Analysis and Design of (G+7) RCC Building Using Time History Analysis Method

Submitted in partial fulfilment of the requirements

for the degree of

Bachelor of Engineering

by

Khan Sameena Anwar (15CE02)

Ombilkar Imad Alisab (15CE33)

Shaikh Rehan Abdul Latif (15CE49)

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Under the guidance of

Prof. Shivaji M. Sarvade

Department of Civil Engineering

School of Engineering and Technology

Anjuman-I-Islam's Kalsekar Technical Campus

New Panvel, Navi Mumbai-410206

2018-19

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CERTIFICATE

This is to certify that the project entitled **"Analysis and Design of (G+7) RCC Building Using Time History Analysis Method"** is a bonafide work of **Khan Sameena Anwar (15CE02), Ombilkar Imad Alisab (15CE33), Shaikh Rehan Abdul Latif (15CE49), Syed Zafar Abbas Rizvi (15CE55)** submitted to the University of Mumbai in partial fulfilment of the requirement for the award of the degree of "Undergraduate" in "Civil Engineering"

Prof Shivaji M. Sarvade
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APPROVAL SHEET

This dissertation report entitled **“Analysis and Design of (G+7) RCC Building Using Time History Analysis Method”** by **Khan Sameena Anwar (15CE02), Ombilkar Imad Alisab (15CE33), Shaikh Rehan Abdul Latif (15CE49), Syed Zafar Abbas Rizvi (15CE55)** is approved for the degree of “Civil Engineering”

Examiners

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Supervisors:

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Date:

Place: Panvel

DECLARATION

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

Khan Sameena Anwar (15CE02) …………..

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Date:

ABSTRACT

From last decade India is heading towards development among all fields which leads development of various infrastructure facilities. There should be some primitive measures to construct economical, aesthetical, resistive infrastructure to protect the structures from the seismic forces during earthquake events. Due to occurrence of earthquake in India there has been immense loss of life and property. After this painful loss, the main attention is to give adequate strength to the infrastructure to resist ground motion. It becomes necessary to put one step further with the advancement in the philosophies for earthquake resistance. After Bhuj earthquake IS 1893 was revised and published in the year 2002 and now in 2016, before this incident it was revised in 1984. The code was first published in 1962 as ‘‘Recommendation of Earthquake Resistant design of structure’’ the main reason for the loss of life and economy is inadequate knowledge of structural behaviour under the ground motion. In India, now-a-days infrastructures are highly affected by earthquakes and result in considerable economic losses. To overcome this problem we have studied advances in earthquake analysis and design for realistic prediction of behaviour of structure during earthquake. If the building is designed for realistic behaviour in advance, it shall experience least damage due to earthquake. The current study aims at understanding realistic behaviour of structure under dynamic loads using Time History Analysis with the use of ETABS software.

Keywords—*Dynamic Analysis; Time History Analysis; Response spectrum; IS 1893:2016; ETA*

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ABBREVIATION NOTATION AND NOMENCLATURE

SDOF	Single Degree of Freedom
MDOF	Multi Degree of Freedom
THA	Time History Analysis
MMI	Modified Mercalli Intensity

Chapter 1
Introduction

1.1 General

The Time History response of a structure is simply the response (motion or force) of the structure evaluated as a function of time including inertial effects. The time history analysis in the advanced level of Visual Analysis allows four main loading types. These include base accelerations, base displacements, factored forcing functions, and harmonically varying force input.

Time history analysis is an important technique for structural seismic analysis especially when the evaluated structural response is nonlinear. To perform such an analysis, a representative earthquake time history is required for a structure being evaluated. Time history analysis is a step-by- step analysis of the dynamic response of a structure to a specified loading that may vary with time. Time history analysis is used to determine the seismic response of a structure under dynamic loading of representative earthquake (Wilkinson and Hiley, 2006). Time-history analysis provides for linear or nonlinear evaluation of dynamic structural response under loading which may vary according to the specified time function. Dynamic equilibrium equations are solved using either modal or direct-integration methods. Initial conditions may be set by continuing the structural state from the end of the previous analysis. In time history analyses the structural response is computed at a number of subsequent time instants. In other words, time histories of the structural response to a given input are obtained ad a result. In response spectrum analyses the time evolution of response cannot be computed. In time history analyses the structural response is computed at a number of subsequent time instants. In other words, time histories of the structural response to a given input are obtained ad a result. In response spectrum analyses the time evolution of response cannot be computed .A full time history will give the response of a structure over time during and after the application of a load. To find the full time history of a structure's response, you must solve the structure's equation of motion.

Nonlinear dynamic analysis utilizes the combination of ground motion records with a detailed structural model, therefore is capable of producing results with relatively low uncertainty. In nonlinear dynamic analyses, the detailed structural model subjected to a ground-motion record produces estimates of component deformations for each degree of freedom in the model and the modal responses are combined using schemes such as the square-root-sum-of-squares. In non-linear dynamic analysis, the non-linear properties of the structure are considered as part of a time domain analysis. This approach is the most rigorous, and is required by some building codes for buildings of unusual configuration or of special importance. However, the calculated response can be very sensitive to the characteristics of the individual ground motion used as seismic input; therefore, several analyses are required using different ground motion records to achieve a reliable estimation of the probabilistic distribution of structural response. Since the properties of the seismic response depend on the intensity, or severity, of the seismic shaking, a comprehensive assessment calls for numerous nonlinear dynamic analyses at various levels of intensity to represent different possible earthquake scenarios. Time-history analysis is the behavioural study of a structure under a past earthquake or wind acceleration data. Structure need not be SDOF system. Time-history is a plot of amplitude (or acceleration) vs time. Time History Analysis of Structures is carried out when the input is in the form of specified time history of ground motion.

Time History Analysis is performed using Direct Integration Methods or by using Fourier Transformation Technique. In the Direct Integration Method, there are many integration schemes; two most popular among them are-

i) Duhamel Integration ii) Newmark's B Method. For both of the above two methods, a recursive relationship is derived to find responses at $(k+1)^{th}$ time station for a given K^{th} time station value. In the recent revision of IS 1893-2016 there is a considerable change for adopting time history analysis.

- According to IS:1983-2002 Clause No. 7.8.1

1) Regular Building greater than 40m in height in Zone IV & V & for greater than 90m in Zone II & III.

2) Irregular Building higher than 12m in Zone IV & V & those greater than 40m in height in Zone II & III.

- According to IS:1983-2016 Clause No. 7.7.1

Linear Dynamic Analysis shall be preferred to obtain the design lateral force for all building lower than 15m and in Zone II.

Earthquake is a natural phenomenon occurring with all uncertainties. During the earthquake, ground motions occur in a random fashion, both horizontally and vertically, in all directions radiating from epicenter. These causes structures to vibrate and induce inertia forces on them. An earthquake is the shaking of the surface of the earth, resulting from the sudden release of energy in the earth's lithosphere that creates seismic waves. Since earthquake forces are random in nature and unpredictable, the static and dynamic analysis of the structure have become the primary concern of civil engineer.

Earthquake may cause structural and non-structural damage during seismic actions. Structural damage consist of distress induced in structural components of lateral and gravity-load-resisting system such as beams, column, load bearing walls, and shear wall as well as horizontal diaphragms, such as slab and roof. Seismic damage in structure is caused either by lack of sufficient strength or lack of inelastic deformability. Structure should be designed for ductility & extra lateral stiffening so resistance is increased & damaged is reduced. No discontinuity should be there in load transferring path. Open Ground Storey intended for parking are weak during earthquake. Behaviour of structure during earthquake depends upon the distribution of mass & stiffness in both horizontal & vertical planes of building. Dual design philosophy should be adopted for design of building in earthquake prone area.

1.2 Principle of Earthquake Resistant Design

The building shall withstand with almost no damage to moderate earthquake which have probability of occurring several times during life of a building. The building shall not collapse or harm human lives during severe earthquake motions, which have a probability of occurring less than once during the life of the building.

1.3 Classification of Earthquake

Table 1.1 Classification of Earthquake

Slight	Magnitude up to 4.9
Moderate	Magnitude 5.0 to 6.9
Great	Magnitude 7.0 to 7.9
Very Great	Magnitude 8.0 and above

1.4 Recent Earthquakes in India

Table 1.2 Recent Earthquakes in India

DATE	TIME	LOCATION	LATITUDE	LONGITUDE	DEATH	MAGNITUDE
23 April 2019	9:15 IST	Arunachal Pradesh	28.48° N	94.58° E	16 Dead	5.9
Oct 14 2018	1:41 IST	Southeast Indian Ridge	42.26°N	88.45°E	0	5.9
April 10 2018	0:45 IST	Southwest of Singrauli, India	24.12°N	82.40°E	3houses were damaged and 1 girl was injured in Singrauli.	4.6
June 11 2018	5:53 IST	Southeast of Dhing, India	26.47°N	92.47°E	2	4.9

Jan 3 2017	2:39 IST	Tripura, India	24.015°N	92.018° E	3 were dead 8 people were injured	5.7
March 14 2017	3:51 IST	Andaman Nicobar Island, India	11.68°N	92.77°E	0	6.0
Oct 25 2016	03:30 IST	Nicobar Island	11.7401° N	92.6586 °N	0	4.7
Oct 23 2016	21:27 IST	Assam	26.1359° N	89.9253 °E	0	4.7
Oct 26 2015	02:30 IST	Northern India , Pakistan , Afghanistan	36°14'45" N	71°50'3 8"E	28 in Pakistan , 115 in Afghanistan and 4 in India	7.7
June 28 2015	06:35 IST	Dibrugarh , Assam	26.6°N	90.1°E	0	5.6
May 12 2015	12:35 IST	Northern India , North East India	27.794°N	85.974° E	218	7.3
April 26 2015	12:39 IST	Northern India	27.794°N	85.974° E	Aftershock	6.7
April 25 2015	12:19 IST	Northern India	28.193°N	84.865° E	Aftershock	6.6
March 21 2014	18:41 IST	Andaman and Nicobar Islands	7.6°N	94.4°E	0	6.7
April 25 2012	08:45 IST	Andaman and Nicobar Islands	9.9°N	94.0°E	0	6.2
March 5 2012	13:10 IST	New Delhi	28.6°N	77.4°E	1	5.2
September 18 2011	18:10 IST	Gangtok , Sikkim	27.723°N	88.064° E	118	6.9
August 10 2009	01:21 IST	Andaman Islands	14.1°N	92.8°E	26	7.7
Oct 8 2005	08:50 IST	Kashmir	34.493°N	73.629° E	1,30,000	7.6

1.5 Need of the Project

Metropolitan cities are growing leaps and bounds every day. To accommodate this population there is a trend of constructing Mid-Rise to High-Rise buildings. It is a very common practice in cities like Mumbai to construct buildings of seven stories for residential purposes. The study aims at forming a guideline to design the structures as per the revised IS 1893-2016 guidelines which insists use of Dynamic analysis procedure for almost all buildings.

1.6 Organization of Report

First chapter gives an introduction to the study followed by the literature review to form the theoretical background for the study. Third chapter presents computational modelling of the structure followed by results of the study. Fifth chapter presents the conclusions of the study and presents the future scope.

Chapter 2

Literature Review

2.1 General

In the review of literature below everyone carried out the analysis on RCC building to know the realistic behaviour of building when the seismic load is acting on a building during the earthquake. All of them uses Time History Analysis method for their analysis and designed a structure. They use this time history method because time history gives realistic response. The structures designed by using time history method are economical as compared to the structure designed from another method.

2.2 Review of Literature

S.M. Wilkinson and R.A. Hiley in September, 2005 performed an analysis on model to understood a non-linear response of high-rise framed buildings. Because of the nature of earthquakes, a dual design philosophy had been adopted for the design of buildings in earthquake prone regions. The first design criterion was to ensure that little or no damage is suffered during an earthquake that can reasonably be expected to occur during the life-time of the structure. The second was that the building does not collapse during the most severe probable earthquake that could occur at that site. The corollary of this was that if the building had to remain cost effective the second criterion would make it necessary to design the building in-elastically. This was the reason that all buildings designed in regions where earthquakes pose a serious threat to infrastructure are in some way designed in-elastically. Three main methods was used to analyse buildings subjected to earthquakes. They were:

1. Response history analysis.
2. Response spectrum analysis.
3. Quasi-static method.

The most commonly employed method was the quasi-static method, as it was the simplest, requires only static analysis, and estimates the response of the structure for an ensemble of earthquakes. The response spectrum method was identical to the quasi-static method except that it considered more than just the fundamental mode of vibration. Most codes require enough modes of vibration are considered to account for 90% of the modal mass. For the quasi-static method and the response spectrum method, the earthquake forces was divided by a behaviour factor (also known as a structural response factor or response modification coefficient). This factor accounts for the reserve strength of the building after the formation of the first plastic hinge and allows a pseudo inelastic design to be achieved without complicating the analysis. The only extra requirement to account for inelastic behaviour was for the designer to choose an appropriate building behaviour factor. Typically, this was done by choosing a value from a table in a relevant earthquake code. This was simple and reasonably effective but it was overly conservative. The various ductility factors had been arrived at empirically based on past experience of structural behaviour during earthquakes and based on generalised analysis of simple models of various building types. Thambiratnam and Thevendran proposed a 5 degree of freedom model to analyse high-rise buildings. Wilkinson and Thambiratnam extended this model to consider more accurately the rotations at the columns. The stiffness of each floor was modified by a factor to account for the contribution of horizontal elements and the configuration and variation of columns. The model was extended to inelastic analysis, by Wilkinson and Hiley by adding a torsional spring to the top and bottom of each column before assembling the stiffness matrix, instead of a modification factor being added to the final stiffness matrix. These torsional springs were successively modified as progressive yielding occurred. The problem with these models was that they lump the behaviour of all elements in a floor into a single element which approximates the ensemble behaviour of individual elements. For a small reduction in computational efficiency it is possible to provide a (static) degree of freedom for each connection and thus model the hysteretic behaviour of each connection in detail, individually. For the case of high-rise buildings, the floors of the buildings are assumed to be rigid diaphragms enabling the lateral displacement of each floor to be modelled by only one degree of freedom.

Badhora Bagheri, *et.al.*in2012 studied on multi-storey irregular buildings with 20 stories had been modelled using software packages ETABS and SAP 2000v.15 for seismic zone V in India. Their study also deals with the effect of the variation of the building height on the structural response of the shear wall building. Dynamic responses of building under actual earthquakes, El-centro 1949 and Chichi10 Taiwan 1999 had been investigated. This paper highlights the accuracy and exactness of time history analysis in comparison with the most commonly adopted response spectrum analysis and equivalent static analysis. The main objective of this paper was to study the seismic behaviour of concrete reinforced building. Also, analysis of structure by using equivalent static method, time history method and response spectrum method had been surveyed. The storey displacements and displacement of center of mass result had been obtained by using both static and dynamic analysis. The pertaining structure of 20 stories residential building had been modelled. The storey plan was changing in the different floors. The building had been analyzed by using the equivalent static, response spectrum and time history analysis, based on IS Codes; the results obtained were compared eventually to determine the structural performance. In this paper they explain various method for analyzing earthquake:-

A. Equivalent Static Analysis.

B. Time History Method.

C. Response spectrum method.

The pertaining structure of 20 stories residential building with the general form of plan shown in figure had been modelled. The storey plan was changing in the different floors was shown in fig.

Height of first floor = 3m,

Other floor height =3.2m

Base plan dimension in x and y direction =23.4m and 18.6m

Loading was applied according to IS:875 part 1 and part 2 of IS:1893

Section including all beam and column:

Storey 1 to 5 column 70x70mm , Storey 5 to 12 column 56x25mm

Storey 10 to 20 column50x50, Storey 1 to 10 Beam size 65x65

Storey 10 to 20 Beam size 45x45, Slab =170mm.

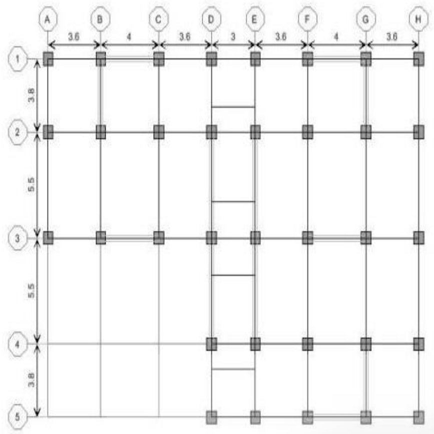

Figure 2.2 6th to 10thFloor Plan[1]

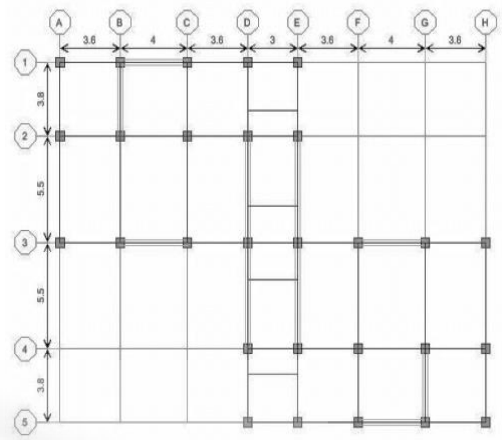

Figure 2.1 11th to 15thFloor Plan[1]

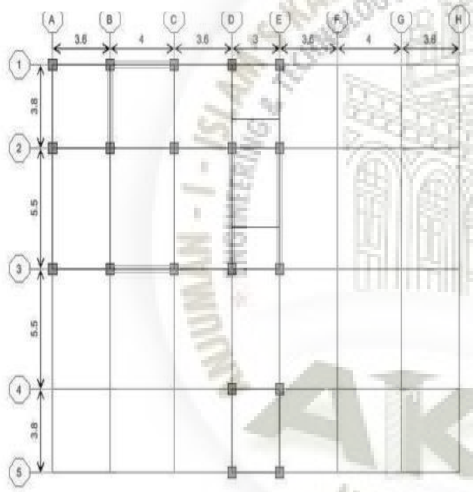

Figure 2.3 16thFloor Plan[1]

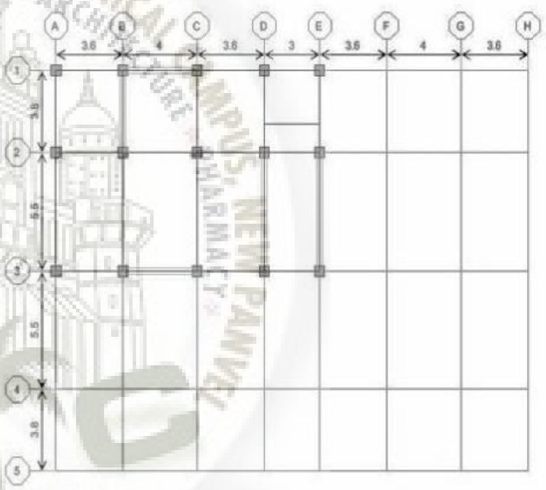

Figure 2.4 17th to 20th Floor Plan[1]

After their analysis they come to conclusion that comparison between three mentioned analysis it was observed that the displacement obtained by static are higher than dynamic analysis including response spectrum and THA. THA is an elegant tool to visualize the performance level of a building under a earthquake.

Nina Zhengand Jing Zhou in 2012 studied on non-linear time history response analysis of low masonry structure with tie-columns. A low masonry structure was the main structural style for buildings in small or medium-sized cities, villages, towns and the countryside in China. The non-linear behaviours of masonry structures under seismic actions were an important issue. To investigate the seismic performance of masonry structures, non-linear history analysis of a masonry model in a shaking table test with core-tie-columns, which was defined by Yingmin (2010), are carried out using the software ABAQUS. The non-linear dynamic time history response analysis of the masonry model are carried out by using the implicit dynamic finite element analysis in the software ABAQUS. The analysis results are compared with those measured from the shaking table test. The two-storey analysis model was as same as the masonry structures model with core-tie-columns in the shaking table test, the height of both floors was 2.8m, and the width of all masonry wall in the model was240mm. The floor in the model was made by some precast hollow concrete slabs, and the thickness of the slab was 120mm. the transversal wall were all solid and the two longitudinal walls were with doors and windows. The masonry walls were built by M15 fired perforated brick and M1.5 cement mortar. The live uniform loads of the first and second floors were 1.8KPa and 1.0 KPa, respectively. There were four core-tie-columns at the four corners of the model. And there were reinforced brick ring beams.

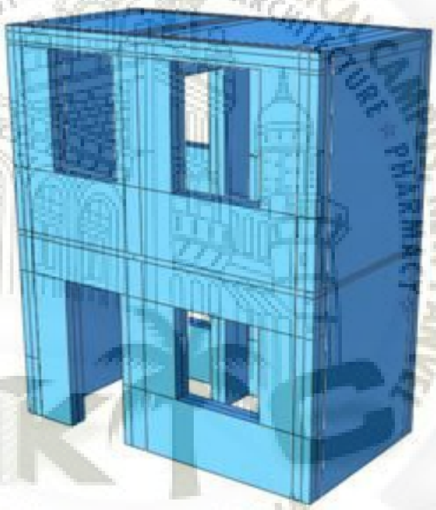

Figure 2.5 Analysis model[2]

The model was built and analyzed by using the software ABAQUS. All the elements such as masonry walls, reinforced concrete floors and core-tie-columns were separation simulated using the three-dimensional reduced integration solid elements named as C3D8R and T3D2. The steels was embedded into the concrete entity. The wall was meshed into two units along the walls thickness direction and the grid size was 120mm. While the wall were meshed into rectangular shape along the length and height of the wall and the grid sizes were not greater than 240mm. The three-dimension finite analysis model is shown in Fig. 2. All the components, such as the walls, the core-tie-columns and the floors are combined together through assembly type named tie. The final model weight was 29.27 tons, and the test model's dead-weight was 29.19 tons. Error between was 0.27%.

Based on the non-linear time history analyses of the masonry model and contrasts on the test, they made some conclusions that the non-linear seismic response analysis of masonry structure under severe earthquake action can be simulated by choosing simple plastic kinematic model and defining appropriate failure criteria with the aid of ABAQUS, and the analysis accuracy was satisfied to some extent. The damage occurs at the corners of doors and windows where the stress concentrations were big. With the earthquake action continuing, the bottom of masonry structure would be damaged severely. Tensile failure images of the model about concrete damage plasticity can simulate the failure characteristics of the masonry structure, constitutively.

A S Patil and P D Kumbhar in August, 2013studied non-linear dynamic analysis of 10-storied RCC building considering different seismic intensities. The analysis was carried out and a seismic response of such building was studied. In this paper 5 different time histories had been used considering seismic intensities V, VI, VII, VIII, IX and X on Modified Mercalli's Intensity scale (MMI) for establishment of relationship between seismic intensities and seismic responses. The results of the study shows similar variations pattern in seismic responses such as base shear and storey displacements with intensities V to X. From the study it was recommended that analysis of multi-storeyed RCC building using Time History Method.

They carried out this analysis to analyze a multi-storeyed RCC framed building (10 Storey) for available earthquake time histories considering different earthquake intensities (i.e., V, VI,VII, VIII, IX and X).Also to compare seismic behaviour of multi-storeyed RC framed building for different earthquake intensities in terms of various responses such as, base shear and displacements. To find the relationship between earthquake intensities and responses. In this paper firstly they explain about type of seismic analysis in which they gave general information on Equivalent static analysis, Non linear static analysis, Linear dynamic analysis, Non linear dynamic analysis.

The finite element analysis software SAP 2000 Nonlinear was utilized to create 3D model and run all analyses. The software was able to predict the geometric nonlinear behaviour of space frames under static or dynamic loadings, taking into account both geometric nonlinearity and material inelasticity. For the study they had taken a ten storied masonry in filled RCC building is considered. The geometry and dimensions of plan had shown in Figure.

Live Load on Typical floors - 3.5 KN/m^2

Live Load on Terrace - 2 KN/m^2

Column size - 0.5 m X 0.5 m

Beams size - 0.23 m X 0.45 m

Slab Thickness - 0.150 m

Brick wall Thickness -0.230 m

Density of Concrete - 25 KN/m^2

Density of Brickwall-20 N/m^2

Modulus of Elasticity for Concrete - 25 KN/m^2

Modulus of Elasticity for Brick wall - 10.5KN/m^2

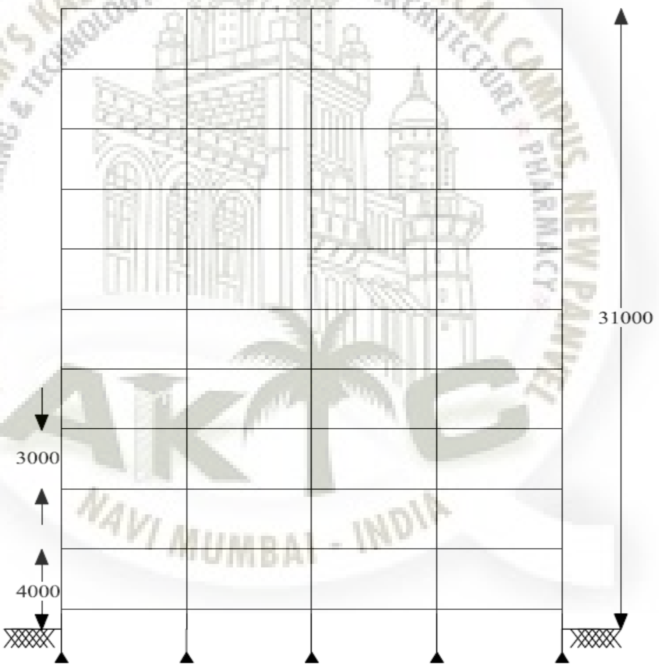

Figure 2.6 Elevation[4]

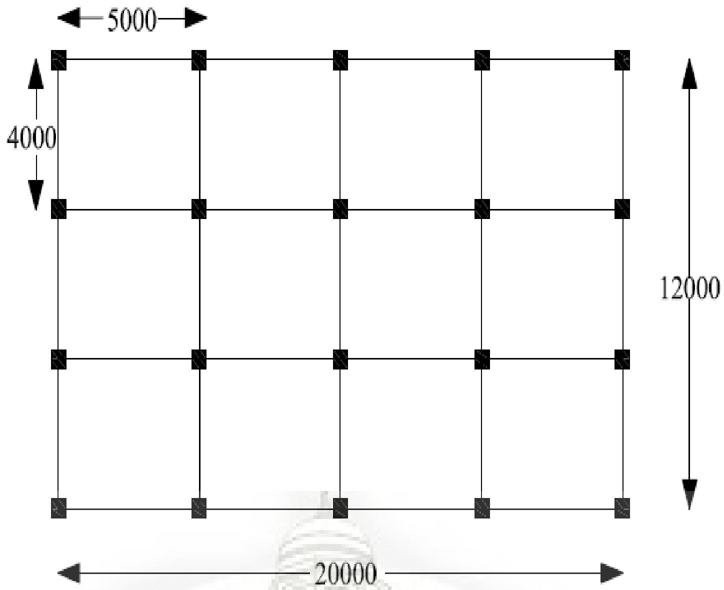

Figure 2.7 Plan[4]

After their analysis they come to conclusion that :-

1. The seismic responses namely base shear, storey displacements and storey drifts in both the directions was found to vary in similar pattern with intensities (V to X) for all the Time Histories and both the models considered for the study.

2. The values of seismic responses namely base shear, storey displacement and storey drifts for all the Time Histories and both the models was found to be of the increased order for seismic intensities varying from V to X.

3. The values of base shear, storey displacements and storey drifts (X and Y directions) for seismic intensities of VI, VII, VIII, IX and X are found to be more by 1.85, 3.56, 7.86, 15.1, and 17.15 times, respectively as compared to seismic intensity of V for both the models (i.e., with and without soft story) and for all the time histories.

4. As Time History is realistic method used for seismic analysis it provides a better check to the safety of structures analyzed and designed by method specified by IS Code.

S.K Dubey in 2015concluded that because of the nature of earthquake a dual design of philosophy had to be adopted for the design of building in earthquake prone region those building which do not fullfill the requirement of seismic design may suffer extensive damage or collapse if earthquake occur seismic evaluation reflects the seismic capacity of earthquake for future use. Therefore it was necessary to study variation in seismic behaviour of multi-storeyed RC building in term of variation response such as displacement & base shear. The main object of the project was to study the seismic behaviour of an concrete reinforced building. Therefore we can analyse building by response spectrum or time history analysis method. The pretaining structure was modelled of G+20 & also the story mass was changing on every floor. The methods here was used are time history analysis method and response spectrum method. Time history analysis method is a dynamic response method of the structure at every increment of time when in base subjected to a specific ground motion time history. It is also known as non-linear dynamic analysis to perform such an analysis a representative earthquake time history is required for structure being evaluated. There was two type problem associated with it.

a. It was difficult to use an appropriate loading of earthquake.

b. It was to computer-intensive to be practical especially if in elastic analysis.

Response Spectrum Method :-The representation of the maximum response of idealized SDOF having certain period an damping during earthquake ground motion. It was also known as linear dynamic analysis in this method peak response of structure during an earthquake was obtained directly from the earthquake response. The peak response is combined to estimate a total response.

Here analysis was being done for - G+20 multi-storey (rigid joint frame) building by computer software using STAAD-Pro by taking preliminary data required as below :-

1. Type of structure -Multi-storey rigid jointed 3-D frames

2. No of storey - G+20, twenty stories

3. Seismic Zones- IV

4a. Floor height - 3.0m.

4b. Depth of foundation 2.0m

5. Building height - 60.00m

6. Plan size - 24.50 x 21.00m

7. Total area - 514.5sqm

8. Size of columns - 0.50x0.50 m

9. Size of beams - 0.30m x 0.60m

10. Walls- (a) External- 0.20m (b) Internal 0.10m

11. Thickness of slab- 125 mm

12. Imposed load- 4.00kN/m^2

13. Floor finish - 1kN/m^2

14. Specific wt. of RCC- 25 KN/m^3

15. Specific wt. of infill-20 KN/m^3

16. Material used-Concrete M-30 and Reinforcement Fe-415(HYSD Confirming to IS-1786)

17. Earthquake load - As per IS-1893-2002
18. Type of soil - Type -III, Soft soil as per IS-1893
19.E_c =5000√fck N/mm^2 (E_c is short term static modulus of elasticity in N/mm^2)
20.F_{cr}= 0.7√fc k N/mm^2 (F_{ck} is characteristic cube strength of concrete in N/mm^2)
21. Dynamic analysis - (a) Response spectrum method (b) Time history analysis
22. Software used - STAAD-Pro dynamic analysis
23.Specified characteristic compressive Strength of 150mm cube at 28 days For M-25 grade concrete - 25 N/mm^2
24. Reinforcement used - 415 High strength deformed steel Confirming to IS-1786.It was having modulus of Elasticity as 200 KN/mm^2
25. Fundamental natural period of building Ta = 0.075 h$^{0.75}$ for moment resisting RC frame building without infills Ta = 0.09 h√d for all other building I/c moment resisting RC frame building with brick infill walls Where h = height of building = base dimension of building at plinth level in m along the considered direction of lateral forces.
26. Zone factor Z as per Is-189-2002 Part -1 for different. Zone as per clause 6.4.2

Table 2.1 Zone Factor as per IS Code Clause no. 6.4.2

Seismic Zone	II	III	IV	V
Zone Factor F	0.1	0.16	0.24	0.36
Seismic Intensity	Low	Moderate	Severe	Very Severe

In his study he was doing study for zone –IV
27.I=Importance factor :- Depending upon the fundamental use of the structures and economic importance. All other buildings = 1.0 Importance service and community building as I = 1.5. For his study he had taken importance factor = 1
28. R=Response reduction factor:-Depending on the perceived seismic damage performance of the structure.
(I) for ordinary RC moment resisting Frame (OMRF) is = 3.00
(II) Special RC moment resisting frame (SMRF) is = 5.0
For his study he had taken reduction factor = 3
29. Average Response acceleration
Coefficient Sa/g - for medium soil sites
Sa/g = 1+15T = 0.00≤T≤0.1 2.5 = 0.1≤T≤0.55 1.36/T = 0.55≤T≤4.00

30. Design horizontal seismic coefficient Ah for structure: Ah =Z /2 x I R x Sa/ g 31 Seismic wt. of building - Sum of the seismic wt. of floors

32. Design lateral force or design base Shear along any principal directions = Ah W where Ah = (Z/2) x (I/R) x (Sa/g)

33. Vertical distribution of base shear to different floors levels

$Qi = (Vb \times Wihi^2)/(\Sigma Wihi^2)$

where Qi = Design lateral force at floor i

Wi = seismic wt. of floor i

Hi = height of floor hi measured from base

N=no. of stories in the building in the no. of levels at which masses are located.

He conclude that for high rise building it was necessary to provide dynamic analysis (Response spectrum analysis or Time history analysis) because of nonlinear distribution of forces. He also said that for important structure time history analysis should be performed it predicts the structural response more accurately & the displacement value will depend upon frequency of earthquake and natural frequency of the structure. After his analysis he also came to conclusion that the base shear value obtained in case of response spectrum analysis are more as compared to time history analysis as its depends on the frequency content of the earthquake data. Storey displacement greater in time history analysis as compared to response spectrum analysis. It was also observed that the base shear is greater in response spectrum analysis compared to time history analysis thus it can be concluded that time history analysis is economically better for designing.

Shashank Bedekar, R. R. Shinde in May, 2015studied how will be the structural behaviour of any building using different accelerogram. Time history analysis was an important technique for structural seismic analysis especially when the evaluated structural response was nonlinear. To perform such an analysis, a representative earthquake time history was required for a structure being evaluated. This research paper describes the results of an extensive the seismic behaviour of structure under different earthquake accelerograph like El Centro, Bhuj, Killari In this work an attempt was made to analyze high rise structure with the help of Esoftware. This work had selected Time History Analysis for analysis purpose of high rise structure with G+25 stories. Time history of earthquake at various places like El Centro, Bhuj, Killari was used for analysis of selected high rise structure. After that comparative study was made between selected places. At first study of all places without damper was made. In this work constant loading parameters was used, also same plan was used for various models of time history. Load combinations was taken from IS code. Risk of damage from future earthquakes. Such designs was based on the specification of ground motion Earthquake resistant design of engineering structures is one of the most important methods of mitigating which can be expected in the event of an earthquake. However, for earthquake design of some important structures like dams and nuclear power plants, located in seismically active areas, it was desirable to have a reliable site-specific design accelerogram. Available records of strong ground motion, after suitable modifications, had been used in the past for detailed dynamic analysis of engineering structures. However, synthetic accelerograms was now increasingly being used in earthquake engineering. Knowledge of regional and local seismicity and seismotectonics, earth model and source characteristics of the design earthquake was required for this purpose. The time history response of a structure was simply the response (motion or force) of the structure evaluated as a function of time including inertial effects. The time history analysis in the advanced level of visual analysis allows four main loading types. These include base accelerations, base displacements, factored forcing functions, and harmonically varying force input. Analysis of a structure over increment time steps as a function of acceleration, force, moment or displacement. Time history analysis was considered to be more realistic compared to response spectrum analysis. It was most useful for very long or very tall structures (flexible structures).

Table 2.2 Model Description

Name of parameter	Value	Unit
Number of stories	25	Nos
Storey height	2.9	M
Total height of the structure(above GL)	77.6	M
Length in long direction	31.60	M
Length in short direction	15.47	M
Dead load , live load, Floor Finish	2.64,2,1	KN/mm^2
Thickness of Deck	150	Mm

They concluded that time history of Bhuj earthquake is more hazardous than time history of Koyna earthquake. Also they said that displacement due to Bhuj Earthquake (case 1) is approximately double as compare to Koyna Earthquake (case 2).Avg. axial force and base shear in case of Bhuj earthquake is greater than Koyna earthquake for selected building plan.

Nilesh Mevawala, Dr. Atul Desai in May-July, 2016 studied the seismic Non-Linear Time History Analysis of building resting on sloping ground (Nepal earthquake study). This study investigates the seismic performance of buildings situated in hilly areas, the buildings situated in hilly areas were generally irregular, torsionally coupled and hence, susceptible to serve damage when affected by earthquake ground motion. The main objective was to understand the behaviour of building on sloping ground for various time history (dynamic analysis).To study the effects of seismic forces on the building, different types of buildings were modelled on different ground slopes and in addition to this variation in storey of the building was also considered. As per their study soil of Nepal was heaving sedimentation composed of rock such as lime stone, dolomite, meta sand stone, quartzite. Hence for accurate seismic response fixed condition at foundation, soil contact was considered.

Table 2.3 Geometry of Building

Size of Column:-300mmx850mm,Size of Beam:- 230mmx500mm, Live load:- 3 KN/M^2		
Sr. No.	Ground slope	No of storey
1	15°	G+05
2	15°	G+10
3	23°	G+05
4	23°	G+10
5	35°	G+05
6	35°	G+10

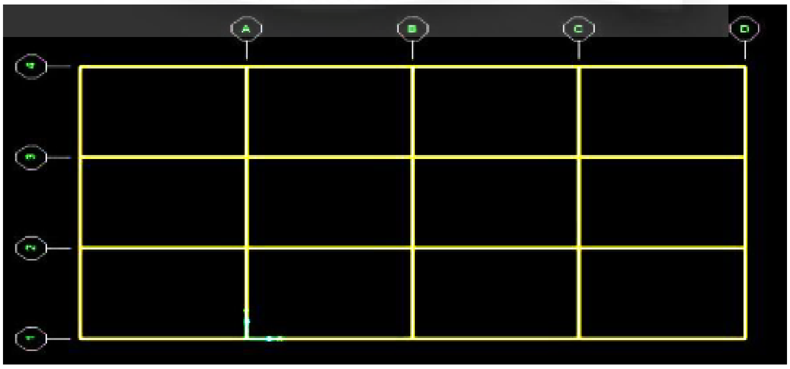

Figure 2.8 Plan[6]

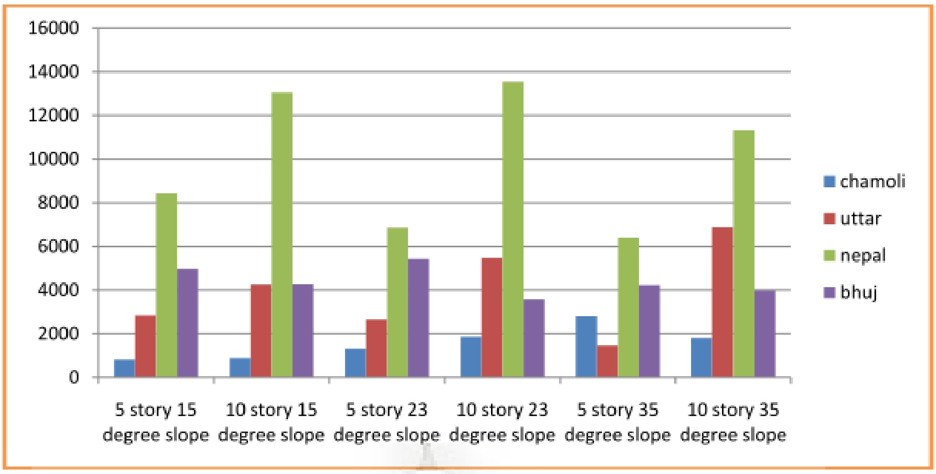

Figure 2.9 Bending moment comparison KNM[6]

The following assumptions was made in the analysis.

a) Material was homogenous, isotropic and elastic.

b) The values of modulus of elasticity and Poisson's ratio were 25000 N/mm2 and 0.20, respectively.

c) Secondary effect P-delta, shrinkage and creep were not considered.

d) The floor diaphragms was rigid in their plane.

e) Axial deformation in column was considered.

f) Each nodal point in the frame has six degrees of freedom, three translations and three rotations. Torsion effect was considered as per IS : 1893 (I) –2002. In addition to time history analysis of all building and response spectrum analysis of all building was also carried out the following data are used for response spectrum analysis.

1) Seismic zone: - Zone V

2) Zone Factor: - 0.36

3) Importance Factor: -1.0

4) Response Reduction Factor:- 5

5) Soil type:- medium

Based on the study they concluded the following:-

1.) As compare to building on level ground, building response on slopes required very special care for safety.

2.) The displacement response of building in Nepal for earthquake was more as compared to others, such as Chamoli, Uttarkasi and Bhuj.

3.) The bending moment and displacement increases as the slope of ground increase, for all type of earthquake.

Table 2.4 Regular & Irregular Building Specification

Specifications	Data
No of storeys	10
No of bays along X direction	10
No of bays along Z direction	7
No of bays along X direction	44 m
No of bays along Z direction	28 m
Concrete grade used	M25
Columns	450×450 mm
Beams	450×230 mm
Slab thickness	125 mm
Unit weight of concrete	25 KN/m3
Live load	3 KN/m3
Dead load	1.5 KN/m3
Zone	II
Soil condition	Hard soil
Damping ratio	5%

4.) The shear force, bending moment and displacement increases as the height of building increases.

5.) They were getting maximum displacement, bending moments and shear force for Nepal time history for all the cases so they conclude that Nepal earthquake occurred in 2015 had very severe effect on all the buildings constructed on sloping grounds.

Md. Saleem,*et.al*. inOctober 2017 carried out the analysis in which there main intention of the study was to evaluate (or) estimate the seismic analysis vulnerability and response of regular and irregular shaped multi-storey buildings context of India. Linear time history analysis had been performed to learn about the influence of shape of a building on its response to various loading. 10-storied regular shaped (rectangular, and L-shape) and irregular shaped (Plan Irregularities, Vertical Irregularities, stiffness irregularity) buildings had been modelled using software ETABS 2016 for Hyderabad (seismic zone 2), India.Earthquake had continually been a hazard to human civilization and all other living organisms. From the day of its existence, damaging human lives, property and man-made structures.Earthquake is an unpredictable disaster therefore there was continuous research work going on around the globe, revolving around development of new and better strategies that can be incorporated in structures to overcome damages of seismic forces.

The following are the major conclusions that they made based on analysis carried on the RC buildings with different types regular and irregular building (taken in dimensions shown above) analyzed in Time history method, Earthquake forces in the seismiczoneII using ETABS Software 2016.From the Base shear curves that the magnitude of Base Shear decreases in regular type building.In irregular building displacement in X and Y directions was decreasing compared to regular buildings in both X & Y directions.Themajor conclusions that they made based on present work carried upon the RC buildings withdifferenttypes Regular and Irregular building (taken in dimension) analyzed in timehistory method, Earthquake forces in the seismic zone II using ETABS Software 2016 was that there would be increase in the bases shear, storeydisplacement andstorey drift in irregular buildingthanin regular building.

Anil Suthar& S. M. Suthar in September,2017carried out the analysis on (G+10) RCC building to know the realistic behavior of building during earthquake.According to them seismic safety of building should had more importance. Hence, it was necessary to take in to account the seismic load for the design of high-rise buildings. Seismic loads were required to be carefully modeled so as to assess the real behaviour of a structure with a clear understanding that damage was expected but it should be regulated. They said that Time History Analysis was carried out when evaluated structural response was non-linear in nature.

During Kobe earthquake, in Japan two buildings were found to be seriously damaged due to mass irregularity as a swimming pool was located at the 10th floor. Here excess mass leads to increase in lateral inertia forces, reduced ductility of vertical load resisting elements and increased possibility towards collapse. Excess mass on higher floors produce more unfavorable effects than those at lower floors. They said that Time history analysis was a step-by-step analysis of the dynamic response of a structure to a specified loading that may vary with time. Time history analysis was used to determine the seismic response of a structure under dynamic loading of representative earthquake. They modeled a building for Indian seismic zone III IS:1893-2002. Plan dimension in X and Y direction is 30 m and 20.0m respectively. The buildings had following dimensions, Columns size 300mm x600mm, All beam size 300mm x 450mm. Floor slabs were taken as 150mm thick. The height of all floors was 3.25m. Soil type was hard. Modal damping 5% was considered. Material concrete grade was M35 Steel Fe500 was used. For a given structure, loading which was applied includes live load, earthquake load and dead load which was according to IS 875 Part I, Part II and IS 1893:2002 respectively. Live load on Staircase = 2.5 kN/m^2, Live load on floor slab = 2.5 kN/m^2, Live load on terrace floor = 3.5 kN/m^2, Staircase = 1.5 kN/m^2, WC and Bath = 2.5 kN/m^2, Terrace floor slab = 1 kN/m^2 , Floor slab = 1.5 kN/m^2.

Table 2.5 Different Time Histories

Place	Magnitude	Year	P.G.A
Elcentro	6.7	1940	0.36
Kobe	6.9	1995	0.60

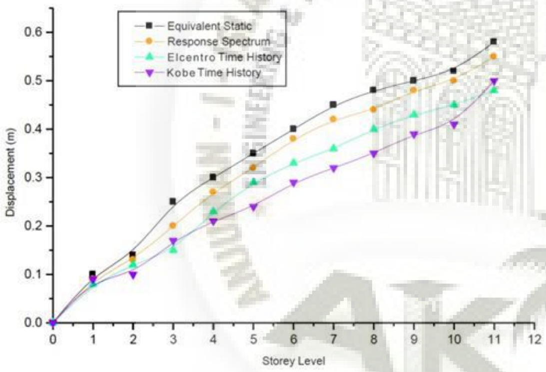

Figure 2.11 Variations in Storey Displacement for Y direction[8]

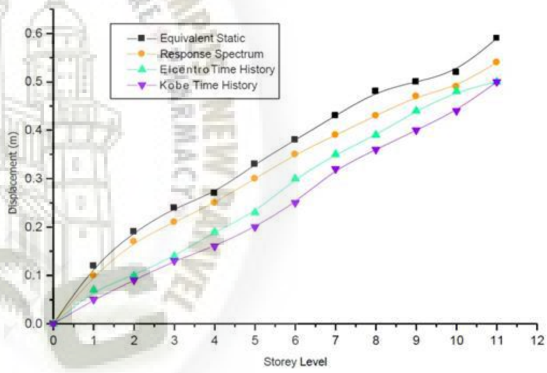

Figure 2.10 Variations in Storey Displacement for X direction[8]

Above graph shows variations in results in X direction and Y direction for storey displacement. The main reason for this change being due to variable mass at different floors. According to them Equivalent static analysis and response spectrum methods fail to catch the same. As Time History Analysis was realistic method used for seismic analysis, it provides a better check to the safety of structures analyzed and designed as compared to Equivalent static analysis and Response spectrum methods.

Pruthviraj N Juni, *et.al*. in March, 2017analyse a multi-storeyed RCC (G+23) building for different earthquake intensities and the response of such building due to earthquake was studied**.** The building was modelled with the help of SAP2000 v.14.00software. Five different time histories had been used with seismic intensities V, VI, VII, VIII, IX and X on MMI for developing the relationship between seismic intensities and seismic responses.

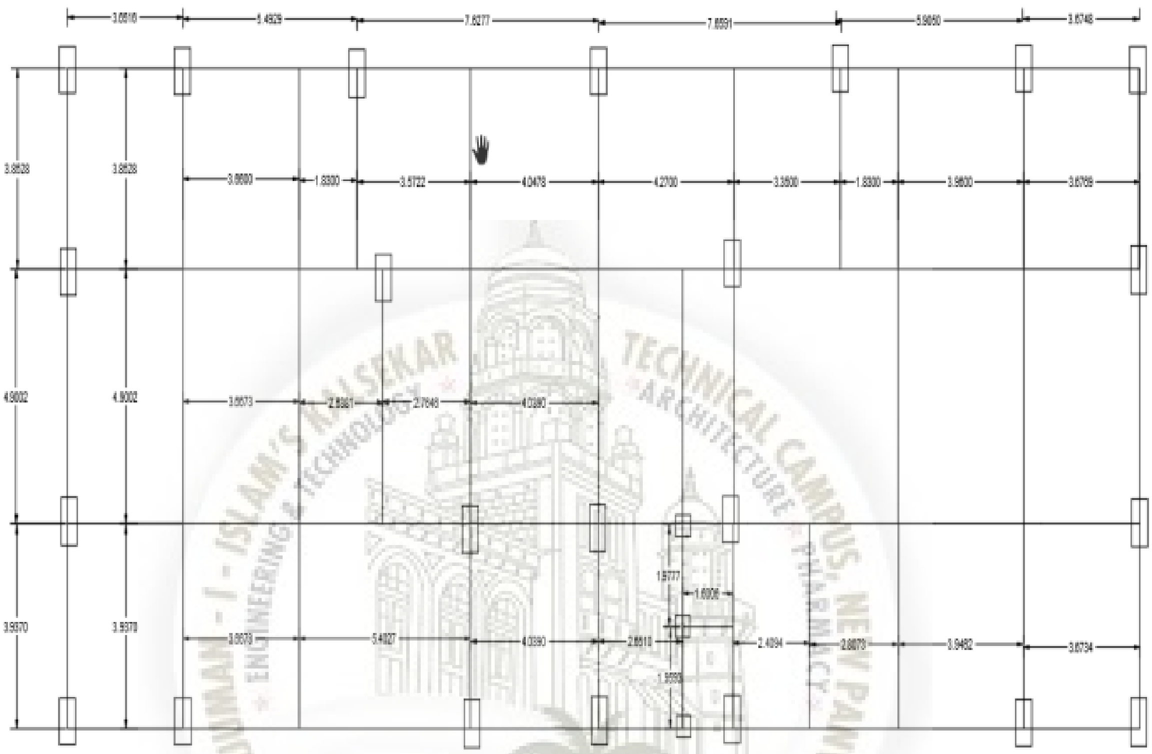

Figure 2.12 Structural Plan[9]

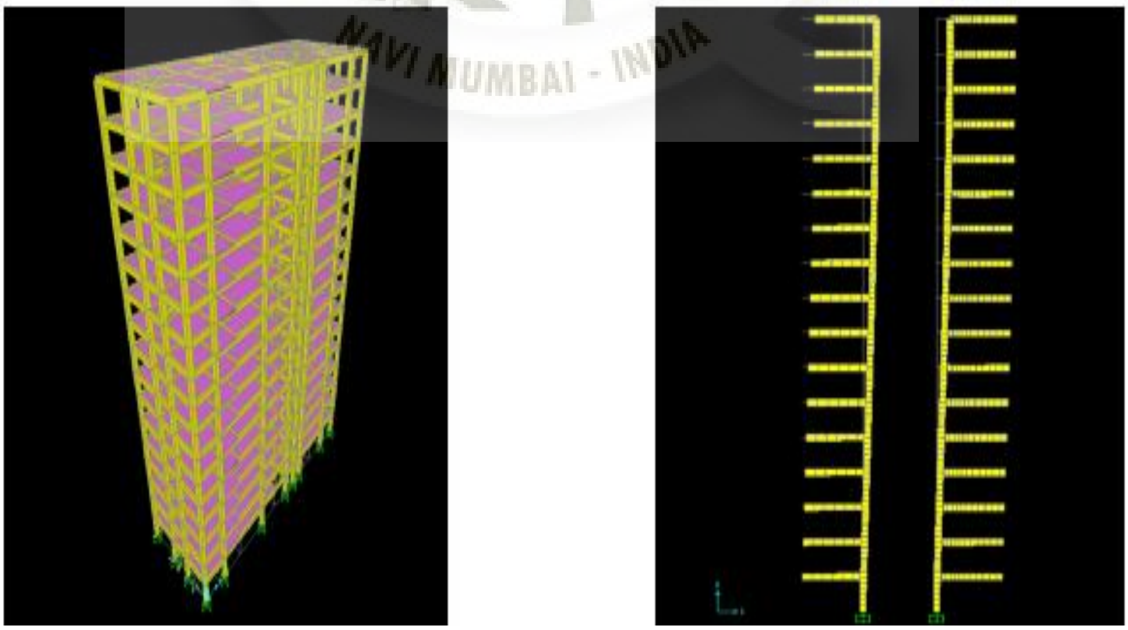

Figure 2.13. Displacement Model in SAP & Model in SAP[9]

Table 2.6 Different Time History

Sr no	EQ	Date	Magnitude richer scale	P.G.A.G
1	Bhuj, India	26-Jan-01	6.9	0.11
2	Koyana, india	11-Dec-64	6.5	0.489
3	Anza, USA	25-Feb-80	4.7	0.11
4	Nahanni, Canada	23-Dec-85	6.9	0.489
5	Northbridge, USA	17-Jan-94	6.7	0.489

Figure 2.14 Architectural Plan[9]

Table 2.7 Materials

Material/Section	Grade/Size	Unit	Material/Section	Grade/Size	Unit
Concrete grade	M30		Slab thickness	0.15	M
Steel grade	Fe500		Wall thickness	0.23	M
E (Concrete)	27386.12788	N/mm^2	Density of concrete	25	KN/m3
E (Steel)	210000	N/mm^2	Density of brick work	20	KN/m3
Beam	0.4 x 0.6	mm	Live load	3	KN/m2

Table 2.8 Result (Variation base shear for X direction)

S.No.	Intensity MMI	Base shear(KN)				
		Bhuj	Koyana	Anza	Nahanni	Northbridge
1	V	666.48	866.424	904.38	1011.48	904.93
2	VI	1666.4	1948.38	2004.48	2211.43	2103.49
3	VII	2665.954	3004.98	3218.32	3400.59	3411.98
4	VIII	3998.391	4108.4	4900.32	5109.66	5003.4
5	IX	5998.39	6211.389	6811.43	7098.42	6911.3
6	X	8331.1065	9013.42	10004.39	11049.61	10940.11

Table 2.9 Result (Variation in base shear for Y direction)

S.No.	Intensity MMI	Base shear(KN)				
		Bhuj	Koyana	Anza	Nahanni	Northbridge
1	V	888.651	930.44	1102.43	1390.11	1750.39
2	VI	2221.62	2444.92	2780.44	3001.29	23640.11
3	VII	3554.62	3842.46	4100.39	4400.41	4711.39
4	VIII	5331.9	5711.39	6008.82	6344.92	6748.31
5	IX	7997.86	8211.79	8411.99	8791.79	9124.48
6	X	11108.142	11209.4	11600.11	12001.92	12409.18

From the study they concluded the following:

1. The seismic responses namely base shear, storey displacements and storey drifts in both the directions was found to vary in similar pattern with intensities (V to X) for all the Time histories.

2. The values of seismic responses namely base shear, storey displacement and storey drifts for all the Time histories was found to be of increased order for seismic intensities varying from V to X.

Shaikh Ibrahim *et.al*. in Feb, 2017 carried out this research for high strength and better performance characteristics of floor and roof systems to be designed to carry gravity loads and transfer these loads to supporting beams, columns or walls. Furthermore, they play a key role in distributing earthquake-induced loads to the lateral load resisting systems by diaphragm action. When building structures was subjected to dynamic loadings, the induced inertial forces are transmitted through floor slabs and resisted by vertical structural components such as shear walls and frames. In this situation, the floor slabs function as diaphragms placed between the vertical components. In analysis and design of three dimensional structures under seismic loading, the diaphragms were frequently assumed to be perfectly rigid. In certain type of structures, however, this assumption was found to create significant discrepancy on the lateral load distribution. This discrepancy frequently occurs in frame-wall structures, in which the vertical components consist of shear walls with high storey stiffness and relatively flexible frames. Therefore, in this research work analytical parametric studies was done on high rise structures with simple frame and plate frame structures. Many urban multi-storey buildings in India had open first storey as an unavoidable feature. This was primarily being adopted to accommodate parking or reception lobbies in the first storey. Whereas the total seismic base shear as experienced by a building during an earthquake is dependent on its natural period, the seismic force distribution was dependent on the distribution of stiffness and mass along the height. The behaviour of a building during earthquakes depends critically on its overall shape, size and geometry, in addition to how the earthquake forces was carried to the ground. The earthquake forces developed at different floor levels in a building need to be brought down along the height to the ground by the shortest path; any deviation or discontinuity in this load transfer path results in poor performance of the building. Buildings with vertical setbacks (like the hotel buildings with a few storey wider than the rest) cause a sudden jump in earthquake forces at the level of discontinuity. Buildings that have fewer columns or walls in a particular storey or with unusually tall storey tend to damage or collapse which was initiated in that storey. Many buildings with an open ground storey intended for parking collapsed or were severely damaged in Gujarat during the 2001 Bhuj earthquake. Buildings with columns that hang or float on beams at an intermediate storey and do not go all the way to the foundation, have discontinuities in the load transfer path.

They carried this research to analyze the multi-storied building with mass irregularity during response spectrum for safety of structure. Also for modelling and analyzing effect of mass irregularity for different stories location of multi-storeyed commercial building and to analyze multi-storeyed commercial building by using E-tabs software as per IS 1893(Part 1):2002 and IS 456-2012 codes. They had also carried out comparative study of structural parameters like base shear, storey drift, displacement of commercial building.

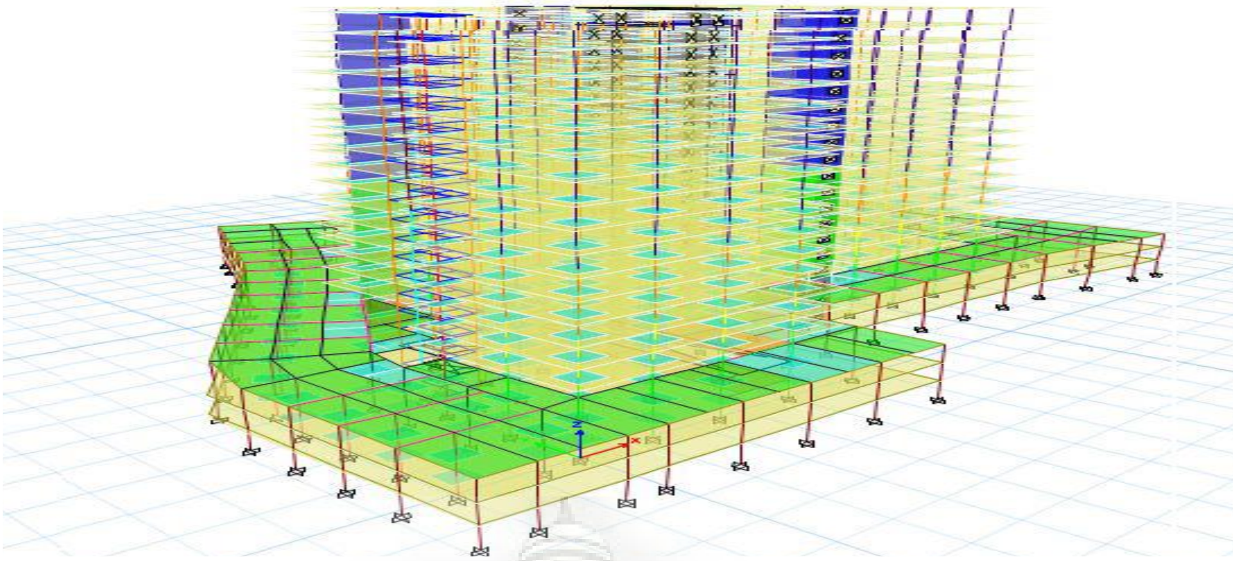

Figure 2.15 Geometry of the Structure[10]

They concluded that the structure displaces maximum of 125mm for the load case EQy, because of unsymmetrical plan in Y direction, which was less than the permissible limit of 241.6mm (0.4% of building height). And the maximum story shear of magnitude 1795 ton was observed in EQx load case. The seismic demand in the capacity spectrum method could be represented by inelastic spectra. In principle, any realistic inelastic spectra could be used. However, they should be compatible with the basic elastic spectrum. The specific demand spectra applied in their paper was simple and reasonably accurate for a broad range of design situations. It had been shown that the performance evaluation procedure, called the N2 method, which can be formulated in the format of the capacity spectrum method. Furthermore, by reversing the procedure, a direct deformation-based design can be performed.

Chetan Chhinda, Pankaj Autadein 2018analysed the six story shear building subjected to base ground motion excitation. The time history records of ground motion for Bhuj earthquake was used for understanding the response of the structural system. A multi-degree freedom system (MDOF) six story shear building with four columns per story at a grid size of 3m x3m having 4m height of columns was subjected to horizontal translational ground motion at base. The size of columns was 400mm x 400mm and floor was with slab thickness of 125mm. In order to perform mathematical analysis, the following assumptions was made to do idealization of building:

a) The total mass of the structure was concentrated in the form of lumped mass at levels of all floors. The beams and floor systems was considered rigid.

b) The motion of structure at all floors was predominantly lateral and in same direction to that of ground motion. The six story shear building would have six degrees of freedom in translation, one at each floor.

c) The axial deformation and forces in beams and columns were neglected.

Result and conclusion: a)The mode shapes obtained from ETABS were compared with theoretical mode shapes by normalizing at the top floor for each mode. It was observed that the mode shapes obtained from ETABS are exactly matching with the theoretically calculated mode shapes.

b)The building system was analyzed using Equivalent Static Method theoretically and using ETABS software and the story shear force results were observed to be same in both the case.

c)Storey Shear forces obtained by linear modal time history analysis of the six storey shear building performed using Newmark's Linear Acceleration Method was compared with ETABS. The storey shear forces due to applied ground excitation by theoretical and ETABS time history analysis vary by 2%.

d)The response of building in terms of story displacement was also compared. There was approximately 3% of variation in the displacement of floors.

e) The variation in the results of the floor displacement response was 1 to 3%.

Ashwin Hardiya & Arpit Chawda in January, 2018 studied on time history analysis of vertical irregular buildings to came to know how will be the actual behaviour of structure during earthquake. They said that the factors responsible to failure of structure under seismic are:

(i) Wrong and weak structure configuration and irregularities in planning phase.

(ii) Lesser strength and ductility considerations in design phase.

(iii) Unplanned and non-scientific construction activities and sequences.

In there research G+19 multi-storey building of plan dimensions 30m x 25m, beam size 325x425 mm, column sizes for Storey 1-7 =625mmx625mm, Storey 8-14 = 525mmx525mm, Story 15-19 = 425mmx425mm was modelled with different vertical irregularities i.e. Setback and mass irregularity and analyzed with various time history data(Holliste and Yermo).The setback irregularities considered in the modelling were as follows:

1. Model A consist of 6x5 bay up to top floor.
2. Model B consist of 6x5 bay up to 10 floor. 2x2 bay up to top floor (corner position).
3. Model C consist of 6x5 bay up to 10 floor. 2x2 bay up to top floor (center position).

4. Model D consist of 6x5 bay up to 10 floor. 2x2 bay up to top floor (edge position).

Building response was planned to test with ETABS software defining all dimensional parameters and material properties. Analysis was to be performed for vertical irregularities in different time history.

Table 2.10 Time History Analysis (Holliste vsYermo)

	Holliste			Yermo		
Model	Base reaction (KN)	Displacement (mm)	Stress (N/mm^2)	Base reaction (KN)	Displacement (mm)	Stress (N/mm^2)
A	2978.89	147.36	964.89	3931.94	201.71	1109.76
B	2421.99	143.08	904.83	3098.93	206.05	1027.64
C	2510.35	138.83	809.54	3284.83	221.43	927.57
D	2566.12	158.28	986.87	3391.78	224.56	893.15

They concluded that four models are considered and modelled in ETABS and two time histories was considered to analyse the models. It was recommended that ETABS can be successfully considered and employed to analyse such cases and buildings considering various time histories.

2.3 Critical Comment on Literature

- Equivalent static analysis is not sufficient when building are irregular building and if they belong to higher seismic zones. It is essential to analyse using dynamic analysis for insights into behaviour of structure under dynamic loads.
- Time history analysis gives better prediction of the structural behaviour compared to other methods of dynamic analysis.
- The irregular configuration of building is more vulnerable to seismic forces hence regular configuration shall be selected. It is unavoidable then all irregularities shall be properly modelled and design shall be verified using Time History Analysis.
- The bending moment and displacement increases as the slope of ground increase for all type of earthquake.

- The shear force, displacement is increases as the height of building increases.
- Static analysis is not sufficient for high rise building and it's necessary to provide dynamic analysis (because of specific and nonlinear distribution of forces).

2.4 Problem Definition

To analyse and design (G+7) RCC building according to IS 1893 using Time History Analysis to resist the seismic force acting on the building.

2.5 Objectives

Following are the objective of project

- To understand the seismic design.
- To analyse the structure under seismic loads.
- To analyse and design (G+7) building by using dynamic (time history analysis) using ETABS software.

2.6 Methodology

To achieve above mentioned objectives, following methodology will be adopted.

i. Study of fundamentals of seismic design.

ii. Review of existing literature pertaining to design of structures with time history analysis

iii. Selection of plan and its mathematical modelling in ETABS software.

iv. Analysis and Design of the structure as per relevant clauses of IS 1893-2012

2.7 Aim

The project aims to analyse and design (G+7) RCC building by Time History Analysis.

2.8 Scope

This project is confined to study the behaviour of regular structure under the influence of seismic load action. Linear Time History analysis is performed and effects of non- linearity is ignored for the present study. No soil structure interaction is considered.

Chapter 3
MATHEMATICAL MODELLING

3.1 General

To perform any sort of analysis i.e. linear/non-linear, static/dynamic it is necessary to develop a computational model. Hence in this chapter we will discuss the parameters defining the computational models and the geometry of the selected building considered for this study. The whole chapter describes about the properties of the materials used for designing, the modelling procedure followed, calculation of base shear as per IS code and obtained RCC design and finally summarizes the whole structure.

3.2 Description of Structure

The dimensions of the building 37.42m X 14.18m. In elevation building has G+7 floors with each floor having height of 3m. Hence total height of building is 21m. The plan of the building is as follows. The building is located in Mumbai which means it has seismic zone III and zone factor=0.16. It is for the residential purpose and thus importance factor is assigned as1.

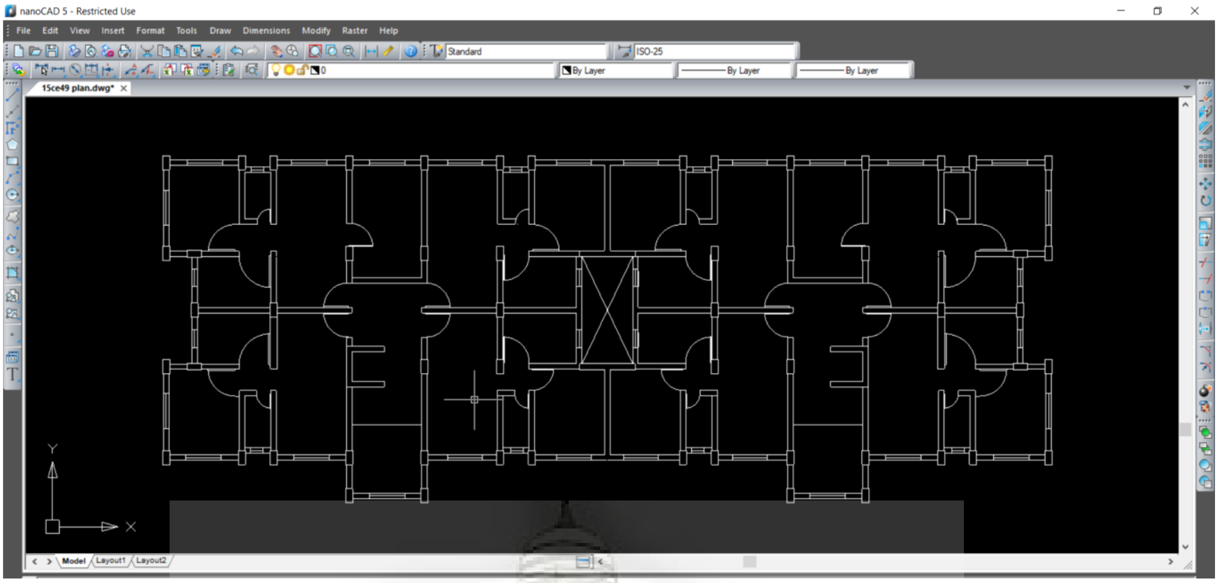

Figure 3.1 Architectural Model

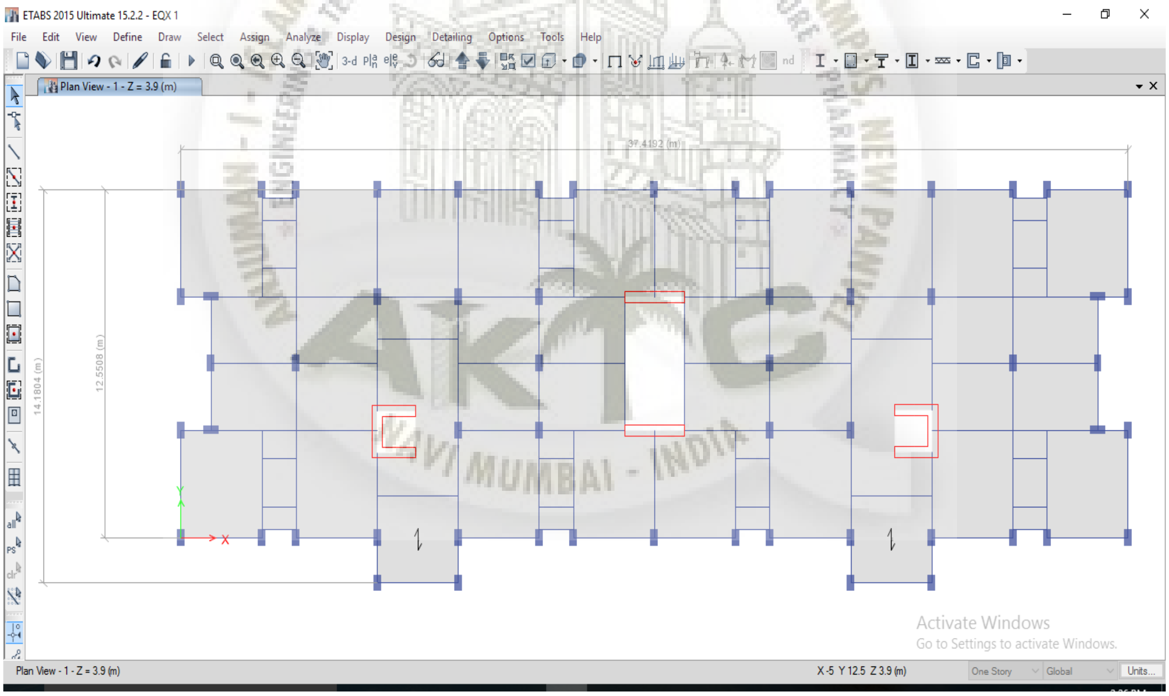

Figure 3.2 ETABS Model

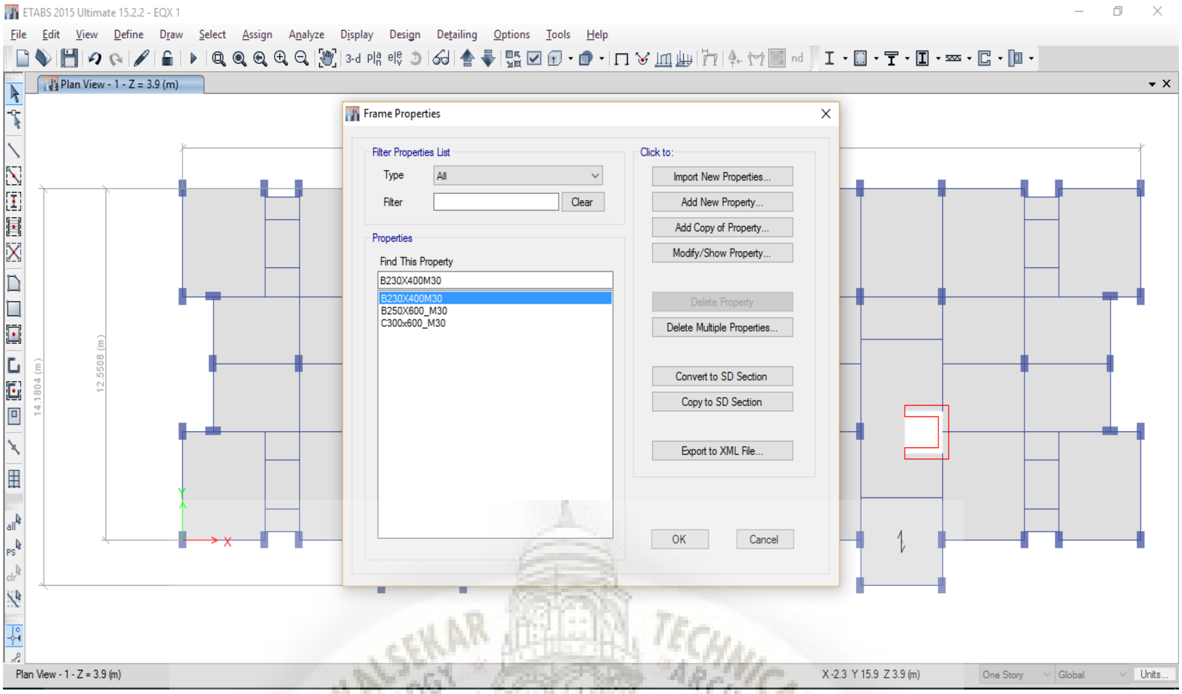

Figure 3.3 Frame section

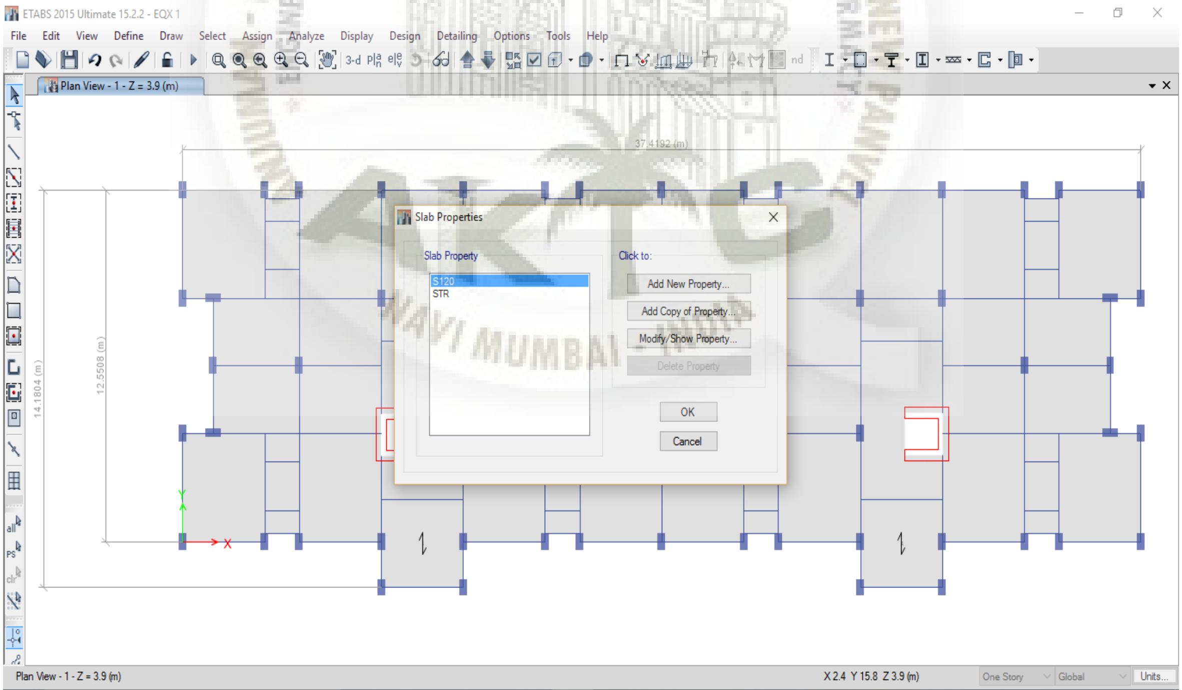

Figure 3.4 Slab section

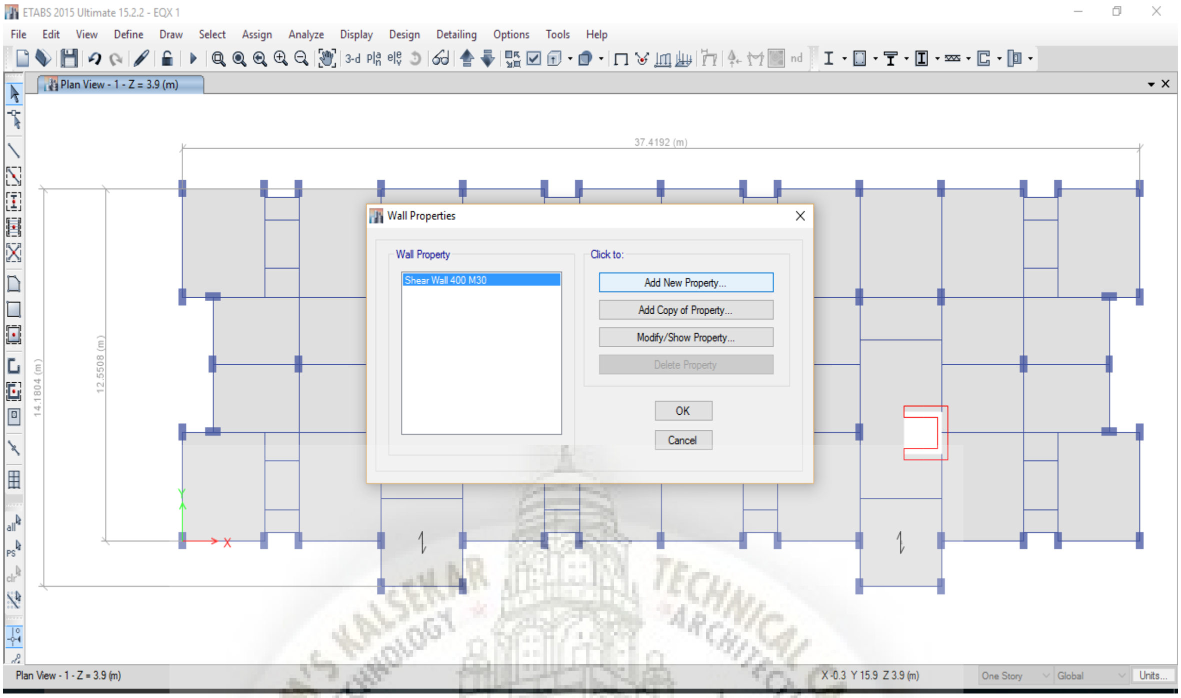

Figure 3.5 Wall section

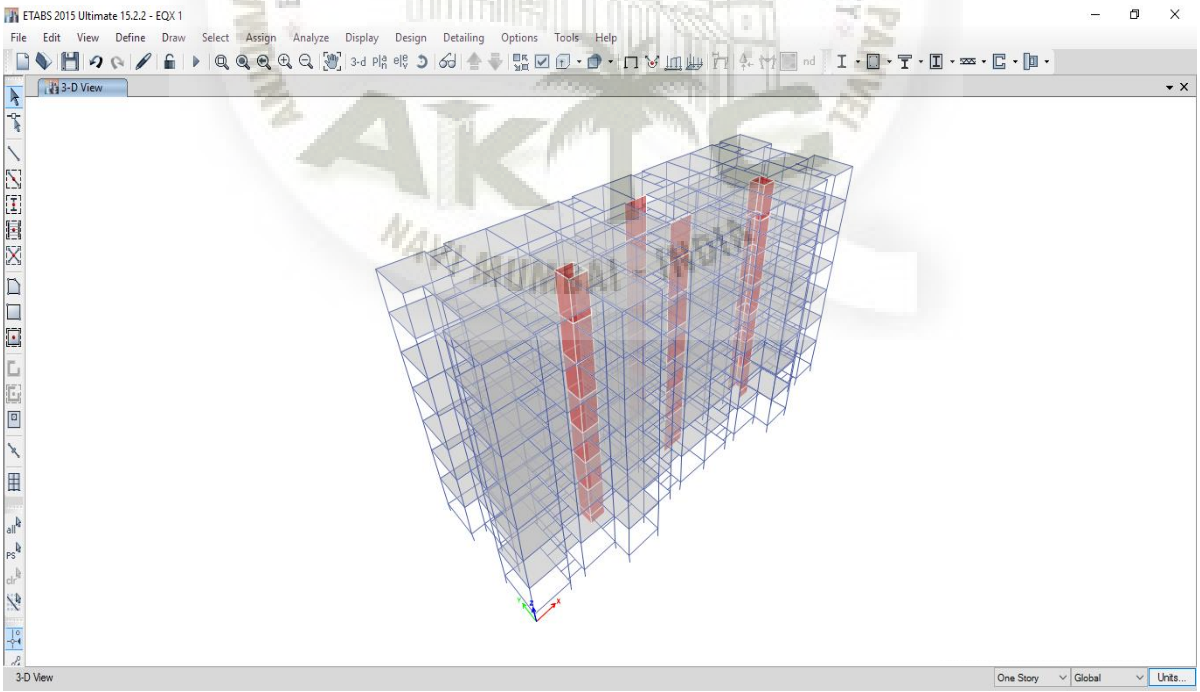

Figure 3.6 3D Structural Model

3.3 Structural Element

The dimensions of the elements of the structure were:

Beam :a) 250 mm x 600 mm of M30concrete

b)230 mm x 400 mm of M30 concrete

Column: 300mm x 600 mm of M30concrete

Slab Thickness: 120 mm, TwoWay, M30.

Staircase slab: 150mm, One Way, M30

Shear Wall Thickness: 400 mm, M30

Diaphragm: RigidD1

3.4 Seismic Design Data

The behaviour of building during earthquake depends on various parameters which governs the intensity of earthquake. Before analysis it is necessary to assume certain values of these parameters to make study more coherent. Since the building is located in Mumbai, the seismic zone is Zone-III as per IS1893-2002. Associated parameters are listed in the following table.

Table 3.1 Seismic Design Data

Design Parameters		
Sr. No.	Design Parameter	Value
1	Seismic Zone	III
2	Zone factor	0.16

3	Response reduction factor	3
4	Importance factor	1
5	Soil type	Medium
6	Damping Ratio	5%
7	Frame type	Dual System

3.5 Material Properties

Table 3.2 Material Properties

Material Properties		
Sr. No.	Design Parameter	Value
1	Unit weight of concrete	25 kN/m^3
2	Characteristic Strength of concrete	30 MPa
4	Characteristic Strength of Steel	500 MPa
6	Damping ratio	5%

3.6 Load Considerations

The types of load considered during the design were:

1. Self weight of beam and column.
2. Self weight of slab.
3. Weight of masonary walls.
4. Floor finish 1.5KN/m^2 on floors and 2KN/m^2 on circulation areas (Staircases).
5. Live load of 2KN/m^2 on floors and 3KN/m^2 on circulation areas (Staircases).

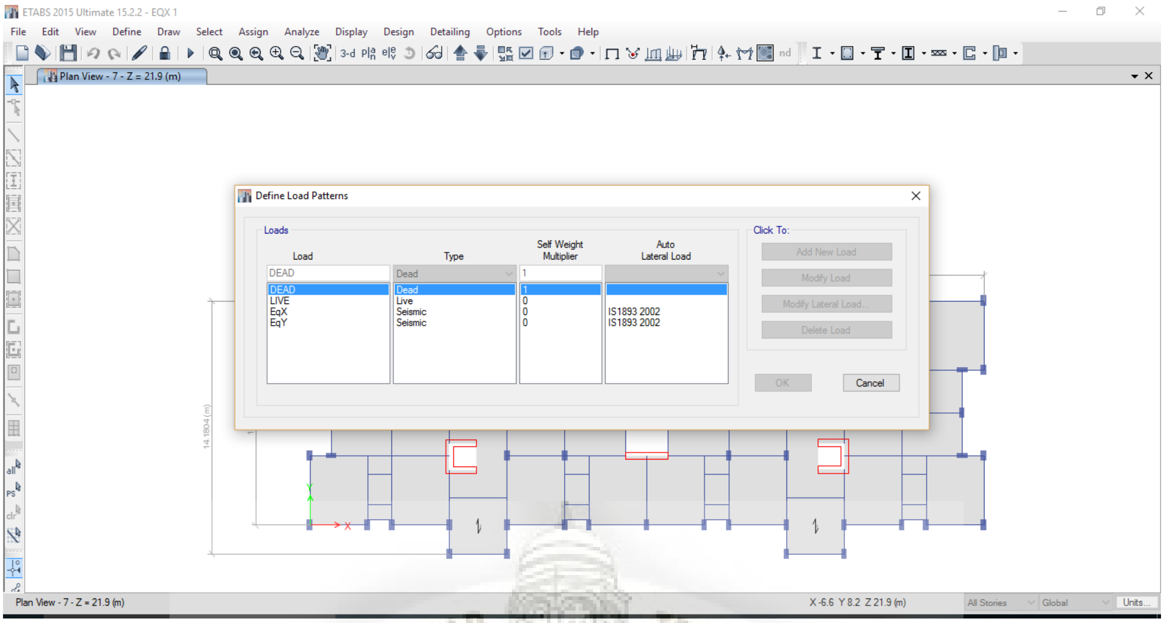

Figure 3.7 Load Patterns

The lateral loading in X and Y direction floor wise are as follows.

Story Response Values

Story	Elevation m	Location	X-Dir kN	Y-Dir kN
7	21.9	Top	929.7773	0
6	18.9	Top	1327.0351	0
5	15.9	Top	939.1891	0
4	12.9	Top	618.2131	0
3	9.9	Top	364.1071	0
2	6.9	Top	176.8711	0
1	3.9	Top	56.5051	0
PLINTH	0.9	Top	2.1753	0
BASE	0	Top	0	0

Figure 3.8 Lateral Loadings in Y Direction

Story Response Values

Story	Elevation m	Location	X-Dir kN	Y-Dir kN
7	21.9	Top	0	929.7773
6	18.9	Top	0	1327.0351
5	15.9	Top	0	939.1891
4	12.9	Top	0	618.2131
3	9.9	Top	0	364.1071
2	6.9	Top	0	176.8711
1	3.9	Top	0	56.5051
PLINTH	0.9	Top	0	2.1753
BASE	0	Top	0	0

Figure 3.9 Lateral Loadings in Y Direction

Chapter 4
RESULT AND DISCUSSION

4.1 General

This chapter presents the results obtained from the mathematical analysis. The structural design is carried out as per IS 456-2000 and IS 1893. The members are designed as ordinary members. Structural response in the form of displacement, drift is also presented in the chapter for visualisation of behaviour of the structure.

4.2 Results of computational modelling.

In this section values of base shear as per equivalent static, response spectrum and time history analysis are compared. The dynamic analysis procedures give lesser values of base shear compared to equivalent static analysis but as per clause 7.7.3 dynamic base shear must be scaled up to match equivalent static base shear. The values are presented in figure

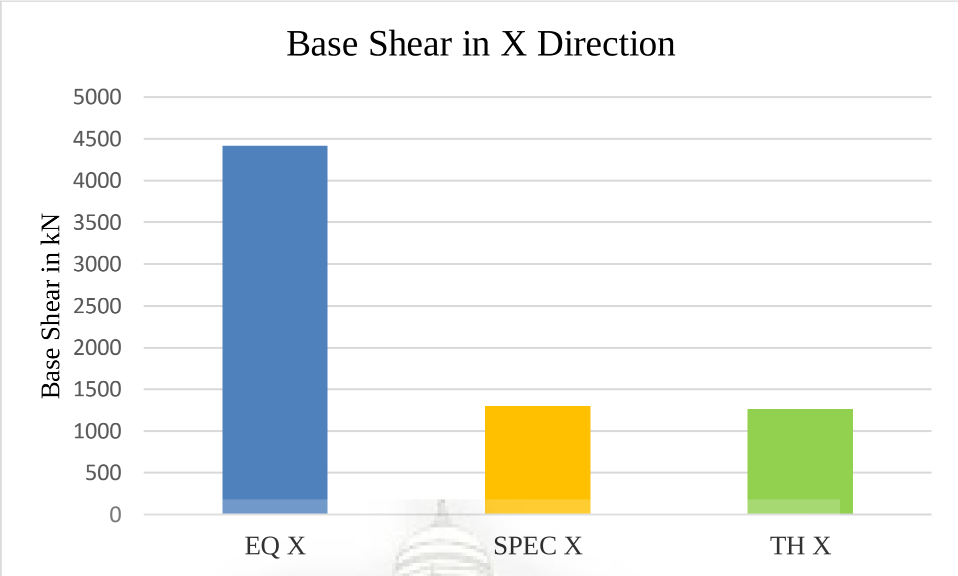

Figure 4.1 Base Shear in X Direction

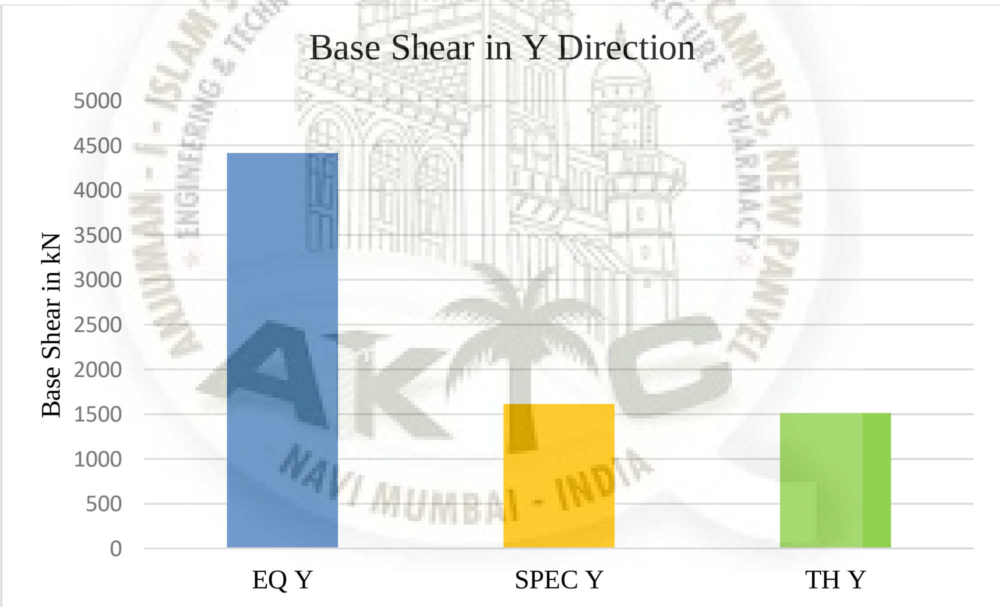

Figure 4.2 Base Shear in Y Direction.

4.2.1 Results of Beam Design

The beams are designed as ordinary beams after defining the load combinations as per IS code. The design is carried out based on worst load combination. All beams have passed design check for flexure, shear and torsion. The frame is designed as an ordinary moment resisting frame.

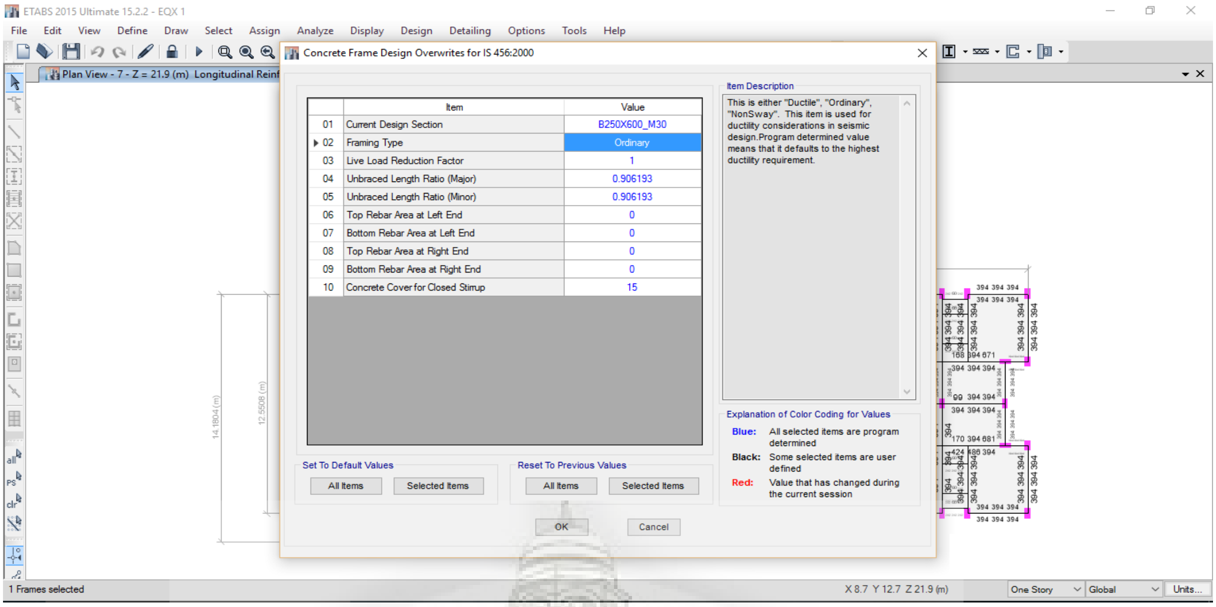

Figure 4.3 Beam Design Overwrites

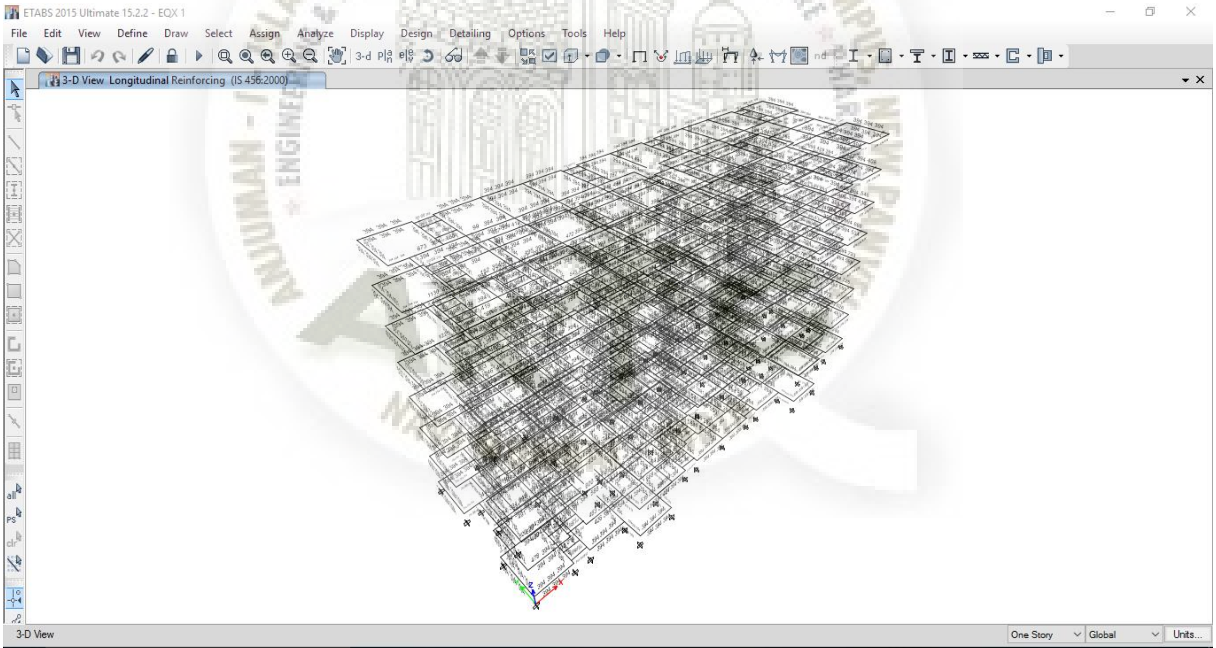

Figure 4.4 Beam Design Results

4.2.2 Results of Column Design

The columns are designed as ordinary members. Columns are designed as biaxial columns as per IS 456-2000. All the columns passed the design checks.

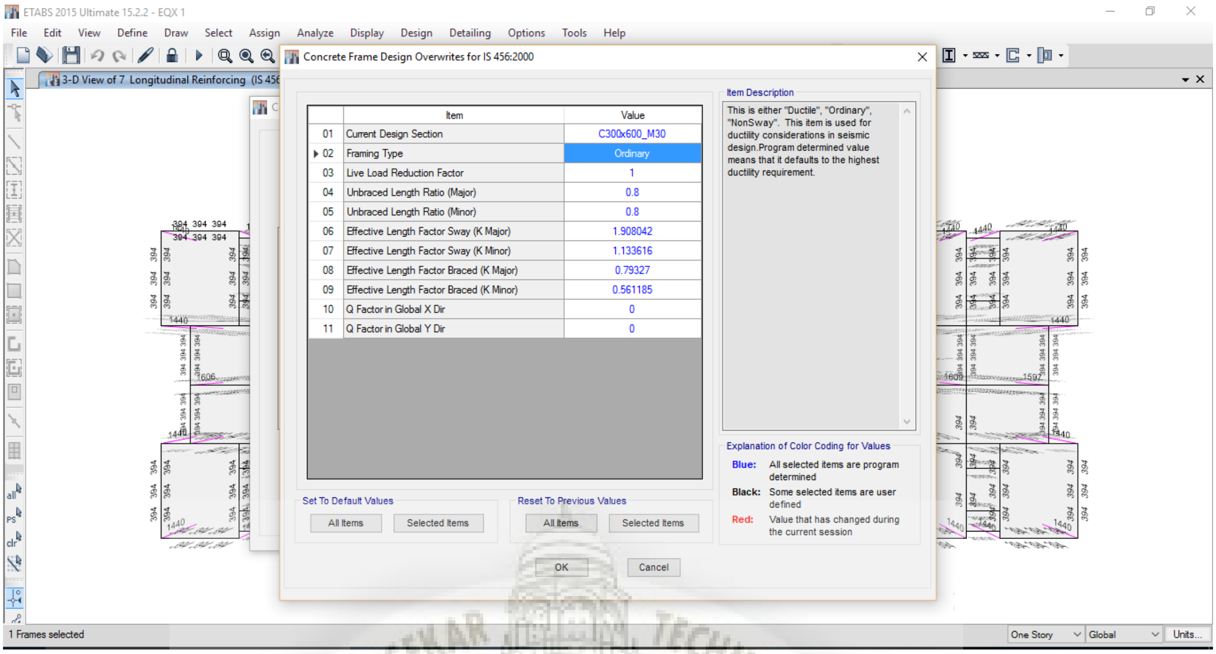

Figure 4.5 Column Design Overwrites

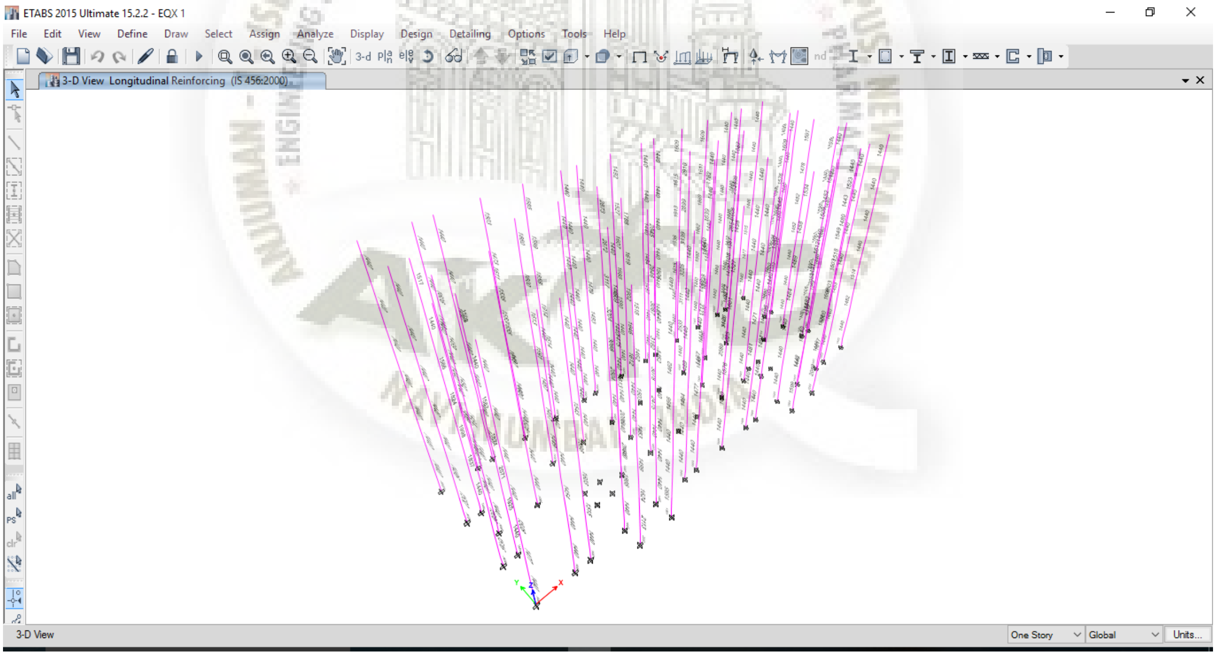

Figure 4.6 Column Design Results.

4.2.3 Shear Wall Design

ETABS can design shear walls after assigning pier labels. The walls were assigned pier labels and designed. All walls passed the design check.

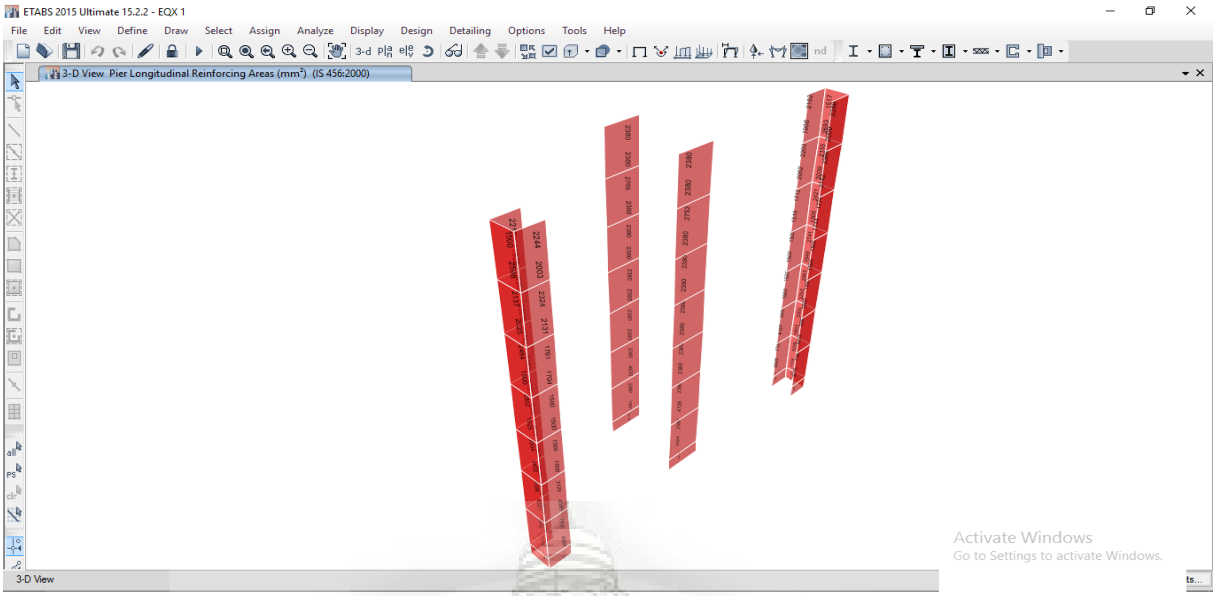

Figure 4.7 Shear Wall Design

4.3 Discussion

Response of the structure is compared and discussion is presented in this section.

4.3.1 Story Displacement

Equivalent static analysis gives higher values of story displacement compared to dynamic analysis. Story displacement in X and Y direction are presented in the following figure.

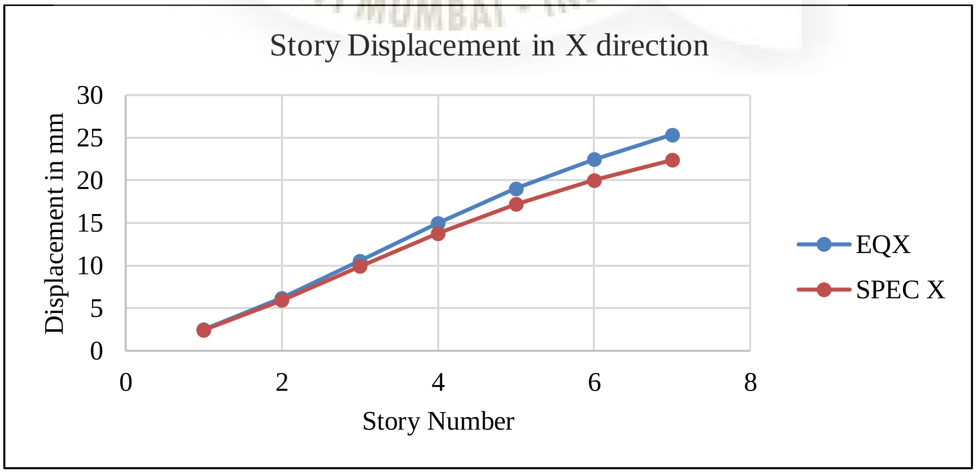

Figure 4.8 Story Displacement in X Direction

Figure 4.9 Displacements in Y Direction

The story displacements are within permissible limits given by IS codes.

4.3.2 Story Drift

Story drift is below the permissible limit for working loads. The structure is regular in terms of geometry hence drift limits are satisfied.

4.3.3 Base Shear

The structure has a regular configuration hence the dynamic base shear by response spectrum and time history analysis is lower that static base shear. The code demands to scale up the responses for dynamic loads. Therefore the design is governed by the equivalent static analysis base shear.

Chapter 5

Conclusion

5.1 General

Conclusions from the current study are presented in this section. The design has satisfied all the design checks by IS codes.

5.2 Conclusion

Following points are observed from the current study.

1. Base shear is sensitive to the seismic weight of the building. Value of Live Load is also major part of seismic weight if the Live Load value exceeds 3 kN / m^2.
2. Response of the building can be studied in a comprehensive manner if dynamic analysis methods are adopted.

3. Response spectrum and Time history analysis give lower values of base shear for regular buildings, however IS code does not allow to use values lesser than equivalent static base shear and the responses for dynamic shears are scaled up for design purpose.

4. Time history analysis gives responses of the structure at a time instance. This approach gives more insights of the structural behaviour than other methods.

5. As per the revised code IS 1893-2016, clause 7.7.1 dynamic analysis must be performed for all other buildings except buildings lower than 15 m in zone II, it is mandatory to perform the dynamic analysis for Mumbai which belongs to zone III. This was not mandatory in the previous code, 1893-2002.

6. For regular building, equivalent static base shear may govern, however dynamic analysis must be performed to check the response.

5.3 Future Scope

Current study performs the Dynamic analysis using linear dynamic analysis without considering the effects of nonlinearities. Non-linear behaviour of the structure may be critical if the geometric configuration is complex. The dynamic analysis with nonlinear effects can be performed as a part of future scope.

REFERENCES

1. S.M. Wilkinson, R.A Hiley, “A Non-Linear Response History Model for the Seismic Analysis of High-Rise Framed Buildings”.(School of Civil Engineering and Geoscience, University of Newcastle, Drummond Building, New castle upon Tyne NEI 7RU, United Kingdom, 318-319 2006).
2. Nina Zheng, Jing Zohu, Yuanyuan Yin, Jun Han, ShuyanJi, “Non-linear Time History Response Analysis of Low Masonry structure with tie-columns”.(15 WCEE, LISBOA 2012).
3. Badhora Bagheri, Ehsan Sailmi Firoozabad, Mohammadreza Yahyaei, “Comparative Study of the Static and Dynamic Analysis of Multi-Storey Irregular Building”. (World Academy of Science, Engineering and Technology International journal of Civil and Environmental Engineering Vol:6 ,No:11, 2012).
4. A S Patil, P D Kumbhar, “Time History Analysis of multi-storeyed RCC Building for different seismic intensities”. (International Journal of Structural and Civil Engineering Research, ISSN 2319-6009 2013).
5. Shashank Bedekar, R.R Shinde, “Time History Analysis of High Rise Structure using different Accelerogram”. (International Journal of Research in Engineering and Advanced Technology, Vol:3, Issue 2, April-May, 2015).
6. Nilesh B.Mevawala, Dr.Atul K. Desai, “Seismic Non-Linear Time History Analysis of Building Resting On Sloping Ground with Special Study on Nepal Earthquake”. (ISOR Journal of Mechanical and Civil Engineering, e- ISSN:2278-1684 p-ISSN:2320—334X, Vol:13, issue 3 May-Jun. 2016).
7. Md. Saleem, M VisweswaraRao, Dr.Jammi Ashok, “Seismic Analysis of Regular and irregular Building by Using Time History Method”. (International Journal for Scientific Research and Development, ISSN(online):2321-0613, Vol:5, issue 10, 2017).
8. Anil Suthar S M Suthar, “Seismic Analysis of Multi-Storey RCC Building by Various Static and Dynamic Analysis Method”. (International Journal for Scientific Research and Development, ISSN(online):2321-0613, Vol:5, issue 09, 2017).
9. Pruthviraj N Juni, S.C Gupta, Dr.Vinubhai R Patel, “Non-Linear Dynamic time History Analysis of Multi-storeyed RCC Residential G+23 Building for Different

Seismic Intensities”. (International Journal of Engineering Research and Science, ISSN:2395-6692, March 2017).

10. Shaikh Ibrahim, Prof.Syed Farrukh Anwar, Mohd Hashmat, “Response Spectrum and Time History Analysis of a Multi-storeyed and Commercial Building”. (Global Journal of Engineering Science and Research, ISSN:2348-8034, February 2017).
11. Chetan Chindan, Pankaj Autade, “Seismic time History Analysis of Six Storey Shear Building”. (International Journal of Research in Engineering and Technology, e-ISSN:2319-1663, p-ISSN:2321-7308, March 2018).
12. Mr.Ashwin Hardiya, Mr. Arpit Chawda, “Time History Analysis of Vertical Irregular Building using ETABS”. (International Journal of Engineering Sciences and Research technology,ISSN:2277-9655 ,January 2018).

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