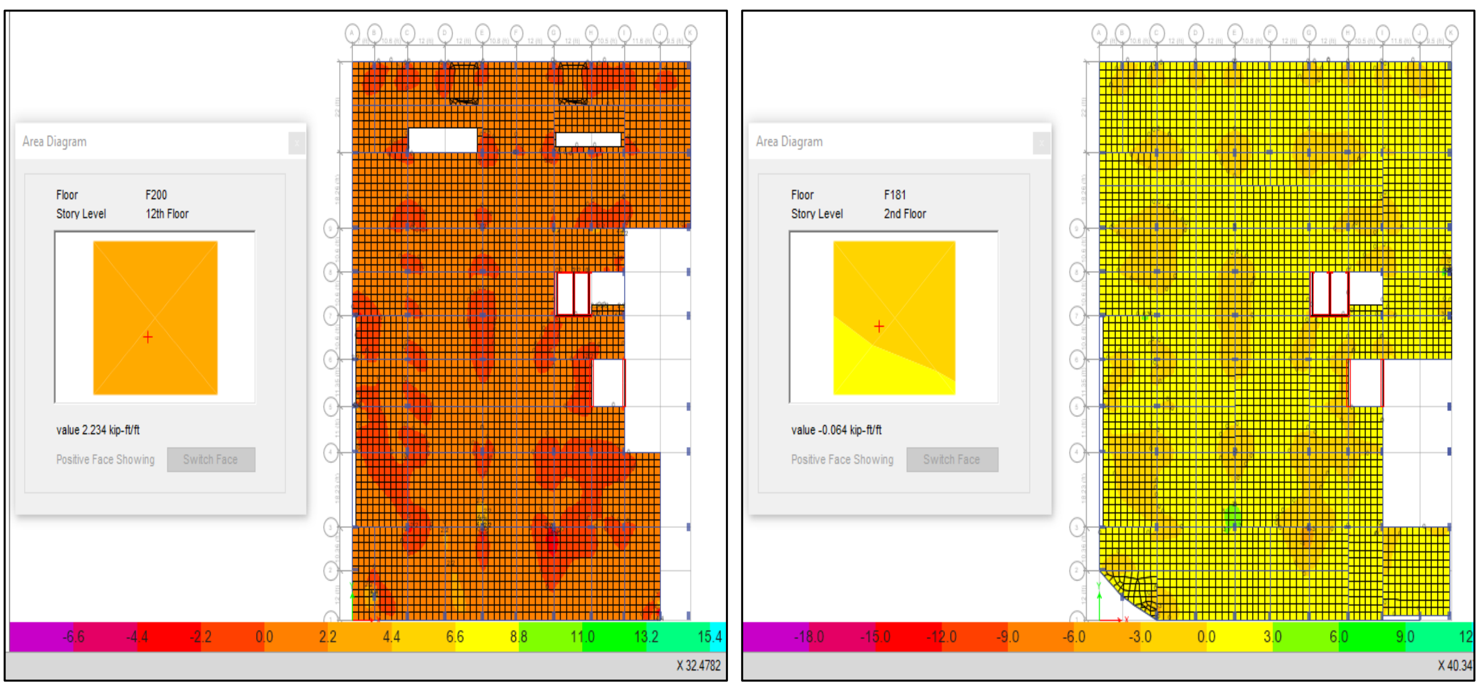


Fig:4.20 Mmax due to LL on 5th and 6th Floor

4.1.11 Shear Force & Bending Moment Diagram of Beam:

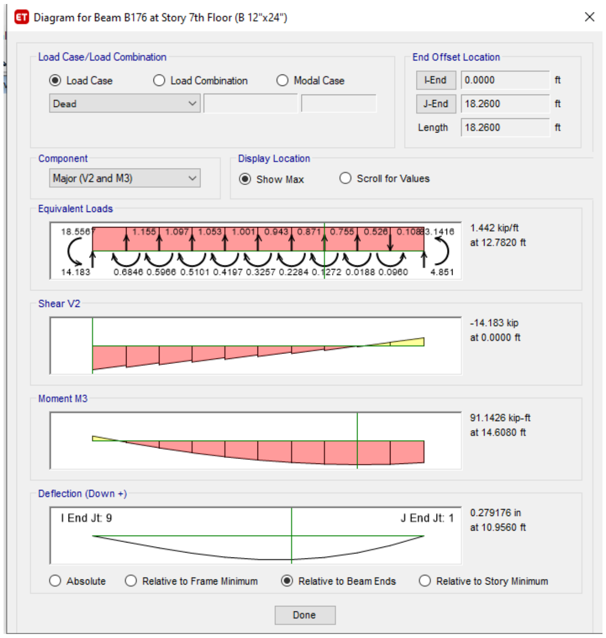


Fig:4.21 Stress due to DL on B176

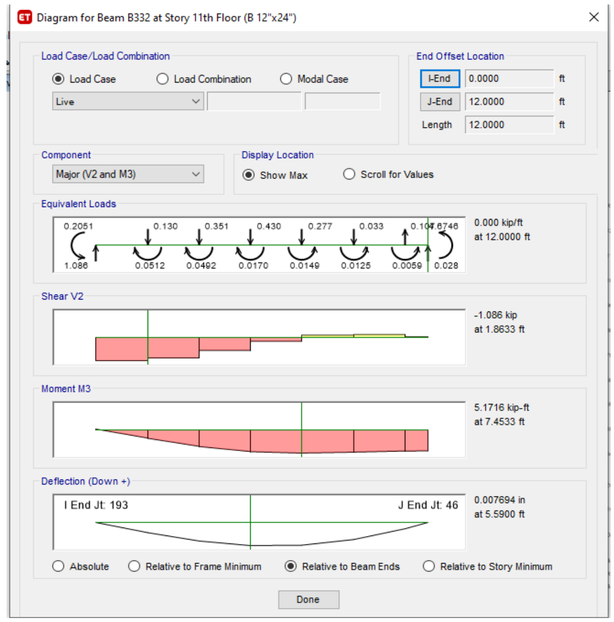


Fig: 4.22 Stress due to DL on B332

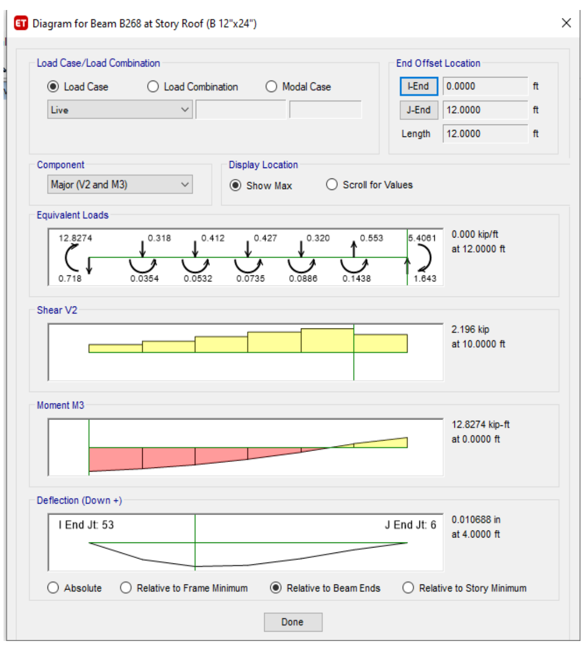


Fig: 4.23 Stress due to LL on B268

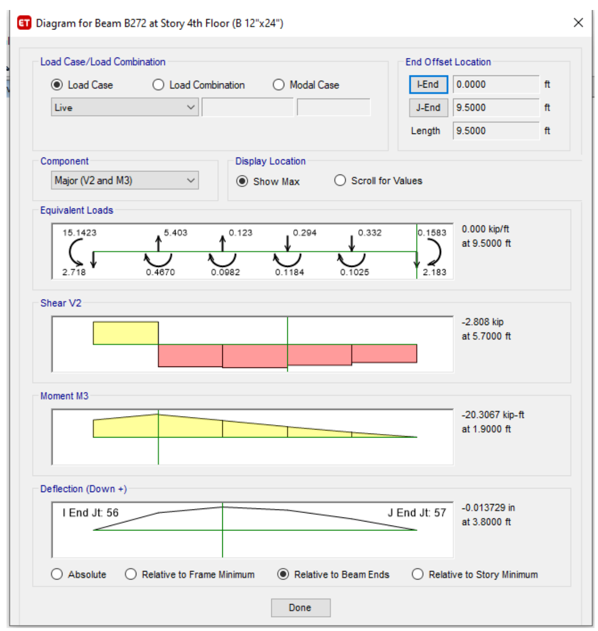


Fig: 4.24 Stress due to LL on B272

4.2 DESIGN OF THE STRUCTURE:

4.2.1 Material Properties:

For design of the structure, we choose the 5000psi concrete strength, because structure is multistory and having high loads on some section due to the provision of floating columns at basement, additionally we provide the 60kips minimum yield strength of the steel bar and 90kips minimum tensile strength for elastic analysis, we are not going to use expected value, because this value is used for the plastic behavior of the material.

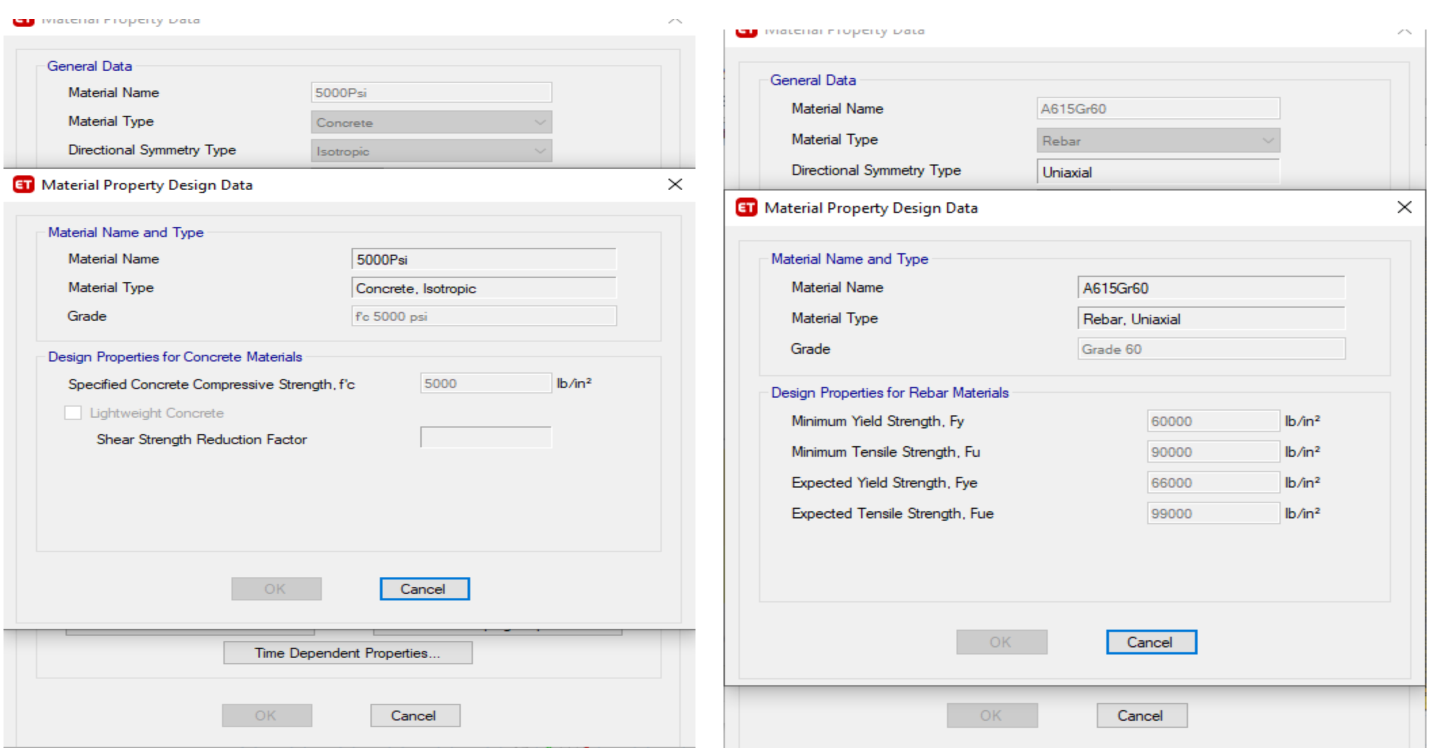


Fig:4.25 Material Properties for Design

4.2.2 Design Check:

From Concrete frame design check weather, the design is correct or not afterward, also check that all the concrete frame passed the design check, as it’s rarely happened that the structure pass the design check on first time, as continuously changing the dimension and strength characteristic this structure is also passed the design.

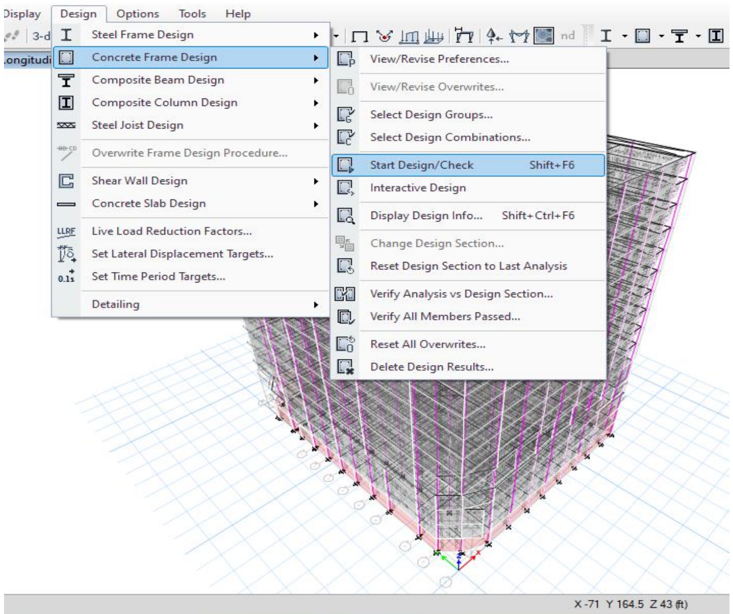


Fig:4.26 Check the Model

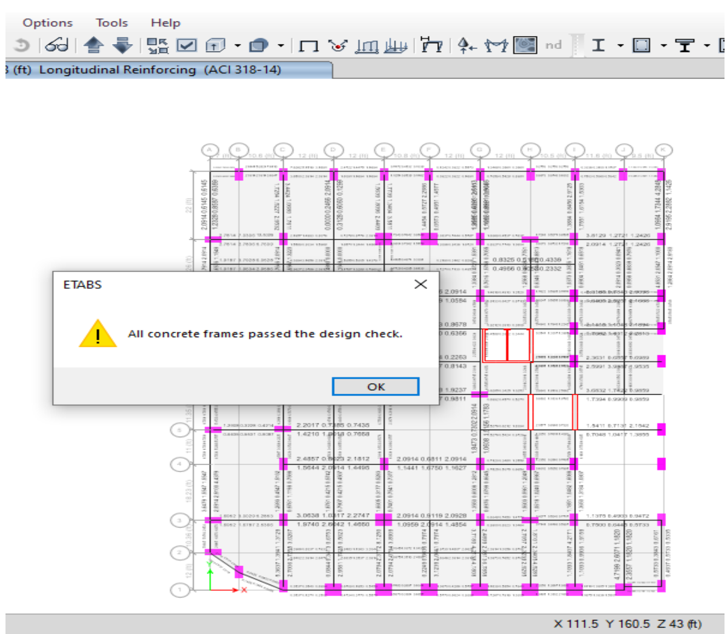
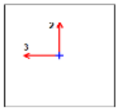


Fig:4.27 Concrete Frame Pass the Design Check

4.2.3 Design of Beams by ACI 318-14:

ETABS Concrete Frame Design

ACI 318-14 Beam Section Design



Beam Element Details (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (in)	LLRF	Type
2nd Floor	B179	1303	B 12"x24"	DCon1	127.2	127.2	1	Sway Special

Section Properties

b (in)	h (in)	b_f (in)	d_s (in)	d_{ct} (in)	d_{cb} (in)
24	24	24	0	1.5	1.5

Material Properties

E_c (lb/in²)	f'_c (lb/in²)	Lt.Wt Factor (Unitless)	f_y (lb/in²)	f_{ys} (lb/in²)
4415201	6000	1	60000	60000

Design Code Parameters

Φ_T	Φ_{CTied}	$\Phi_{CSpiral}$	Φ_{Vns}	Φ_{Vs}	Φ_{Vjoint}
0.9	0.65	0.75	0.75	0.6	0.85

Design Moment and Flexural Reinforcement for Moment, M_{u3}

	Design Moment kip-ft	Design P_u kip	-Moment Rebar in²	+Moment Rebar in²	Minimum Rebar in²	Required Rebar in²
Top (+2 Axis)	-264.262	-12.853	2.8089	0	2.0914	2.8089
Bottom (-2 Axis)	132.131	-12.853	0	1.4479	1.9305	1.9305

Shear Force and Reinforcement for Shear, V_{u2}

Shear V_{u2} kip	Shear ϕV_c kip	Shear ϕV_s kip	Shear V_p kip	Rebar A_v /S in²/ft
60.853	62.742	23.528	69.051	0.2789

Torsion Force and Torsion Reinforcement for Torsion, T_u

T_u kip-ft	ϕT_{th} kip-ft	ϕT_{cr} kip-ft	Area A_o in²	Perimeter, p_h in	Rebar A_t /s in²/ft	Rebar A_l in²
2.8426	16.1176	64.4703	357.21	82	0	0

ETABS Concrete Frame Design

ACI 318-14 Beam Section Design

Beam Element Details (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (in)	LLRF	Type
7th Floor	B176	2285	B 12"x24"	DCon2	153.384	219.12	1	Sway Special

Section Properties

b (in)	h (in)	b_f (in)	d_s (in)	d_{ct} (in)	d_{cb} (in)
24	24	24	0	1.5	1.5

Material Properties

E_c (lb/in²)	f'_c (lb/in²)	Lt.Wt Factor (Unitless)	f_y (lb/in²)	f_{ys} (lb/in²)
4415201	6000	1	60000	60000

Design Code Parameters

Φ_T	Φ_{CTied}	$\Phi_{CSpiral}$	Φ_{Vns}	Φ_{Vs}	Φ_{Vjoint}
0.9	0.65	0.75	0.75	0.6	0.85

Design Moment and Flexural Reinforcement for Moment, M_{u3}

	Design Moment kip-ft	Design P_u kip	-Moment Rebar in²	+Moment Rebar in²	Minimum Rebar in²	Required Rebar in²
Top (+2 Axis)	-26.026	0.619	0.2517	0	0.3356	0.3356
Bottom (-2 Axis)	122.4382	0.619	0	1.2197	1.6262	1.6262

Shear Force and Reinforcement for Shear, V_{u2}

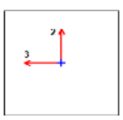
Shear V_{u2} kip	Shear ϕV_c kip	Shear ϕV_s kip	Shear V_p kip	Rebar A_v /S in²/ft
1.351	62.742	0	20.991	0

Torsion Force and Torsion Reinforcement for Torsion, T_u

T_u kip-ft	ϕT_{th} kip-ft	ϕT_{cr} kip-ft	Area A_o in²	Perimeter, p_h in	Rebar A_t /s in²/ft	Rebar A_l in²
0.66	16.7603	67.0412	357.21	82	0	0

ETABS Concrete Frame Design

ACI 318-14 Beam Section Design



Beam Element Details (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (in)	LLRF	Type
1st Floor	B267	3170	B1	DCon1	129.6	129.6	1	Sway Special

Section Properties

b (in)	h (in)	b_f (in)	d_s (in)	d_{ct} (in)	d_{cb} (in)
48	48	48	0	1.5	1.5

Material Properties

E_c (lb/in²)	f'_c (lb/in²)	Lt.Wt Factor (Unitless)	f_y (lb/in²)	f_{ys} (lb/in²)
4415201	6000	1	60000	60000

Design Code Parameters

Φ_T	Φ_{CTied}	$\Phi_{CSpiral}$	Φ_{Vns}	Φ_{Vs}	Φ_{Vjoint}
0.9	0.65	0.75	0.75	0.6	0.85

Design Moment and Flexural Reinforcement for Moment, M_{u3}

	Design Moment kip-ft	Design P_u kip	-Moment Rebar in²	+Moment Rebar in²	Minimum Rebar in²	Required Rebar in²
Top (+2 Axis)	-4212.1613	3.568	21.2987	0	8.6445	21.2987
Bottom (-2 Axis)	2106.0807	3.568	0	10.3148	8.6445	10.3148

Shear Force and Reinforcement for Shear, V_{u2}

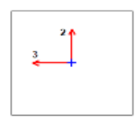
Shear V_{u2} kip	Shear ϕV_c kip	Shear ϕV_s kip	Shear V_p kip	Rebar A_v /S in²/ft
101.388	259.335	0	758.923	0

Torsion Force and Torsion Reinforcement for Torsion, T_u

T_u kip-ft	ϕT_{th} kip-ft	ϕT_{cr} kip-ft	Area A_o in²	Perimeter, p_h in	Rebar A_t /s in²/ft	Rebar A_l in²
110.9272	134.1844	536.7376	1683.21	178	0	0

ETABS Concrete Frame Design

ACI 318-14 Beam Section Design



Beam Element Details (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (in)	LLRF	Type
3rd Floor	B268	3054	B1	DCon11	144	144	1	Sway Special

Section Properties

b (in)	h (in)	b_f (in)	d_s (in)	d_{ct} (in)	d_{cb} (in)
48	48	48	0	1.5	1.5

Material Properties

E_c (lb/in²)	f'_c (lb/in²)	Lt.Wt Factor (Unitless)	f_y (lb/in²)	f_{ys} (lb/in²)
4415201	6000	1	60000	60000

Design Code Parameters

Φ_T	Φ_{CTied}	$\Phi_{CSpiral}$	Φ_{Vns}	Φ_{Vs}	Φ_{Vjoint}
0.9	0.65	0.75	0.75	0.6	0.85

Design Moment and Flexural Reinforcement for Moment, M_{u3}

	Design Moment kip-ft	Design P_u kip	-Moment Rebar in²	+Moment Rebar in²	Minimum Rebar in²	Required Rebar in²
Top (+2 Axis)	-205.2046	1.246	0.9714	0	1.2952	1.2952
Bottom (-2 Axis)	102.6023	1.246	0	0.4791	0.6388	0.6388

Shear Force and Reinforcement for Shear, V_{u2}

Shear V_{u2} kip	Shear ϕV_c kip	Shear ϕV_s kip	Shear V_p kip	Rebar A_v /S in²/ft
63.206	0	63.206	35.896	0.3625

Torsion Force and Torsion Reinforcement for Torsion, T_u

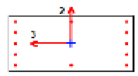
T_u kip-ft	ϕT_{th} kip-ft	ϕT_{cr} kip-ft	Area A_o in²	Perimeter, p_h in	Rebar A_t /s in²/ft	Rebar A_l in²
5.2625	133.967	535.8681	1683.21	178	0	0

Fig:4.28 Design of Different Beams

4.2.4 Design of Columns by ACI 318-14:

ETABS Concrete Frame Design

ACI 318-14 Column Section Design



Column Element Details (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (in)	LLRF	Type
11th Floor	C77	494	C 12"x24"	DCon14	0	126	0.464	Sway Special

Section Properties

b (in)	h (in)	dc (in)	Cover (Torsion) (in)
48	24	2.5688	1

Material Properties

E_c (lb/in²)	f'_c (lb/in²)	Lt.Wt Factor (Unitless)	f_y (lb/in²)	f_{ys} (lb/in²)
4415201	6000	1	60000	60000

Design Code Parameters

Φ_T	Φ_{CTied}	$\Phi_{CSpiral}$	Φ_{Vns}	Φ_{Vs}	Φ_{Vjoint}	Ω_0
0.9	0.65	0.75	0.75	0.6	0.85	2

Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3}

Design P_u kip	Design M_{u2} kip-ft	Design M_{u3} kip-ft	Minimum M2 kip-ft	Minimum M3 kip-ft	Rebar Area in²	Rebar % %
623.632	-165.0997	-208.2368	106.0174	68.5995	11.52	1

Axial Force and Biaxial Moment Factors

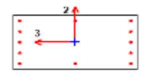
	C_m Factor Unitless	δ_{ns} Factor Unitless	δ_s Factor Unitless	K Factor Unitless	Effective Length in
Major Bend(M3)	0.336649	1	1	1	102
Minor Bend(M2)	0.260655	1	1	1	102

Shear Design for V_{u2} , V_{u3}

	Shear V_u kip	Shear ϕV_c kip	Shear ϕV_s kip	Shear ϕV_p kip	Rebar A_v /s in²/ft
Major, V_{u2}	44.577	151.876	0	44.577	0
Minor, V_{u3}	38.039	160.978	0	38.039	0

ETABS Concrete Frame Design

ACI 318-14 Column Section Design



Column Element Details (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (in)	LLRF	Type
8th Floor	C92	646	C 12"x24"	DCon13	0	126	0.434	Sway Special

Section Properties

b (in)	h (in)	dc (in)	Cover (Torsion) (in)
48	24	2.5688	1

Material Properties

E_c (lb/in²)	f'_c (lb/in²)	Lt.Wt Factor (Unitless)	f_y (lb/in²)	f_{ys} (lb/in²)
4415201	6000	1	60000	60000

Design Code Parameters

Φ_T	Φ_{CTied}	$\Phi_{CSpiral}$	Φ_{Vns}	Φ_{Vs}	Φ_{Vjoint}	Ω_0
0.9	0.65	0.75	0.75	0.6	0.85	2

Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3}

Design P_u kip	Design M_{u2} kip-ft	Design M_{u3} kip-ft	Minimum M2 kip-ft	Minimum M3 kip-ft	Rebar Area in²	Rebar % %
919.607	86.6554	101.1568	156.3333	101.1568	11.52	1

Axial Force and Biaxial Moment Factors

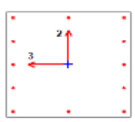
	C_m Factor Unitless	δ_{ns} Factor Unitless	δ_s Factor Unitless	K Factor Unitless	Effective Length in
Major Bend(M3)	0.32607	1	1	1	102
Minor Bend(M2)	0.415615	1	1	1	102

Shear Design for V_{u2} , V_{u3}

	Shear V_u kip	Shear ϕV_c kip	Shear ϕV_s kip	Shear ϕV_p kip	Rebar A_v /s in²/ft
Major, V_{u2}	21.129	167.23	0	21.129	0
Minor, V_{u3}	38.477	177.252	0	38.477	0

ETABS Concrete Frame Design

ACI 318-14 Column Section Design



Column Element Details (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (in)	LLRF	Type
Roof	C31	2970	C1	DCon15	102	126	1	Sway Special

Section Properties

b (in)	h (in)	dc (in)	Cover (Torsion) (in)
48	48	2.5688	1

Material Properties

E_c (lb/in²)	f'_c (lb/in²)	Lt.Wt Factor (Unitless)	f_y (lb/in²)	f_{ys} (lb/in²)
4415201	6000	1	60000	60000

Design Code Parameters

Φ_T	Φ_{CTied}	$\Phi_{CSpiral}$	Φ_{Vns}	Φ_{Vs}	Φ_{Vjoint}	Ω_0
0.9	0.65	0.75	0.75	0.6	0.85	2

Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3}

Design P_u kip	Design M_{u2} kip-ft	Design M_{u3} kip-ft	Minimum M2 kip-ft	Minimum M3 kip-ft	Rebar Area in²	Rebar % %
46.182	16.276	-156.7034	7.8509	7.8509	23.04	1

Axial Force and Biaxial Moment Factors

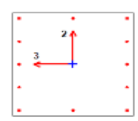
	C_m Factor Unitless	δ_{ns} Factor Unitless	δ_s Factor Unitless	K Factor Unitless	Effective Length in
Major Bend(M3)	0.474097	1	1	1	102
Minor Bend(M2)	0.854584	1	1	1	102

Shear Design for V_{u2} , V_{u3}

	Shear V_u kip	Shear ϕV_c kip	Shear ϕV_s kip	Shear ϕV_p kip	Rebar A_v /s in²/ft
Major, V_{u2}	34.481	0	34.481	34.481	0.2024
Minor, V_{u3}	0.696	204.731	0	0	0

ETABS Concrete Frame Design

ACI 318-14 Column Section Design



Column Element Details (Summary)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (in)	LLRF	Type
2nd Floor	C31	2981	C1	DCon14	0	120	0.489	Sway Special

Section Properties

b (in)	h (in)	dc (in)	Cover (Torsion) (in)
48	48	2.5688	1

Material Properties

E_c (lb/in²)	f'_c (lb/in²)	Lt.Wt Factor (Unitless)	f_y (lb/in²)	f_{ys} (lb/in²)
4415201	6000	1	60000	60000

Design Code Parameters

Φ_T	Φ_{CTied}	$\Phi_{CSpiral}$	Φ_{Vns}	Φ_{Vs}	Φ_{Vjoint}	Ω_0
0.9	0.65	0.75	0.75	0.6	0.85	2

Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3}

Design P_u kip	Design M_{u2} kip-ft	Design M_{u3} kip-ft	Minimum M2 kip-ft	Minimum M3 kip-ft	Rebar Area in²	Rebar % %
1344.625	-156.517	-20.5448	228.5862	228.5862	23.04	1

Axial Force and Biaxial Moment Factors

	C_m Factor Unitless	δ_{ns} Factor Unitless	δ_s Factor Unitless	K Factor Unitless	Effective Length in
Major Bend(M3)	0.735172	1	1	1	96
Minor Bend(M2)	0.839307	1	1	1	96

Shear Design for V_{u2} , V_{u3}

	Shear V_u kip	Shear ϕV_c kip	Shear ϕV_s kip	Shear ϕV_p kip	Rebar A_v /s in²/ft
Major, V_{u2}	15.816	327.309	0	15.816	0
Minor, V_{u3}	7.86	261.847	0	0	0

Fig:4.29 Design of Different Columns

4.2.5 Results of Design:

Floors	Drift due to DL (in)	Drift due to LL (in)	As in Column (in2)	As Top in Beam (in2)	As Bottom in Beam (in2)
Basement	0	0	2711.3635	1049.0915	1357.2576
Ground Floor	0.5	0.05	2707.2	913.1407	1165.8477
1st Floor	0.9	0.1	3080.5914	3275.24	3046.471
2nd Floor	1.2	0.19	3022.1151	2670.0677	2503.632
3rd Floor	1.8	0.37	3168	2538.5342	2420.3704
4th Floor	2.4	0.52	2649.6	2360.3825	2366.6515
5th Floor	3	0.68	2649.6	2441.1071	2480.3068
6th Floor	4.2	0.84	2649.6	2381.4391	2427.6496
7th Floor	5	1	2649.6	2359.8393	2419.3818
8th Floor	6	1.17	2649.6	2299.6824	2374.0981
9th Floor	6.7	1.35	2684.16	2267.2555	2343.8868
10th Floor	7.5	1.45	2684.16	2236.9731	2317.7346
11th Floor	8.4	1.64	2684.16	2237.5638	2323.1701
12th Floor	9.6	1.8	2684.16	1901.0681	2122.1233
Roof	10.12	1.95	2745.5726	1739.936	1887.1671

Table 4.1: Result of Design

4.2.6 Design Results Dashboard:

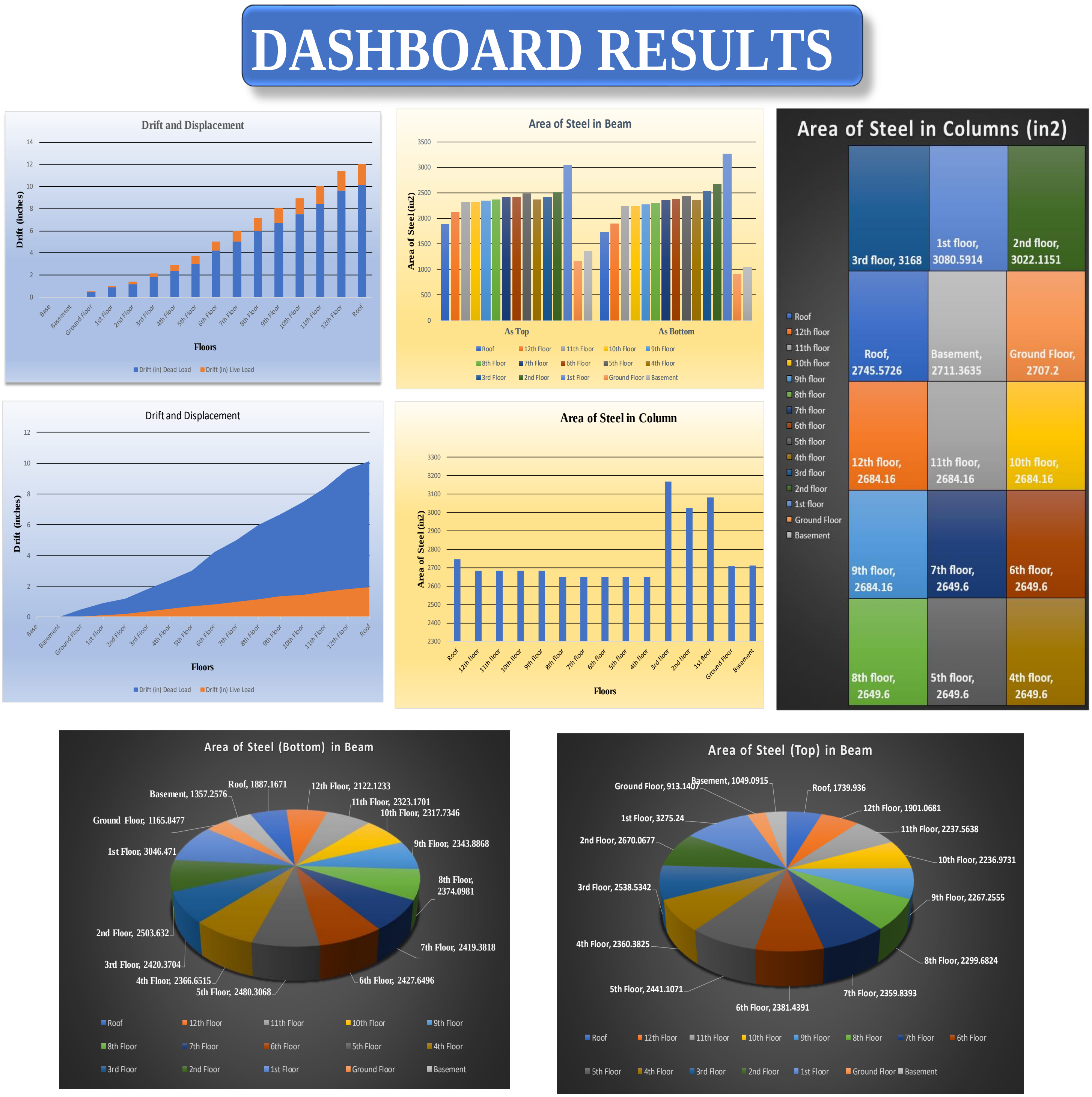


Fig:4.30 Design Results Dashboard

CHAPTER 5

CONCLUSION

5.1 POINT DISPLACEMENT AND DRIFT

- The results show that under the loads, seismic and wind excitations, the bottom storey or Basestorey will carry zero drift.

- The value of drift increases as one moves from the bottom to the top storey, as shown in figure that shows that the upper floors will move and vibrate for long time intervals as compared to the bottom floors.

- An increase in the translation and rotation movement of frame elements was observed as we go from the bottom to the top stories.

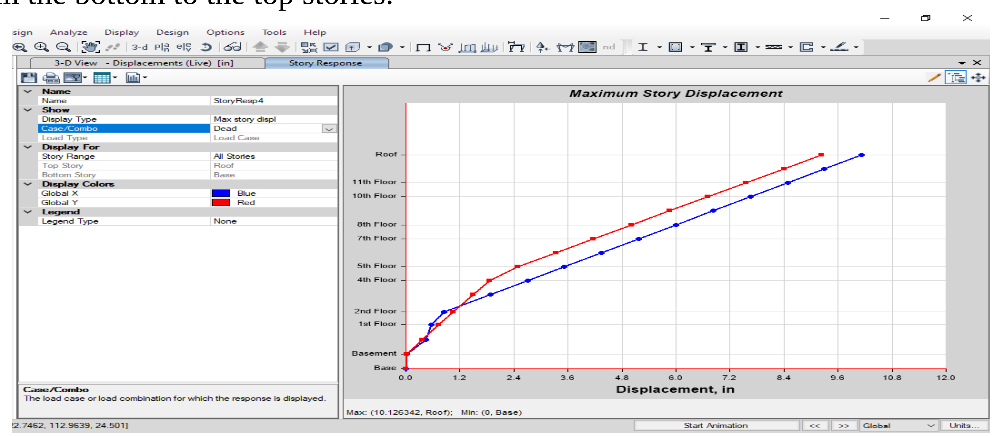


Fig:5.1 Drift due to DL

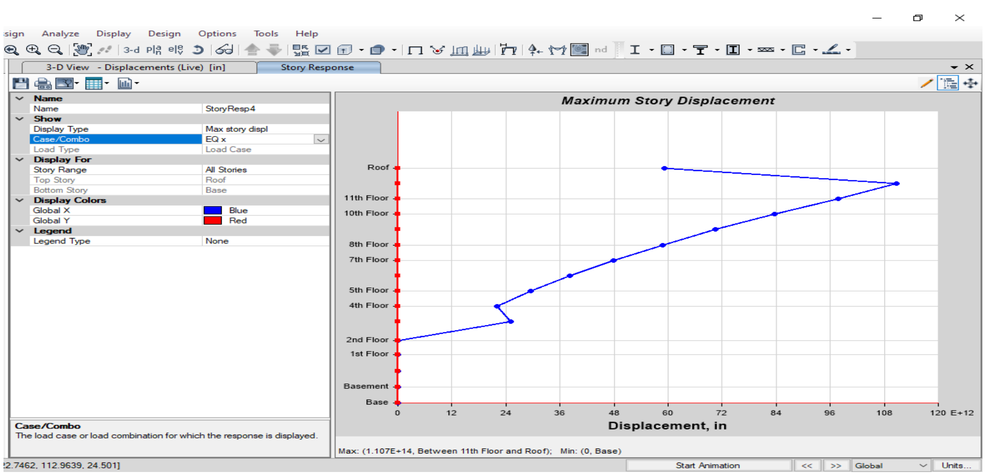


Fig:5.2 Drift due to EQx

5.2 MOMENT AND SHEAR FORCE DIAGRAM

➢ The Bending Moment and Shear Force Diagrams were observed under each load i.e. Dead loads, Live loads, Wind X, Wind Y, EQX, EQY and it was observed that the max values were basically due to Dead Loads or Live Loads, it is also observed that the more bending moment and shear force is created in 1st floor due to the presence of floating column, to resist hic more area of steel is needed in 1st floor both in beams and columns.

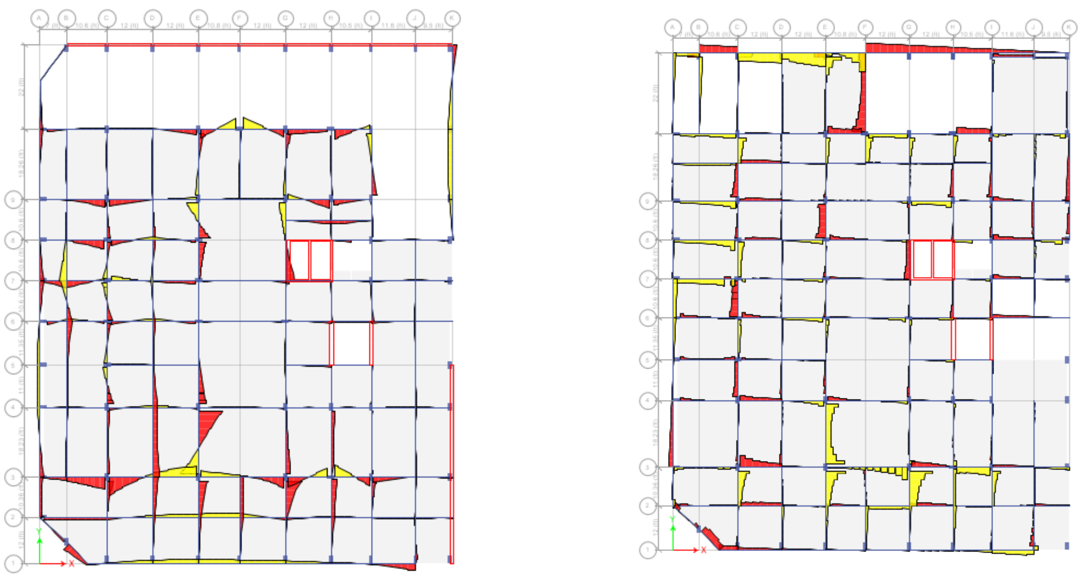


Fig:5.3 SFD & BMD of 1st Floor

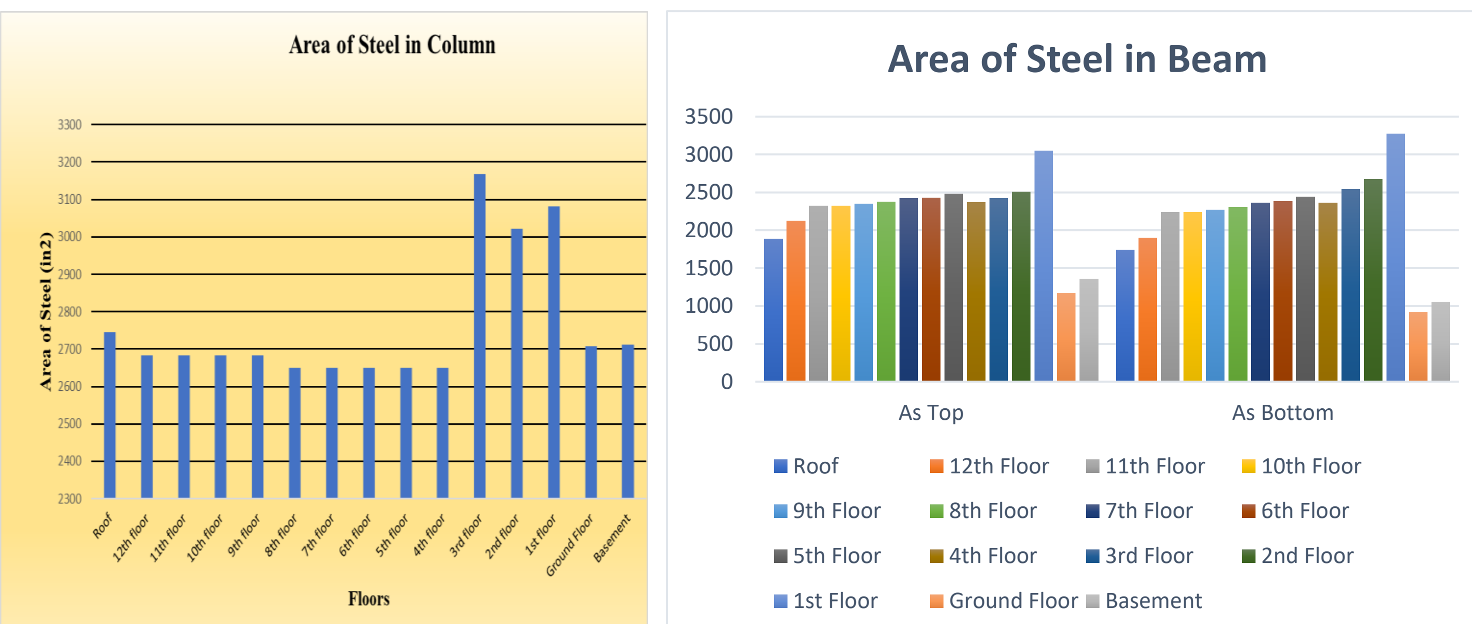


Fig:5.4 Area of steel in column & beams

5.3 DESIGN OUTCOMES

- By following the ACI code 318-14, a detailed design report is obtained that shows various parameters i.e. Section properties, Material properties, Design Moment and Flexural Reinforcement, Shear force and Reinforcement for Shear, Torsion Force and Torsion Reinforcement.

- It is observed from the dashboard that the area of steel in 1st floor is more than any other floor is caused due to the provision of floating column in 1st floor large bending and shear force is created, so to restricted that we have to provide the large no: of steel bar both in column and beams.

- Also, from the dashboard we can see that there is no drift produce in lower stories and drift produce in upper stories are in under permissible limits, as per code for risk category I or II maximum allowable drift is 0.025h ("h" height of structure), our structure has height (h=130ft).

  Allowable drift = 0.025x130ft = 3.25ft

  Here, the maximum drift produce due to the dead load is 10inches, so the structure is safe against drift or displacement.

Table 12.12-1 Allowable Story Drift, Δ_a [a,b]

Structure	Risk Category I or II	Risk Category III	Risk Category IV
Structures, other than masonry shear wall structures, four stories or less above the base as defined in Section 11.2, with interior walls, partitions, ceilings, and exterior wall systems that have been designed to accommodate the story drifts	$0.025h_{sx}$ [c]	$0.020h_{sx}$	$0.015h_{sx}$
Masonry cantilever shear wall structures [d]	$0.010h_{sx}$	$0.010h_{sx}$	$0.010h_{sx}$
Other masonry shear wall structures	$0.007h_{sx}$	$0.007h_{sx}$	$0.007h_{sx}$
All other structures	$0.020h_{sx}$	$0.015h_{sx}$	$0.010h_{sx}$

[a] h_{sx} is the story height below level x.
[b] For seismic force-resisting systems solely comprising moment frames in Seismic Design Categories D, E, and F, the allowable story drift shall comply with the requirements of Section 12.12.1.1.
[c] There shall be no drift limit for single-story structures with interior walls, partitions, ceilings, and exterior wall systems that have been designed to accommodate the story drifts. The structure separation requirement of Section 12.12.3 is not waived.
[d] Structures in which the basic structural system consists of masonry shear walls designed as vertical elements cantilevered from their base or foundation support that are so constructed that moment transfer between shear walls (coupling) is negligible.

Fig:5.5 Allowable story drift

5.4 CONCLUSION:

This research work is based on the comparison between the structure with and without floating column and following conclusion are drawn by this research.

1. From the results it is observed that the building with floating column has more displacement as compared to the building without floating column, so it is recommended the area in which frequently earthquake is occurring, so they construct the building without floating column.

2. It is also observed that the building with floating column need more steel bars to resist both flexural and shear force as compared to building without floating column, but it also has advantages like more space for parking and large halls and reception area.

3. The torsional effect occur during the earthquake cause the sway of the structure which cause the collapse of building, so design it in such way that it can easily take the torsional load without effecting the structure.

As we see from the above points that floating column have some Con’s and Pro’s, selection of floating column in structure depends upon the need if there is necessary to provide open space, we have to remove some columns, but take care while removing the column select those columns which cause less effect on the structure.

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