# Static and Dynamic Analysis for Multistorey Building Along with Foundation Details

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***Abstract*— This project deals with Static and Dynamic Analysis of Multi-story building along with its foundation details. Multi-story are most common type of construction in urban India. These are subjected to several type of forces during their life time such as static force due to dead load and live load. Dynamic forces due to lateral movements and earthquakes. Here considering a tall building G+13 F story height. It is performed to be situated in Thiruvananthapuram near Peroorkada. Where the ground is considered to be in seismic zone 3. Analysis is carried out by ETABS software. The project is a residential apartment. The building coverage is 44 cent. The plinth area of building is 8225 Sq.ft and the carpet area is 6580 Sq.ft. The parking area for a unit is 160 Sq.ft. This structure consists of 15 stories. (BF1 + GF +13F). The height of building is 42 meters. For this building we are using Combined pile and raft foundation. The methods used for analyzing the project are static analysis and dynamic analysis. For static analysis Equivalent static method is used and for dynamic analysis, Response spectra method and Time history method is used. For foundation analysis STADD FOUNDATION software is used.**

***Keywords*— Static and dynamic analysis of multi storey building, types of foundation, ETABs analysis.**

## I. INTRODUCTION

At present peoples facing the problem of land scarcity. The population expansion and advent of industrial revolution leads to the construction of Multi-storey building. If this high rise structure is not properly analyzed for the resistance of lateral forces, then it may leads to complete failure. Therefore static and dynamic analysis is carried out.

Structural design of building seismic loads is primarily concerned with structural safety, during major ground motions, but serviceability and the potential for economic loss are also of concern. Seismic loading requires an understanding of the structural performance under large inelastic deformation. Irregularities in arrange and lack of symmetry might imply vital eccentricity between the building mass and stiffness centers, give rise to damaging coupled lateral response.

A natural calamity an earthquake has taken toll of millions of lives through the ages, in the unrecorded and recorded history. A disruptive disturbance that causes shaking of the surface of the earth due to underground movement along a fault plane or from volcanic activities are called earthquake. The earthquake rank as one of the most destructive events recorded so far in India in terms of death toll and damage to infrastructure last hundred years. All over the world, there is a high demand for construction of all buildings due to increasing urbanization and spiraling population, and earthquakes have the potential for causing the greatest damage to tall structures. Since the earthquake forces are random in nature and unpredictable, the engineering tools need to be sharpened for analyzing structures under the action of these forces. Structural analysis is mainly concerned with finding out the behavior of a structure when subjected to some action. This action can be in the form of load due to weight of things such as peoples, furniture, wind and snow etc. or some other kind of excitation such as earthquake, shaking of the ground due to a blast nearby etc. The distinction is made between the dynamic and static analysis on the basis of whether the applied action has enough acceleration in comparison to the structure’s natural frequency..

A static load is one which varies very slowly. A dynamic load is one which changes very quickly. Dynamic analysis is related to inertia forces. Dynamic loads are wind, blast, explosion and earthquake. When the load is applied sufficiently slowly building obeys Newton’s first law of motion then static analysis is carried out. When load is applied suddenly in earthquake or wind then dynamic analysis is carried out.

Commonly the dynamic analysis is carried out in regular building and irregular building. In regular building, those greater than 40m in height having the seismic zone 4&5. Those greater than 90m in height having the seismic zone 2&3. In case of irregular building all the framed building in seismic zone 4&5 and those greater than 40m in seismic zone 2&3.The design of structure based on some factors, such as natural frequency, damping factor, type of foundation and ductility of structure. Any real structure will dissipate energy (mainly for friction) can be modeled by modified DAF.

**1.2 AIM**

- To study and analyze the static and dynamic behavior of Multi-storey building.
- For analyzing and design of foundation details of Multi-storey building.
- To carry out the analysis building in Seismic zone 3.

**1.3 SCOPE**

- Lateral movement such as earthquake and wind are analyzed.
- Depth of exploration and reinforcement details are covered.

**1.4 DETAILING**

**1.4.1 Static analysis**

Static analysis also called static code analysis is a method of computer program debugging that is done by examining the code without executing the program. The process provides an understanding of the code structure, and can help to ensure that the code adhere to industry standards. Automated tools can assist programmers and developers in carrying out static analysis. The process of scrutinizing code by visual inspection alone, without the assistance of automated tools, is sometimes called program understanding or programmed comprehension

The principle advantage of static analysis is the fact that it can reveal errors that do not mini port themselves until a disaster occurs weeks, months or years after release. Nevertheless, static analysis is only a first step in a comprehensive software quality control regime. After static analysis has been done, dynamic analysis is often performed in a effort to uncover stuble defects or vulnerabilities. In computer terminology, static means fixed, while dynamic means capable of action or change. Dynamic analysis involves the testing and evaluation of a program based on execution. Static and dynamic analyses, considered together, are sometimes referred to as glass-box testing.

**Limitations**

- Automated tools do not supported all programming languages.
- It can be used only for simple and regular structures.
- Results requires review

**1.4.2 Dynamic analysis**

Dynamic analysis is the testing and evaluation of a program by executing data in real time. The objective is to find errors in a program while it is running, rather than by repeat examining the code offline. By debugging a program in all the scenarios for which it is designed, dynamic analysis eliminates the need to artificially create situations likely to produce errors. Other advantage include reducing the cost of testing and maintenance, identifying and eliminating unnecessary program components, and ensuring that the program being tested is compatible with other programs.

**Limitations**

- It is a time consuming process and requires the mass of the structure.
- Automated tools provide false sense of securely that everything is being addressed.
- Lacks code level details

**1.4.3ETABS**

ETABS stands for “Extended three dimensional analysis of building system”. ETABS commonly used for analysis of Skyscrapers, Parking garages, Steel and concrete structures, low and high rise building and Portal frame structures. ETABS provides both static and dynamic analysis for wide range of gravity, thermal and lateral loads. Post analysis of structure, Bending moment, Maximum shear force and storey displacement are computed.

**1.4.4 STAAD FOUNDATION SOFTWARE**

STAAD is a structural analysis and design software. Originally developed by research engineers international in 1997. In late 2005, research engineers international was bought Bentley systems.

STAAD Foundation is software developed by its parent company STAAD. This software enables up to analysis the substructure. Different foundation can be analyzed in this software.

### 1.4.5 FOUNDATION DETAILS

Due to increasing economic development, rapid industrialization and decreasing availability of land for construction in thickly populated countries like India, scope for extending construction in horizontal direction is becoming lesser. Resulting in construction of high rise building with increasing number of floors. In such cases if raft foundations are proposed. It is generally observed allowable bearing capacity of such rafts are quite high so that such foundation can withstand the applied loads due to high rise building to a greater extend without causing shear failure but the major problem of such foundation is that total settlement below the foundation of different locations will be very high beyond permissible limits.

In such cases pile foundations are used causing very large cost for such foundations. The settlements are successfully controlled in such foundation. However in the late, it has been recognize if few number of piles are installed at suitable locations below the raft foundation for such structures, the resultant settlement under such structures will be much smaller and will be with in permissible limits compared to that below raft without provision of the piles. Use of raft in conjunction with some piles will be costlier than in case where only raft is used if possible but much less than the case when only piles are used. As a result in the post decades there has been increasing recognition to use some piles with raft to produce the total and differential settlement of raft leading to considerable economy without compromising the safely and performance of the foundation structure system. Such foundation system is called pile raft. The adoption of piled-raft foundation for high rise buildings is also very common in European cities. Thus it seems on the context of increasing construction of buildings of large heights in metropolis in India and other countries; Piled-raft foundation will be increasingly adopted as most economic safe foundation system. In this project piled-raft foundation has been considered.

### 1.4.6 Pile foundation

A pile is basically long cylinder of a strong material such as concrete that is pushed into the ground to act as a steady support for structure built on the top of it. The pile foundations are used in the following situations.

1. When there is a layer of weak soil at the surface. This layer cannot support the weight of the building, so the loads of the building have to bypass this layer and to be transferred to the layer of stronger soil or rock that is below the weak layer.
2. When a building has very heavy concentrated loads, such as in a high rise structure, bridge or water tank then the pile foundation is adopted.
3. Pile foundations are capable of taking higher loads than spread footings.

There are two fundamental types of pile foundations.

- End Bearing pile
- Friction pile

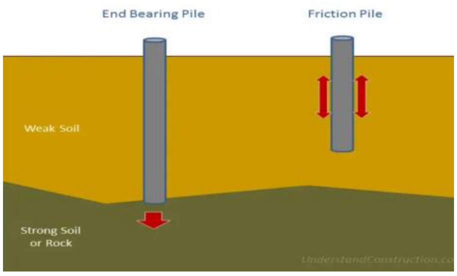



**Fig: 1** Pile Foundation

**How to use piles**

As pile foundations carry a lot of loads, they must be designed very carefully. A good engineer will study the soil the piles are placed into ensure that the soils is not overloaded beyond its bearing capacity.

Every pile has a zone of influence on the soil around it. Care must be taken to space the piles far enough apart. So the loads are distributed evenly over the entire bulb of the soil that carrying them, and not concentrated into a few area.

Engineers will usually group of a few piles together and top them with a pile cap. A pile cap is very thick cap of concrete that extends over a small group of piles, and serves as a base on which a column can be constructed. The load of this column is then distributed in all the piles in the group.

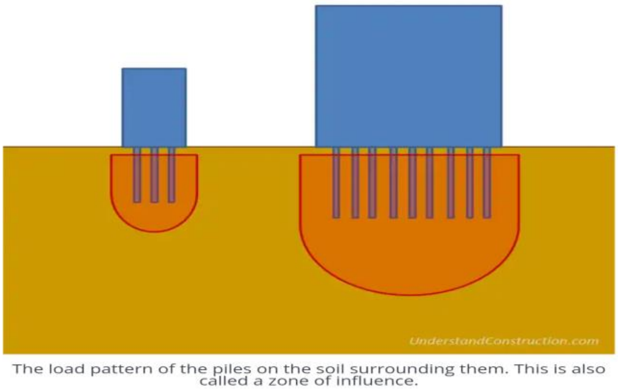



**Fig: 2** Zone of influence of pile

### 1.4.7 Raft foundation

Raft foundations are sometimes known as mat foundation. It is large concrete slab which can support a number of columns and walls. The slab is spread out under the entire building or at least a large part of it which lowers the contact pressure compared to the traditionally used strip or trench footing. Because of the speed and volume of houses required after the Second World War, the raft foundation was widely used. The raft foundation was cheaper, Easier to install and most importantly, did not require as much excavation as the usual strip foundation. When the building regulations were introduced in 1965 there were no genetic rules for raft foundations as there were for strip foundations. This meant that to use a raft foundation, it had to be designed and approved by building control. This made the entire operation much more difficult and time consuming so raft foundation becomes less widely used earlier.

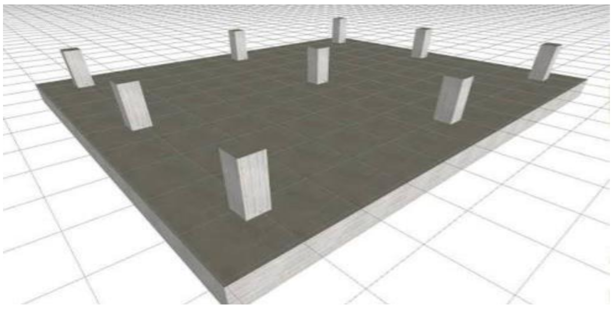


**Fig: 3** Raft foundation

**Usage of Raft Foundation**

Rafts are most often used these days when the strata is unstable or a normal strip foundation would cover more than 50% of the ground area beneath the building. There are also situations where there may be areas of movement in the strata. They are much more commonly used in the construction of commercial building in UK that they are for domestic homes, but can be used very successful in both situations. A raft foundation spreads the weight of the building over the whole ground floor area of that building. The raft is laid on a hardcore or scalping bed and usually thickened at the edges, especially in very poor ground. Rafts are most suitable when the ground is of good load bearing capacity and a little work is required to get a solid foundation. Raft foundations are built in the following step.

1. The soil removed down to carry depth.
2. The foundation bed is then compacted by ramping.
3. Lay reinforcement on spacer over the foundation bed.
4. Pour the concrete over the reinforcement.

The foundation may be stiffened by ribs or beams built in during construction which will add extra strength and rigidity.

A raft foundation is usually prepared under a number of circumstances:

- It is used for large loads, which is why they are so common in commercial building which tend to be much larger, and therefore heavier than domestic homes.
- The soil has a low bearing capacity so the weight of the building needs to be spread

out over a large area to create a stable foundation.
- The ratio of the individual footings to total floor space is high. Typically if the footing would cover over half of the construction area then raft foundation would be used.

**Advantages of Raft Foundation**

- The foundation and floor slab is combined which saves time and materials.
- Less excavation is required.
- Spreads load effectively.

**Disadvantages of Raft Foundation**

- Prone to edge erosion if they are not treated properly.
- Not effective if the load of the building is going to focused on a single point.

### 1.4.8 Combined Pile and Raft Foundation

The piled raft foundation is an innovative design concept with the purpose of reducing settlements and differential settlements caused by concentrated building loads and load eccentricities. In the last decade, a quick increase in the number of combined pile raft foundations has happened. CPRF solutions have been observed, particularly in shift clay soils. Such soils after reasonably good support for raft foundations, generally providing
adequate bearing capacity for the structure. Nevertheless, excessive settlement may occur without the introduction of piles. The main question that arise in the design of piled rafts concern the relative proportions of the load carried by raft and piles, and the effect of pile support on total and differential settlements.

The worldwide largest project founded on a CPRF was established from 1988 until 1990, the 256m high Messetrum Frankfurt am main. From the begging it was clear that for this building shallow foundation was not possible; because it would have led to settlements in the order of 40 to 50cm and differential settlement in the order of 15cm. a pure pile foundation represents a large number of long piles and therefore high cost for the foundation. For this reason, a CPRF was designed for this building consists of 64 piles with a medium length of 30m. About 60% of the total load is supported by piles, with the remaining being transferred directly to the ground. As a result, settlements of 13cm were reached ground. As a result, settlements of 13cm were reached.

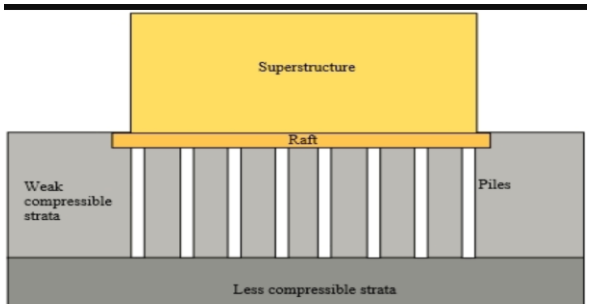



**Fig: 4** Combined pile and Raft foundation

**Concept of Piled Raft Foundation**

The combined pile raft foundation is a composite construction consisting of the three bearing elements piles raft and sub soil.

P tot=Pr +Pp

Where,

P tot→ total load of the building

Pr →load of the raft

Pp →load of the pile group

The combined pile raft foundation allows the reduction of total settlements and differential settlements in a very economical way compared to traditional foundation concepts, because the contribution of both the piles and the raft, in the load distribution process is considered. One of the main issues concerning the analysis of a combined piled raft foundation is the combination of the bearing effect of both foundation elements, raft and pile due the interaction between the foundation elements and the subsoil.

## II. LITERATURE STUDY

The project requires lot of paper work. Basic concepts and idea has been gathered through examinations of various literatures related to this topic. The literature has been helpful in many ways. The title of literature, author and year of publications along with its important details has been listed below.

Romy Mohan, "Dynamic Analysis of the RCC Building with shear wall" International Journal for

Earth Science s and Engineering (Vol.4 ,2011, pp 659-662)

Linear equivalent static analysis is performed for regular buildings up to 90m height in zone 1 and 2 . Dynamic analysis should be performed for regular and irregular building in zone 4 and 5. Six different types of shear wall with its variation in shape are considered for studying their effectiveness in resisting lateral forces. The paper also deals with the effect of variation of the building height on the structural response of the shear wall. Dynamic responses under prominent earthquake, EI- center have been investigated. This paper high lights the accuracy and exactness of Time history analysis in comparison with most commonly adopted response spectrum analysis and Equivalent Static Analysis.

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. The analysis may be liner or nonlinear. Time history analysis is used to determine the dynamic response of structure to arbitrary loading.

The word spectrum in seismic engineering conveys that the idea that the response of buildings having a broad range of periods is summarized in a single graph. For a given earthquake motion and a percentage of critical damaging, a typical response spectrum gives a plot of earthquake related responses such as acceleration, velocity and deflection for a complete range or a spectrum of building periods. Thus a response spectrum may be visualized as a graphical representation of the dynamic response of a series of progressively longer cantilever pendulums with increasing natural periods subjected to a common lateral seismic motion of the base.

From the above studies it can be concluded that Equivalent static method can be used effectively for symmetric buildings up to 25m height. For higher and unsymmetrical buildings Response Spectrum method should be used. For important structures Time history analysis should be performed as performed as it predicts the structural response more accurately in comparison with other two methods since it incorporates P-delta effects and material non linearity which is true in real structures. Even the above studies it is evident that square shaped shear wall is the most effective and L-shaped is the least effective.

ETUM, et al, 2012, “Comparative study of the static and dynamic analysis of multi-story irregular building”

New seismic design procedure requires structural engineering to perform both static and dynamic analysis for the design of structures. Linear equivalent static analysis is performed for regular buildings up to 90m height in zone1 and zone 2. Dynamic analysis should be performed for regular and irregular building in zone 4 and zone 5. The main objectives of this paper is to study the seismic behavior of concrete reinforced building, also analysis of structure by using equivalent static method, time history method and response spectrum method.

Equivalent static method is used in simple regular structures. It begins with an estimation of the base shear load and its distribution on each story calculated by using formulas given in IS code. Time history method is an analysis of the dynamic response of the structure of each increment of time. Recorded ground motions data base from past natural events can be a reliable source. The three parameters for this method are analog magnitude, distance and soil condition. In Response spectra method maximum response of idealized single degree freedom system having certain time period and damping is represented. Various damping values are explained in terms of maximum absolute acceleration, maximum relative velocity or maximum relative displacement.

The result shows that displacement in static analysis is higher. In time history method predicts structural response more accurately than other two methods.

Mohit Sharma, et al “Dynamic Analysis of Multi-storied Regular Building” IOSR Journal of Mechanical and Civil Engineering (Vol. 2 Issue 1, Jan 2014)

The criteria of level adopted by codes for fixing the level of fixing the level of seismic loadings are generally as follows:

- Structures should be able to resist minor earthquake, (DBE), without damages.

- Structures should be able to resist moderate earthquakes (DBE) without significant structural damages with same nonstructural damages.
- Structures should be able to resist major earthquake (MCE) without collapse.

"Design Basic Earthquake (DBE) is defined as the maximum earthquake that represent can be expected to experience at the site once during life time of the structure. The earthquake corresponding to the ultimate requirements is often called maximum considered Earthquake (MCE). Generally DBE is half of MCE. During an Earthquake, ground motion occurs in a random fashion both horizontally and vertically, in all direction radiating from the epicenter. The ground accelerations cause structures to vibrate and reduce inertial forces on them. Hence structures in such locations need to be suitably designed and detailed to ensure stability, strength and serviceability with acceptable levels of safety under seismic effects.

The magnitude of the forces induced in a structure due to given ground acceleration or given intensity of earthquake will depend among other things such as mass of the structure, the material and type of constructions, the damping and ductility energy dissipation capacity of structure, the induced seismic force can be reduced and a more economical structure or alternatively the probability of collapse reduced.

Abhey Galesia, et al, "Structural analysis of a multi-storeyed building using ETABS for different plan configurations" International Journal of Engineering Research & Technology (Vol. 3 Issue 5, Dec 2014)

The case study in this paper mainly emphasizes on structural behavior of multi-story building for different plan configurations like rectangular, C, L and I shape. Modeling of 15-stories RCC framed building is done on the ETABS software for the analysis. ETABS was used to create the mathematical model of the Burj Khalifa, designed by skidmme, owings and Merill LLP. ETABS provides both static and dynamic analysis for wide range of gravity, thermal and lateral loads. Dynamic analysis includes seismic response spectrum or accelerogram time history.

In case of rectangular plan, the moment produced is higher than other shapes. Story overturning moment decreases with increase in story height for all cases. It has been concluded that the story shear decreases with increase in story height. Story shear is less in L – shapebuilding among all the cases.

Storey displacement increases with increase in storey height. Displacement of rectangular shape building is less than other cases. The analysis of multi-storey building is reflected that the storey over-turning moment varies inversely with storey height. Dynamic analysis, made shapes are generated and it can be concluded that a symmetrical plans undergo more deformation that symmetrical plans.

Oiga IVANKOVA, et al, "Effects of bracing of high rise buildings upon their static and dynamic behavior" Department of Structural mechanics , Slovak University(Vol. 10 Issue 1, 2014)

This paper describes the effect of bracing of high-rise building upon their static and dynamic behavior. The calculations were made for building both fixed in to the ground and rested on the elastic supports.

For the purpose of static analysis, structures were loaded by most un favorable combination of permanent , variable and wind loads. For dynamic analysis the load was considered according to Euro code. Structures were considered as fixed or rested on elastic support in to the ground.

The Winkler model had been used for modeling of subsoil. For static calculation the input value of the coefficient of compressibility was taken 19.6 $MN/m^{3}$. For dynamic calculations were standards recommended to take higher value of coefficient of compressibility. In static calculations, after addition of stiffening elements the maximum value of displacements was reduced by 137mm for building fixed into the ground and by 14.3mm for building rested on the elastic supports. It can be observed that the stiffening wall helps to reduce displacements.

An-Nasah National University, 2015, Foundation of Multi- Storey

The lowest part of a structure is generally referred to as the foundation. This foundation is to transfer the load of the structure to the soil to which resisting. A properly designed foundation is one that transfers the load throughout the soil without Over stressing the soil. Over stressing the soil can result in either excessive settlement or shear failure of the soil, both of which cause damage to the structure. Thus the geotechnical and structural engineer who design foundations must evolved the bearing capacity of the soil.

Foundation is the supporting portion of a structure located below the structure and it is supported only by soil or rock. It is mainly used to support the structure and then distribute the weight of the structure, so it settles to the ground evenly rather than unevenly. There are two types of foundations. They are shallow foundation and deep foundation. To perform satisfactory, shallow foundation must have two main characteristics. They have to safe against overall shear failure in the soil that support them and they cannot undergoes excessive displacement or settlement.

Raft is a combined footing that may cover the entire area under a structure supporting several columns and walls. Some type of raft foundations are

- Flat plate, the mat is of a uniform thickness
- Flat plate thickened –under column
- Beams and Slabs, the beam run both ways , and the column are located at the intersection of the beam.
- Flat plate with pedestals

Mohamad Rizwon Sultan, etal, "Dynamic analysis of multi-story building for different shapes"International Journal of Innovative Research in Advanced Engineering (Vol. 2 Issue 5, Aug 2015)

Buildings with irregular shape are vulnerable to earthquake damages. The most important objective of this study is to grasp the behavior of structure in high seismic zone and also to estimate story overturning moment, story drift, displacement, design lateral forces. In this journal we compose rectangular, L-shape, U-shape, C-shape are used as comparison. The models were analyzed using ETABS.

Irregularities in arrange and lack of symmetry might imply vital eccentricity between the building mass and stiffness centers , give rise to damaging coupled lateral response. In IS 1893 explains the plan and elevation irregularities. The irregularity of the structure might will classify in 2 section 'i.e.' plan and vertical. For plan contains torsional, re-entrant corner, diaphragms separation, out of arrange offset and nonparallel system. For vertical irregularities stiffness (soft stones), mass, vertical geometry, in place separation in vertical components resisting lateral force and separation in capability (weak story)

The code, IS 1893 part2 -2002 describes outline the re-entered corners irregularities. The method used is equivalent static force analysis and response spectrum method. Equivalent static forces analysis is useful since it contains a dynamic analysis into a partly static and dynamic analysis to evaluate the maximum displacement produced in the structure

For earthquake resistant design of structure only these maximum displacement are of interest, but not the time history of stresses. This concepts has some drawbacks since it uses only a single mode of vibration of structures. Response spectrum method, In this concept the multiple modes of vibration of a structure can be used .This method is used complex structures. The vibration of building is defined as the combination of many special modes that are in a vibrating string. Computer analysis is used to determine this mode shape for the structures. From these mode shapes the design spectrum responses are studied,with the help of parameters such as model participation mass and model frequency and then they are combined to evaluate responses of the structure. Result shows that irregular shapes are severely affected during earthquakes especially in high seismic zone. Irregular shape building undergoes more deformation and hence regular shape building must be preferred. C- Shape building is more vulnerable compared to all other different shapes.

Balaji. V.A, et al "Design and Analysis of Multi-Storeyed Building under Static and Dynamic loading conditions using ETABS" International Journal of Technical Research and (Vol. 4 Issue 4, July Aug 2016)

In this project a residential of G+13 multi-storey buildings studied for earthquake loads using ETABS. The seismic action is dynamic in nature, building codes often recommend equivalent static load analysis for design of earthquake resistant buildings due to its simplicity. This is done by focusing on the predominant first mode response and developing equivalent static forces that produce the corresponding mode shape, with some empirical adjustments for higher mode effects.

Dynamic analysis becomes even more complex and questionable when nonlinearity in materials and geometry is considered. Therefore analytical tools used in earthquake engineering have been a subject for further development and refinement with significant advances achieved in recent years.

In terms of seismic design, lateral deflection and drift can affect both the structural `elements that are part of the lateral force resisting system and structural elements that are not part of the lateral force resisting system. In terms of lateral force resisting system, when the lateral forces are placed on the structure, the structure response and moves due to those forces. Consequently, there is a relationship between the lateral forces resisting system and movement under lateral loads, this relationship can be analyzed by hand or by computer. Using the result of this analysis, estimate of other design criteria, such as rotations of the joints in eccentric braced frames and rotations of joints in special moment resisting frames can be obtained. Lateral movements on structural elements that are not part of the lateral force resisting system, such as beams and columns that are not considered as being part of the lateral force resisting system.

Without proper considerations of the expected movement of the structure, the lateral force resisting system might experience premature failure and corresponding loss of strength. In addition, if the lateral deflections of any structure become too large, P-delta effects can cause instability of the structure and potentially results in collapse.

Gauri G Kokpure, "Comparative study of Static and Dyanmic Seismic Analysis of Multi-storied RCC building by ETABS : A Review" International Journal of Engineering Research in Management & Technology(Vol. 5 Issue 12, Dec 2016)

The earthquake reacts as one of the most destructive events recorded. So far in India in terms on death toll and damages to infrastructure. The major cities affected by earthquake are Bhuj, Rajkot etc. Every earthquake leaves a trail of misery because of the loss of life and destruction.

Reinforced concrete Multi-Storey building in India was for the first time subjected to a strong ground motion. Shaking in Bhuj earthquake, It has concluded that the principle reasons of the failure may attributed to soft-stories, poor quality of construction materials and faulty construction practices, inconsistent earthquake response soil and foundation, effect of pounding of adjacent structures.

Structural analysis is mainly connected with finding out the behavior of a structure when subjected to some action. This action can be in the form of load due to the weight of things such as people, furniture, snow etc. or some other kinds of excitation such as earthquake, shaking of the ground due to a blast nearby etc. In essence all these loads are dynamic including the self-weight of the structure because of some point in time these loads were not there, The distinction is made between the Dynamic and Static analysis on the basic of whether the applied action has enough acceleration in comparison to the structures natural frequency.

This paper presents a review of the comparison of Static and Dynamic analysis of Multi-storied building. Design parameters Such as displacement, bending moment, base shear, storey drift, torsion, axial forces were the focus of study. It was found that, Static analysis is not sufficient for high rise buildings and its necessary to provide dynamic analysis. Building with re-entrant corners experienced more lateral drift and reduction in base shear capacity to regular building. Base shear value is more in zone 5 and that it the soft soil in irregular configuration. Irregular shapes are severely affected during the earthquakes especially in high seismic zones.

Arpana Jain, et al, 2017, "A comparative study of Static and Dynamic analysis of Irregular multi storey Building with Different location of shear wall"

The main objectives of this paper are to be study the seismic analysis of of structure for static and dynamic analysis of an irregular multi-storey structure. Method of analysis adopted for the equivalent static and response spectrum techniques to analyze the model for the present study

We considered the residential building of G+ 11 storied structures for the seismic analysis and it is located in zone 3. The total structure was analyzed by computer. This study aims at comparing various parameters such as shear force, Bending moment, Maximum displacement, Storey displacement etc. of a building under lateral loads. For this purpose, three models are considered without shear wall, with shear wall at interior and shear wall at boundary.

The behavior of building during earthquakes depends on its overall shape, size and geometry. Progressive collapse refers to a phenomenon in which local damage in primary structural elements leads to total or partial structural system failure. To ensure safety against seismic forces of multi-storied building hence, there is need to study of seismic analysis to design earthquake resistant structures.

Mohd Jamaluddin Danish, et al, "Static and Dynamic analysis of Multi-storey Building with the effect of Ground and intermediate soft storey having Floating Columns" International Journal of Scientific Research & Development (Vol. 5 Issue 10, 2017)

RC framed Building with open ground storey is called as soft storey. In recent earthquake it is observed that a building with discontinuous in stiffness and mass subjected to concentration of forces and the point of discontinuity which may lead to the failure of members at the junction and collapse of building. One of the most economical ways to eliminate the failure of soft storey is by adding shear walls to tall buildings. The analytical model of the building includes all important compound that influence the strength, stiffness, mass and deformability of structure.

The objective of seismic analysis started as the structure should be able to ensure minor shaking intensity without sustaining any damage. High rise building is the most complex built structure since they are many conflicting requirements and complex building systems to integrate.

Fundamental time period reduces when the effect of infill masonry wall and concrete shear wall is considered. In the upper storeys the presence of floating column reduces storey drift because of increase in stiffness. It is observed that by introducing any type of shear wall the storey displacement is reduced by 50%.

G.B Bhaskar, Amresh.A.Das, "Static and Dynamic analysis of multi-storey Building" IJRT (Vol. 2 Issue 7, 2017)

The earthquake resistant structures are designed based on some factors. The factors are natural frequency of structure, damping factor, type of foundation, importance of the building and ductility of the structure. The structure designed for ductility need for designed for less lateral loads as it has better moment distribution properties

Structural dynamics therefore is a type of structural analysis which covers the behavior of the structures subjected to dynamic loading. Dynamic loads including people, wind, waves, traffic, earthquake and blasts. Any structures can expose to dynamic loading. Dynamic analysis can be used to find dynamic displacements, time history and model analysis.

In the present study, Response spectrum analysis is performed to compare the result with static analysis. In order to perform the seismic analysis and design of structure to be built at a particular location, the actual time history record is required. However, it is not possible to have such records at each and every location. Further the seismic analysis of structures cannot be carried out simply based on the peak value of the ground acceleration as response of the structure depend upon the frequency content of the ground motion and its own dynamic properties. To overcome the above difficulties, earthquake response spectrum is most popular tool in the seismic analysis of structures.

Dynamic analysis shall be performed to obtain the design seismic force, and its distribution to different levels along the height of the building and to the various lateral loads resisting element, for the following building. Greater than 40m height in Zone 4 and 5 and those greater than 90m height in zone 2 and 3 in regular building. All framed buildings higher than 12m in zone 4 and 5 and those greater than 40m in height in zone 2 and zone 3 in irregular building.

There is remarkable increase in axial force for static State as compared to Dynamic state. There is a remarkable increase in shear force for Static state compared to Dynamic state. In beams the bending moment for Dynamic state is more as compared to Static state. As the floor height increases, the bending moment in beam decreases. The bending moment due to earthquake load in columns is highly increasing with storey height. So if earthquake load is not considered for the analysis these will be a chance of overturning.

Mr Surjeet Kumar Varma, Er. Shubham Srivastava, Mr Mohd Zain, "A comparative study on static and dynamic analysis of high rise buildings with and without open ground story" International Journal of Engineering Technology Science and Research (Vol. 4 Issue 5, May 2017)

Soft story is an un avoidable feature in the multi-storey building. It is an open for the purpose of parking or reception lobbies and soft story at different loads of the building for office use. It is also called stilts story. Masonry infills are normally considered as nonstructural elements and their stiffness contributions are generally ignored in practice. Such an approach can lead to an unsafe design. In the soft story, the inter stories drifts and seismic demands of the columns are excessive that causes heavy damage or collapse of the building during several earthquake.

The distributions are made between dynamic and the static analysis on the basis of whether the applied action has enough acceleration to the comparison to the structure's natural frequency. If the load is applied sufficiently slowly the inertia formation can be ignored and the analysis can be simplified as static analysis. In case of earthquake forces the demand is for ductility. Ductility is an essential attribute of the structure that most respond to the strong ground motions. Larger of the capacity to deform plasticity without collapse, more is the resulting ductility and the energy dissipation. This causes the reduction in effective earthquake forces.

The method used for analysis is equivalent static analysis and response spectra method. The result shows that the displacement of each storey at centre of mass is lower compared to those at joint of maximum displacement. From the analysis results for both equivalent static and response spectrum analysis the storey displacement and story drift is more along the shorter span.

Gauri. G. Kakpure, et al, "Comparative study of static and dynamic seismic analysis of analysis of multi storied RCC building by ETABS" (2017)

In this work , two tall buildings of G+10 and G+25 are presumed to be situated in seismic zone 3 and analyzed by equivalent static analysis and response spectra method by using ETABS. From this analysis having the parameters such as story drift, story-displacement, axial load, Bending moment are determined by the comparative study.

The distinction made between the dynamic and static analysis on the basis of whether the applied action has enough acceleration in comparison to structures natural frequency. For single and regular building and for low to medium size buildings analysis is carried as equivalent static analysis. In response spectrum analysis various damping values can be expressed in terms of maximum absolute acceleration, maximum relative velocity or maximum relative displacement.

Results show superiority of response spectrum method over equivalent static analysis method. Story drift values are less in dynamic analysis than static analysis. As the height of story increases the displacement values gradually increases. Dynamic analysis gives lesser values for all parameters than static analysis. Hence dynamic analysis is economical.

Egar Kosiakov, "Foundation of Multi-storey residential building"(2018)

Increasing the economic efficiency of foundations design solution contributes to the improvement of the methods for their calculation and design. One of the characteristic features of the foundations is the variant nature of their design. When it is necessary to consider to several variants of foundation and choose from them the most economical feasible. Corresponding to the modern technology of the erection and ensuring long term and safe operation of the constructions, as well as environmental safety of the building environment. In the thesis, two types of the foundations were considered a shallow foundation and as an alternative option, a pile foundation.

Ratio of depth to width at the foundation base d/b does not exceed 4 in shallow foundations. Load is transferred on the foundation soil mainly through the foundation base. Usually the depth of laying of these foundations does not exceeds 4 to 6 meters. The main type of shallow foundations are pad foundation, strip foundation, raft foundation and massive foundation. Raft foundations are often used under different structures, all the elements of the structure rest on this foundation, well, column, pillars etc.

Pile foundations are used in case when the soils in foundations are represented by high-powered mound, peat, sediments of silts, cohesive soil in fluid and flow-plastic state etc. And also the pile foundation is used when a building has very heavy, concentrated loads, such as high rise structure, bridge on water tank.

## 2.2 SUMMARY OF LITERATURE STUDY

The study of these literature draws to conclude about the method to be adopted for static and dynamic analysis of multi-storey building. From this journal, for static analysis, equivalent static analysis adopted. For this dynamic analysis response spectrum method and Time history method has been adopted. The parameters which will obtained after carrying out of these analysis has been noted down. Story drift, story displacement, axial loads, bending moments are determined by using equivalent static method. Maximum absolute acceleration, maximum relative velocity, maximum relative displacements are found out by using response spectrum method. Time History method is used for dynamic analysis of structure at each increment of time. Recorded ground motions, data base from past natural events are the reliable source for this method. The parameters for time history are analog magnitude, distance and soil condition. The types of foundation which will consider in multistory have been studied. Pile foundation, raft foundation, and Combined Pile and raft foundation has been used in nowadays. For this project combined pile and Raft foundation is adopted.

## III. METHDOLOGY

The project is Static and Dynamic analysis of multistory building along with its foundation details. ETABS, STADD FOUNDATION software's are used for this analysis. The methods chosen for static and dynamic analysis are Equivalent static method, response spectrum method and time history method. These methods are carried out in ETAB software. The parameters of each method will be obtained after analysis. STADD FOUNDATION software is used for analyzing the foundation of this structure.

## 3.2 METHODS OF ANALYSIS

In this project three methods are considered for analysis such as Equivalent static analysis, Response spectrum analysis, Time history method.

### 3.2.1 Equivalent static analysis

This method is used for analyzing static load. It beings with an estimation of base shear load and its distribution on each story calculated by using formulas given in code

This method is mainly used for simple structures that is for low to medium size building that is less than 75m.

### 3.2.2 Response spectrum method

The vibration of the building is defined as the combination of many special modes that are in vibrating strings. It is used in multiple mode vibration of a structure it can be used in simple or complex building.

The representation of the maximum response of idealized single degree freedom system having certain fixed and damping, during earthquake ground motions. The maximum response plotted against of undamped natural period and for various damping values and can be expressed in terms of maximum absolute accelerations, maximum relative velocity or maximum relative displacement.

**3.2.3 Time history method**

It is an analysis of the dynamic response of the structure at the increment of time, when its base is subjected to a specific ground motion time history. Alternatively, recorded ground motions date base from post natural events can be reliable source for time histories. Recorded ground motion are randomly selected from analysis magnitude, distance, and soil condition category. These are the three main parameters in time history generation. Time history analysis is a step by step analysis of the dimensional response of structure to a specified loading that may vary with time. The analysis may be linear or nonlinear. Time history analysis is used to determine the dynamic response of the structure to arbitrary loading.

**3.3 MATERIAL COLLECTION**

**3.3.1 Concrete**

M25 grade concrete having density of 25KN/$m^3$ is used for this construction of Multi-Storey building. The young's modulus of M25 grade concrete is 25000.

**3.3.2 Steel**

Grade of Structural Steel - 415 Grades

Yield stress for steel - 415 Mpa

Young's modulus of steel - 210000 Mpa

Tensile strength - 545N/$mm^2$

Elongation of steel - 12%

0.2% proof stress for steel - 500N/$mm^2$

**3.3.3 Brick**

8 in hollow bricks of dimension 14×20×20

4 in hollow bricks of dimension 14×9×9

4 in burnt bricks of dimension 19×9×9

**3.3.4 Glass**

Guardian solar silver glasses are used in this structure. The Guardian solar silver glass which gives a silver appearance, energy performance, uniform reflection and transmitting colors.

**3.3.5 Wood**

Rose and Teak wood is used.

**Rose wood**

Color - Golden brown, purplish brown

Texture - Has a medium texture and fairly small pours.

Grain - Grain is narrowly interlocked.

Modulus of rupture - 114.4 MPa

Elastic Modulus - 11.50 GPa

**Teak wood**

Color - Golden or medium brown

Grain and Texture - Grain is straight. Coarse uneven texture.

Modulus of rupture - 97.1 MPa

Elastic Modulus - 12.28 GPa

## IV. MODELLING

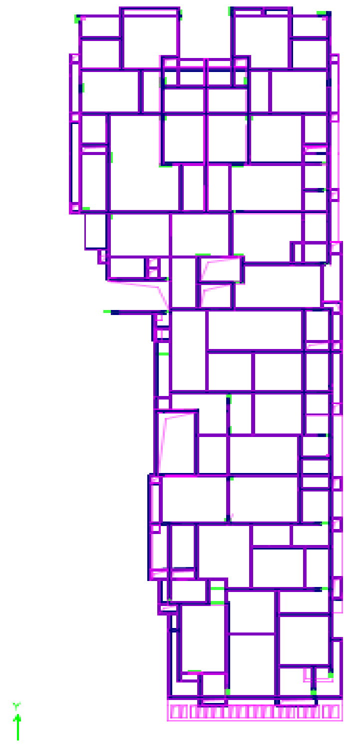


**Fig: 5** Plan view in Etabs

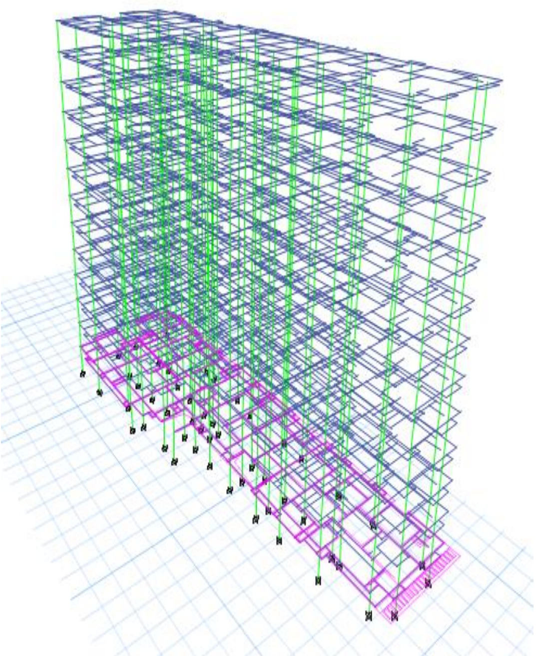


**Fig: 6** Beam column arrangement of Multi story building

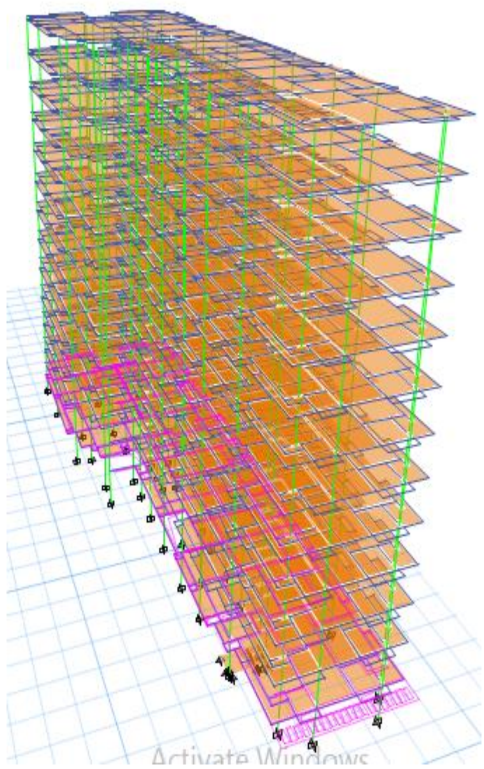


**Fig: 7** Slab arrangements in Building

**4.2 BUILDING DATA**

| | |
|---|---|
| Details of building | - BF1+BF2+GF+13F |
| Outer and inner wall thickness | -230mm |
| Floor height | -3m |
| Height of building | -42m |
| Seismic zone | -III |
| **4.2.1 Material Properties** | |
| Grade of Column concrete | -M25 |
| Grade of slab, beam Concrete | -M25 |
| Grade of steel | -Fe 500 |
| Density of Concrete | -25KN/m$^3$ |
| **Design Data Section Properties** | |
| Size of Column | -500×500 |
| | 800×400 |
| | 800×500 |
| | 500×300 |
| Size of Beam | 250×250 |
| | 300×250 |
| | 500×250 |
| Slab Thickness | -120mm |

## V. STRUCTURAL ANALYSIS

**5.1 EQUIVALENT STATIC ANALYSIS INPUT DATA**

**Dead load : ( IS 875 PART 1)**

Unit weight of Burnt Brick= 15.70 to 18.75 kN/ m$^3$

i. Weight of brick wall= Unit wt ×Height × Width

= 18×3× 0.2

=10.8 kN/m

ii. Weight of plastering for wall

Unit weight of cement plaster = 20.40kN/ m$^3$

Weight of plastering = Unit wt ×plastering thickness × Width

= 20.40×0.01× 3

=0.612 kN/m

Weight of plastering of two sides= 0.612×2

=1.224 kN/m

iii. Weight of parapet wall

Unit weight of Burnt Brick= 18 kN/ m$^3$

Weight of parapet wall = Unit wt × thickness × Height

=18× 0.1 ×0.6

=1.08 kN/m

iv. Weight of plastering for parapet wall

Unit weight of cement plaster = 20.40kN/$m^3$

Weight of plastering =(20.40×0.01×0.6)×2

=2.48kN/m

v. Weight of marble or tile

Unit weight of marble = 26.50kN/ $m^3$

Weight of marble or tile =Unit wt of marble× Thickness

= 26.50×0.02

= 0.53 kN/ $m^2$

**Live load : ( IS 875 PART 2)**

All rooms and kitchens =2 kN/ $m^2$

Toilets and bath rooms =2 kN/ $m^2$

Corridors, passages, Staircase including fire escapes and storeroom =3 kN/ $m^2$

Balconies =3 kN/ $m^2$

**Seismic load : ( IS 1893 PART 2)**

Seismic zone factor = 0.16

Response reduction factor = 3

Site type = 1

Importance factor = 1

Time period = 0.25

Story range for Top story = 13

Story range for bottom story = Base

**Result**

**i. Base Shear**

**Table no: 1 Calculation of Base shear**

| Direction | Period Used (sec) | W (kN) | $V_B$ (kN) |
|---|---|---|---|
| X | 1.253 | 93135.3921 | 1981.7934 |
| Y | 1.253 | 93135.3921 | 1981.7934 |
| X + Ecc. Y | 1.253 | 93135.3921 | 1981.7934 |
| Y + Ecc. X | 1.253 | 93135.3921 | 1981.7934 |
| X - Ecc. Y | 1.253 | 93135.3921 | 1981.7934 |
| Y - Ecc. X | 1.253 | 93135.3921 | 1981.7934 |

**ii. Shear force and Bending moment diagram**

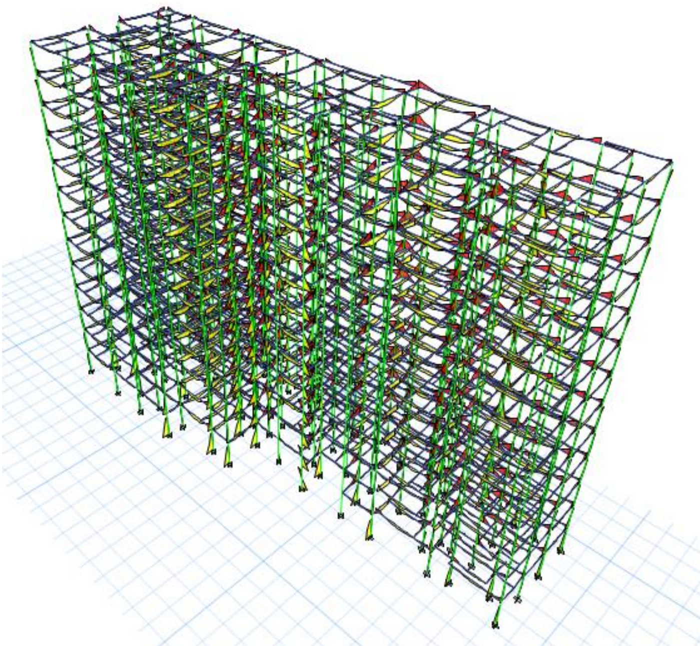


**Fig: 8** Bending moment and shear force Building

**iii. Reaction**

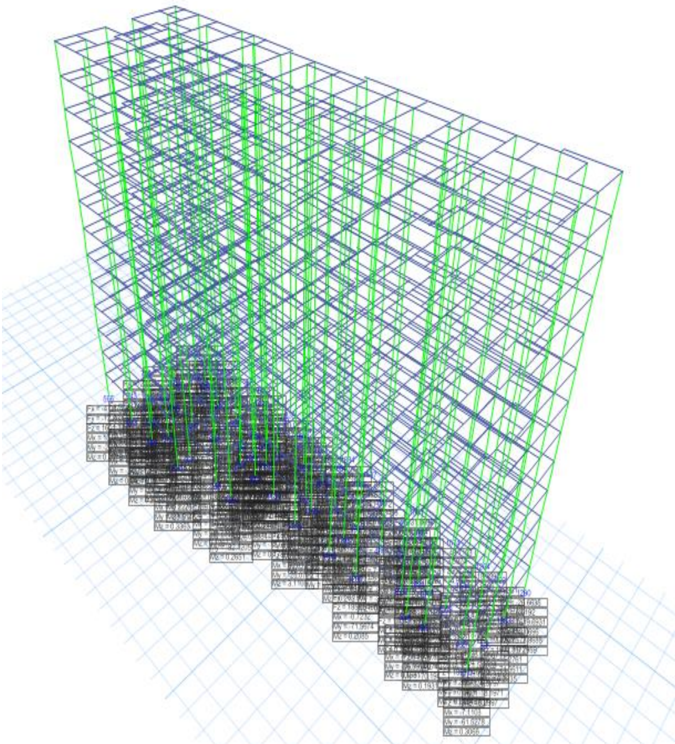
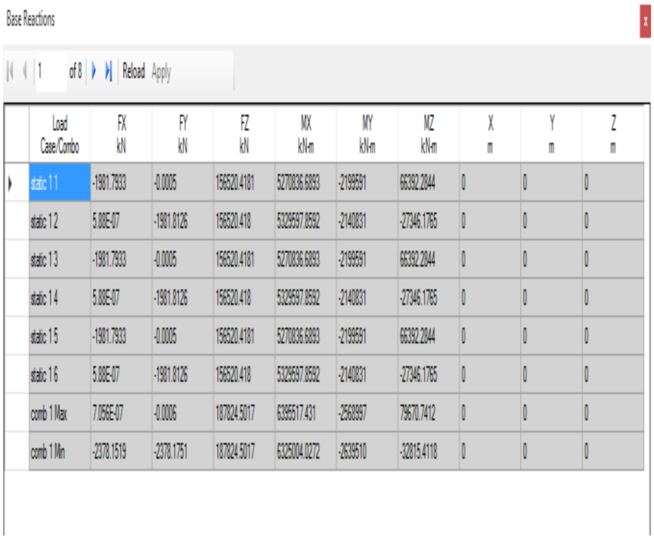


**Fig: 9** Reaction values of Building

**Table no: 2** Calculation of Base reaction



Base Reactions

| Load Case/Combo | FX kN | FY kN | FZ kN | MX kN-m | MY kN-m | MZ kN-m | X m | Y m | Z m |
|---|---|---|---|---|---|---|---|---|---|
| static 1 1 | -1981.7933 | -0.0005 | 156520.4181 | 5270836.6893 | -2199591 | 66392.2844 | 0 | 0 | 0 |
| static 1 2 | 5.88E-07 | -1981.8126 | 156520.418 | 5329597.8592 | -2140831 | -27346.1765 | 0 | 0 | 0 |
| static 1 3 | -1981.7933 | -0.0005 | 156520.4181 | 5270836.6893 | -2199591 | 66392.2844 | 0 | 0 | 0 |
| static 1 4 | 5.88E-07 | -1981.8126 | 156520.418 | 5329597.8592 | -2140831 | -27346.1765 | 0 | 0 | 0 |
| static 1 5 | -1981.7933 | -0.0005 | 156520.4181 | 5270836.6893 | -2199591 | 66392.2844 | 0 | 0 | 0 |
| static 1 6 | 5.88E-07 | -1981.8126 | 156520.418 | 5329597.8592 | -2140831 | -27346.1765 | 0 | 0 | 0 |
| comb 1 Max | 7.056E-07 | -0.0006 | 187824.5017 | 6395517.431 | -2568997 | 79670.7412 | 0 | 0 | 0 |
| comb 1 Min | -2378.1519 | -2378.1751 | 187824.5017 | 6325004.0272 | -2639510 | -32815.4118 | 0 | 0 | 0 |

### iv. Story shear

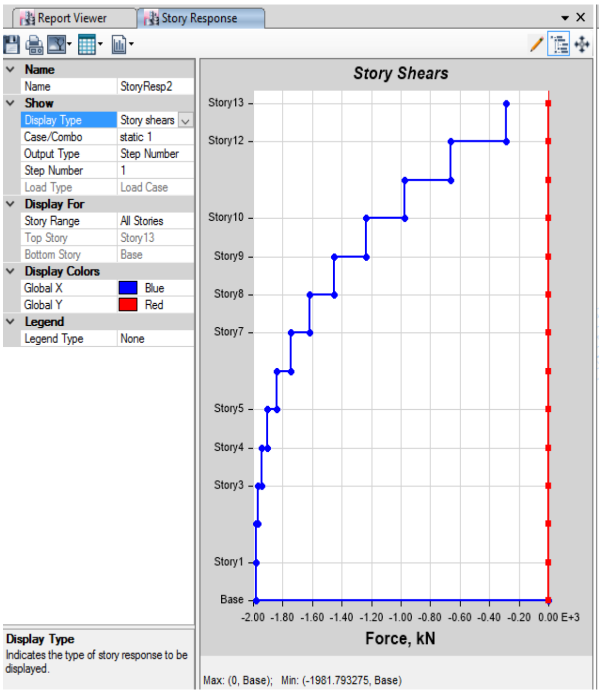



**Fig: 10** Story shear in Linear static analysis

Max story shears = 0
Min story shears = -1981.7932 kN

## VI. Story overturning moment

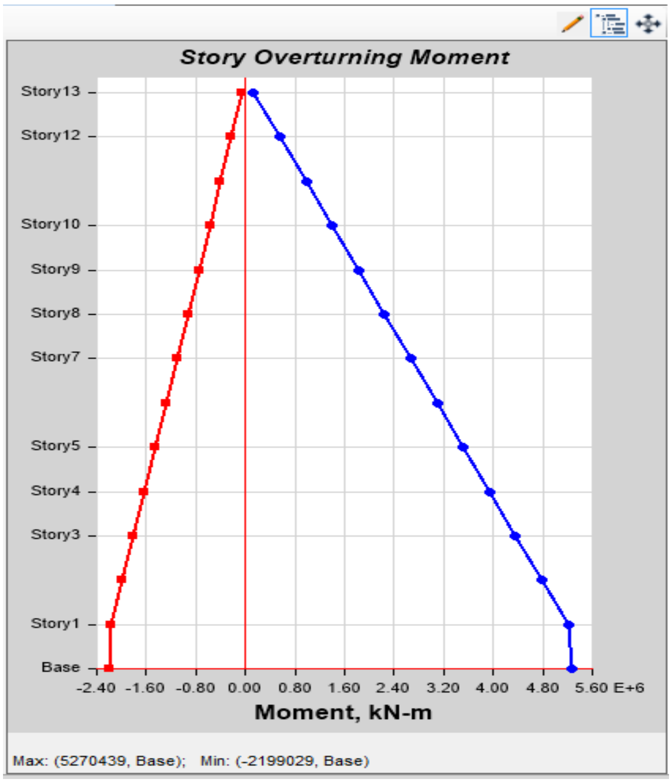



**Fig: 11** Story overturning moment in Linear Static analysis

Max story overturning moment = 0
Min story overturning moment = -1981.7932 kN-m

### 5.2 RESPONSE SPECTRA ANALYSIS

**INPUT DATA**

Seismic zone - III
Soil condition – Type 1 hard soil
Number of modes – 6

## Result

### i. Story displacement

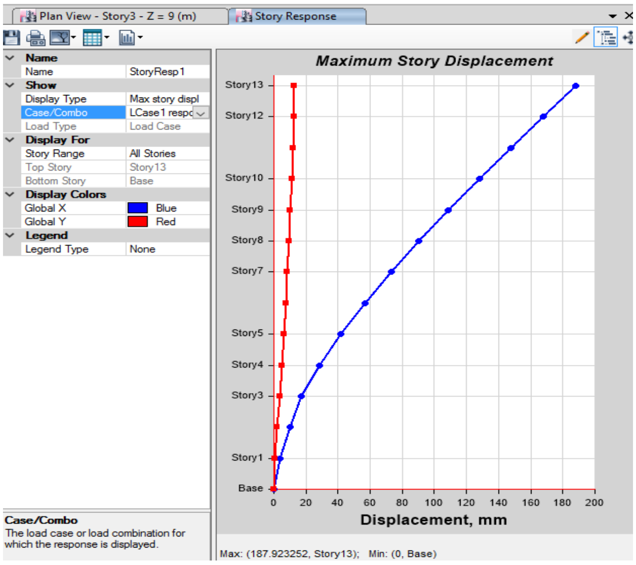



**Fig: 12** Story displacement in response spectra analysis

Max story displacement = 187.92mm
Min story displacement = 0

### ii. Story drift

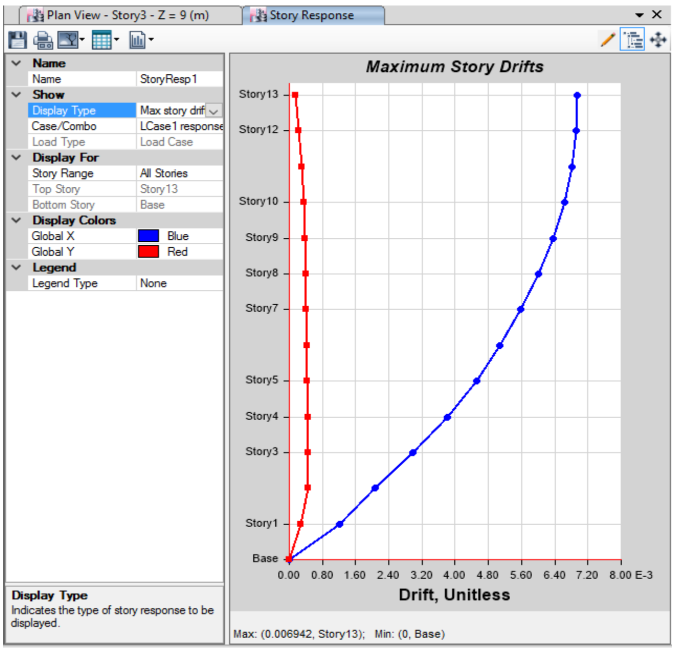



**Fig: 13** Story drift in response spectra analysis

**Table no: 3** Result of response spectra analysis

| Story | Load Case/Combo | Location | P kN | VX kN | VY kN | T kN-m | MX kN-m | MY kN-m |
|---|---|---|---|---|---|---|---|---|
| Story13 | LCase1 response Max | Top | 1.244E-05 | 1111.1857 | 71.601 | 39921.6729 | 0.0005 | 0.0002 |
| Story13 | LCase1 response Max | Bottom | 1.244E-05 | 1111.1857 | 71.601 | 39921.6729 | 214.8027 | 3333.5569 |
| Story12 | LCase1 response Max | Top | 2.907E-05 | 2409.7252 | 156.8631 | 85414.0218 | 214.8024 | 3333.5567 |
| Story12 | LCase1 response Max | Bottom | 2.907E-05 | 2409.7252 | 156.8631 | 85414.0218 | 685.3672 | 10561.9977 |
| Story11 | LCase1 response Max | Top | 4.029E-05 | 3615.9936 | 237.7539 | 126087.7268 | 685.367 | 10561.9977 |
| Story11 | LCase1 response Max | Bottom | 4.029E-05 | 3615.9935 | 237.7539 | 126087.7268 | 1398.5035 | 21405.5286 |
| Story10 | LCase1 response Max | Top | 4.57E-05 | 4716.5375 | 313.083 | 161376.3274 | 1398.5035 | 21405.5285 |
| Story10 | LCase1 response Max | Bottom | 4.57E-05 | 4716.5375 | 313.083 | 161376.3274 | 2337.295 | 35539.2158 |
| Story9 | LCase1 response Max | Top | 4.881E-05 | 5705.8841 | 382.01 | 191512.054 | 2337.295 | 35539.2156 |
| Story9 | LCase1 response Max | Bottom | 4.881E-05 | 5705.8841 | 382.01 | 191512.054 | 3482.0757 | 52615.2989 |
| Story8 | LCase1 response Max | Top | 0.0001 | 6585.1738 | 444.0264 | 217407.3945 | 3482.0756 | 52615.2988 |
| Story8 | LCase1 response Max | Bottom | 0.0001 | 6585.1738 | 444.0264 | 217407.3945 | 4811.4272 | 72283.8552 |
| Story7 | LCase1 response Max | Top | 0.0001 | 7358.6178 | 498.8559 | 240257.1062 | 4811.4272 | 72283.8551 |
| Story7 | LCase1 response Max | Bottom | 0.0001 | 7358.6178 | 498.8559 | 240257.1062 | 6302.9998 | 94206.3476 |
| Story6 | LCase1 response Max | Top | 0.0001 | 8026.7852 | 546.1153 | 260936.1799 | 6302.9998 | 94206.3476 |

### iii. Storyshear

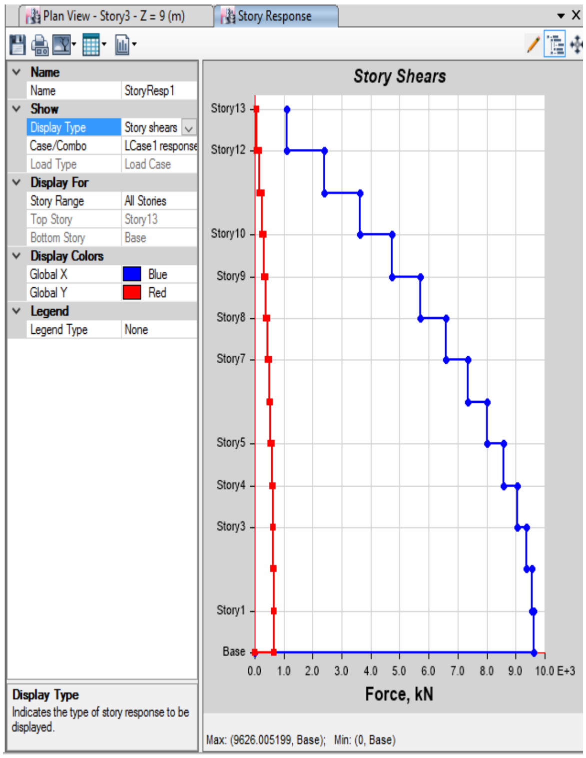



**Fig: 14** Story shears in response spectra analysis

### 5.3 TIME HISTORY ANALYSIS

**INPUT DATA**

**Earthquake data :** Bhuj Earthquake, It occured in 2001 at Gujarat on 26th January, 8.46 am, lasted over 2 min.

Magnitude of Earthquake : 7.7( rector scale)

**Funtamental time period of building:** 6.029
**Time interval of data:** 0.005 s

Scale factor = $\frac{Ig}{R}$

I - Importance factor =1
g - Acceleration due to gravity = 9.81m/s$^2$
R – Response reduction factor = 3

**Result**

i. **Base shear plotted with respect to time period**

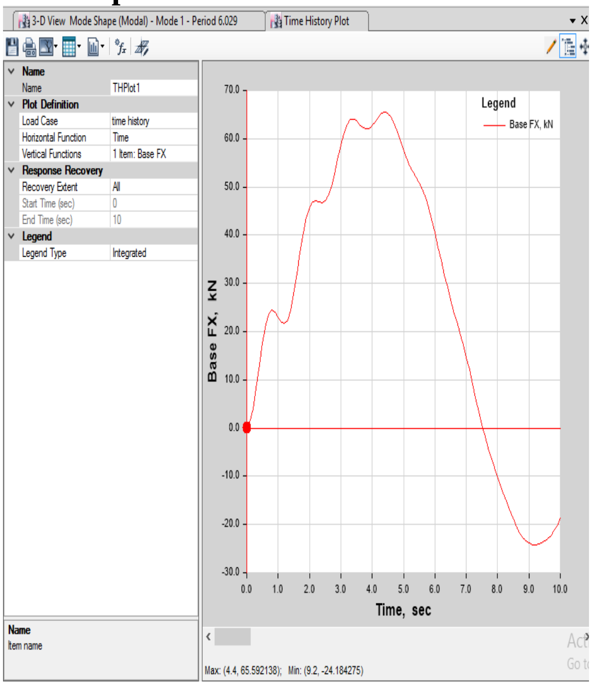



**Fig:15** Base shear plotted with respect to time period

Max Base shear = 65.59 kN, 4.4 s
Min Base shear = -24.18 kN, 9.2 s

ii. **Base Reaction**

**Table no: 4** Result of base reaction in Time history analysis

Base Reactions

| Load Case/Combo | FX kN | FY kN | FZ kN | MX kN-m | MY kN-m | MZ kN-m | X m | Y m | Z m |
|---|---|---|---|---|---|---|---|---|---|
| time history Max | 65.5921 | 0.1641 | 0 | 7.2979 | 1705.6674 | 815.4934 | 0 | 0 | 0 |
| time history Min | -24.1843 | -0.3249 | 0 | -5.4399 | -628.8272 | -2181.613 | 0 | 0 | 0 |
| Comb time history... | 65.5921 | 0.1641 | 0 | 7.2979 | 1705.6674 | 815.4934 | 0 | 0 | 0 |
| Comb time history... | -24.1843 | -0.3249 | 0 | -5.4399 | -628.8272 | -2181.613 | 0 | 0 | 0 |

## VII. CONCLUSION

In this way we can study the behavior of structure with respect to time history method, response spectrum method and Equivalent static analysis and we will obtain the result of base shear, story drift, story displacement, reactions ,shear force and bending moment.

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