SEISMIC PERFORMANCE OF BRACED FRAMED STRUCTURE WITH FLOATING COLUMN

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***Abstract* - In present scenario buildings with floating columns are of typical feature in the modern multi-storey construction practices in urban India. Such features are highly undesirable in a building built in seismically active areas. This paper studies the analysis of a G+30 storey.**

Floating column building for external lateral force. The analysis is done by the use of ETABS 9.7.4. Lateral force caused by earthquake or wind are commonly prevented by bracing system. This paper aims to investigate the effect of a floating column under earthquake excitation for various Inverted V Braced frame section. Linear Static and Dynamic Analysis is done for multi storey frame with floating column to achieve the above aim i.e. the responses (effect) and factors for safe and economical design of the structure under different earthquake excitation. Hence the determination of such factors for safe and economical design of a building having floating column. Earthquake analysis is carried out know the static and dynamic analysis. The different studies are carried out and the comparative studies is carried out in terms of displacement, Storey=drift, time period and base shear.

***Keywords*: ESA: Equivalent Static Analysis. RSA: Response Spectrum Analysis. THA: Time History Analysis.**
OMRF: Ordinary Moment Resisting Frame. SMRF: Special Moment Resisting Frame. DBE: Design Basic Earthquake.
MCE: Maximum Considered Earthquake.

1. INTRODUCTION In civil engineering, structures undergoes, two types of loading i.e., Static loads and Dynamic loads. The examples for static loads are dead load, live load, which are constant with respect to time but dynamic loads will vary with respect to time. In many cases buildings are designed for static loads. Dynamic loads such as earthquake loads and wind loads are not considered in many cases due to time consuming and complex to design, but sometimes neglecting dynamic loads causes' failure of the structure. The dynamic loading causes sudden tremor, which induces the instant peak acceleration. Due to this behaviour effect to structure will be more severe. It is a fact that the whole world is affected by the severe natural disasters from a very long period. It is considered that other than the various natural disasters, the earthquake was one of the major natural disaster affecting the natural economy by resulting into the consequences of the loss of completely destruction of the properties and also the lost of human lives. It is recorded that in the past people faced a severe earthquake in the world. In the execution based system, the desired levels of seismic performance for a structure for specified levels of earthquake ground motion are determined. As it is well known for the structural engineers who are very much familiar towards the lateral loads resisting systems to resist the wind and earthquake loads moment resisting frames, Shear walls or bearing wall and Dual system.

Earthquake causes seismic motion in several directions, these motions emerging from the Epicenter, this result in disintegration of structure, the lack of awareness of earthquake performance in building still continued. In multistory structure which are most vulnerable to earthquake and wind forces. From top to bottom cross-section of the member increases, this leads to structure uneconomical overdue to safety of structure, therefore it is necessary to design a braced framed structure to counter the Lateral forces. Floating column is structural element which imposes directly on beam without contact on ground. These type of column provided where ground floor need large space for parking and to eliminate column obstacle to use the space in below floor.

The primary goal of this project is to tackle the seismic forces by designing stable seismic resisting R.C Braced structure having Floating column. Earthquake affects ground to vibrate, the structure which is constructed in this ground causes deformation, structural failure. According to statics ground motion consists three translational and three rotational components, but rotational components of ground information is not available due to complex to record, translational components are recorded by an instrument ''Accelerograph". The study of generation, propagation and recording of Elastic waves in the earth due to Tectonic earthquakes, Volcanic earthquake, rock falls, mining, cultural noise etc can be defined as Seismology. Earthquake can be analyzed by Intensity and Magnitude, Seismic intensity scale is reference to know the earthquake intensity at different sites. Earthquake magnitude is a calculation of amount of energy released at the time of earthquake. Earthquake magnitude is directly depends to the size, nature and location of an earthquake. Earthquake magnitude can be measured by ''Richter scale. Most of the earthquakes occur as concentrated in narrow belts along the boundaries of the plate; these earthquakes are called as Interplate earthquakes. The earthquake which occurs within the plate is called as Intraplate earthquake. To overcome all the effects of lateral forces and wind loads, Structural design plays an important role in this new Era of construction field, by keeping this in mind the design of a structure should meet some of the requirements, which are explained below;

Stability; The designed structure should be stable to avoid overturning, buckling, or sliding of the Structure, under the action of loads.

Strength; The structure should be strength enough to resist the stresses developed by the loads, Including environmental loads, the different structural members and their connections.

Serviceability; To have sufficient performance of the structure under service loads which implies giving enough stiffness and reinforcement to contain deflection, cracking, and vibrations within the permissible limits.

1.3 OBJECTIVE

The main objective of this study is to study the performance of the high rise building. Then the specified columns are removed to check the floating column effect in the building subjected to seismic load. Further the bracings are introduced in the place of removed column. Attempt is made to know the importance of the bracing in the absence of the column. Earthquake analysis is carried out know the static and dynamic analysis. The different studies are carried out and the comparative studies is carried out in terms of displacement, Storey drift, time period and base shear.

1.4 TYPES OF EARTHQUAKES

There are mainly three types of earthquakes are studied;

1) Shallow focus earthquake
2) Intermediate focus earthquake
3) Deep focus earthquake

Shallow focus earthquakes are the earthquakes with a depth of focus < 70km.
generally 80% of the earthquakes are under this category.
Intermediate focus earthquakes are the earthquakes occurs with a depth of 70 to 300km.
Deep focus earthquake are the earthquake which are having focal depth > 300km

1.5 EARTHQUAKE RESISTANT STRUCTURES

The structures designed to resist earthquakes are called earthquake-resistant structures. No structure can be perfectly designed to completely resist the earthquake without damage. But it can partly resist the earthquakes and try to maintain the structures during the seismic activity. Earthquake-resistant structures are designed to withstand large earthquakes in certain places where they are expected. Through this pre-detection of earthquakes in certain places reduce the loss of life by preventing the destruction of the building, deformation of the structures etc., The buildings, which are excessively stiff and strong, are resisting the earthquakes since ancient times. The main focus in the design of the earthquake-resistant structure is that it must focus on providing the required performance for the seismic threat at a particular location. Therefore, it is necessary that the structures be strong and deformable so that they can withstand the shaking of the ground and minimize the destruction. The following criterion has to be studied for Earthquake Resistant Structures. A) Design Basis Earthquake - characterizes the top flat increasing velocities with 10% likelihood of exceedance in 50 years.

B) Maximum Considered Earthquake - characterizes the top flat increasing velocities with 2% likelihood of exceedance in 50 years. DBE and MCE are seismic configuration parameters for building code design. They are inferred based on statistical analysis of past seismicity information. It is a part of the usual probabilistic seismic hazard investigation of the site. The DBE is said to be 2/3 times the MCE.

1.6 METHODS OF ANALYSIS

Seismic analysis is classified under the type of load applied externally; depending upon the type of construction analysis can be broadly classified as Linear and Non-linear analysis. Further linear analysis is classified as Linear- static1analysis and Non Linear dynamic analysis. Linear static analysis is used in normal building and less height in structures. Linear- dynamic analysis is advanced than that of the linear static; it can be analyzed by Response spectrum method or Elastic time history method. Non- linear analysis split into non- linear static analysis i.e., (nothing but Pushover analysis) and nonlinear dynamic analysis. Non linear static analysis is more advanced analysis than that of linear static analysis and linear dynamic analysis and in this type of analysis the structure is analyzed by considering it in a elastic form. From this analysis we come to know the Ductility, Strength, and Deformation of the structure. In seismic analysis Non-linear dynamic analysis which only able to analyze bear of structure during the earthquake, this analysis is formed by Elasto-plastic deformation of the structural element and numerical integration motion differential equation.

1.7 FLOATING COLUMN

Floating column is defined as a vertical member which Floats or moves in above stories such that to provide more open space. These Floating columns are constructed, especially above the base floor so that it is desirable to have open space for Assembly hall or Parking purpose.

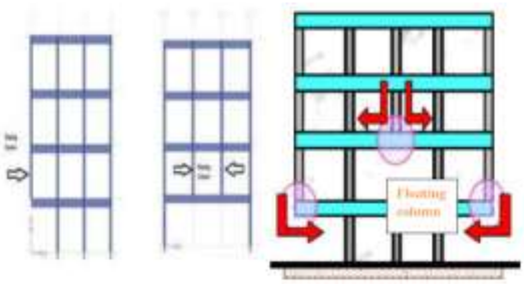


Fig 1.1: Floating column

1.7.1 ADVANTAGES OF FLOATING COLUMN

1. It helps to divide the rooms.
2. For creating a more space in ground floor we adopt floating column.
3. It facilitates more area for parking.

1.7.2 DISADVANTAGES OF FLOATING COLUMN

1) The floating column get affected by more displacement, storey drift, lateral forces than structure without Floating column.
2) The structure having floating column is generally uneconomical structure.
3) The structure with floating column is not preferable for the area where seismic zone is high.

1.8 LOADING

As an integrated system, the structure must resist and transmit all the effects of gravity loads and lateral loads acting on it to the foundation and ground below. The various loads to which a building is subjected to, are as follows:

1. Gravity load
2. Live load
3. Dead load
4. Wind load
5. Earthquake load

1.8.1 GRAVITY LOAD

Gravity loads are called as vertical loads. The earth's gravitational force that acts in the vertical direction. Gravity loads are further distinguished as dead loads and live loads. Gravity loads comprises of the components that constitutes the structure and material, as well as human beings, rain water, furniture, equipment, snow, and all included within the structure.

1.8.2 DEAD LOAD

The dead1load in a building shall comprises the self weight of all the framework, walls, partition walls, roofs and floors and will contain the weight of all other superimposed loads that are permanently affixed to the structure. For such loads, which do not change their position and do not constitute a preliminary section can be assumed by the design engineer using experience in size.

1.8.3 LIVE LOAD

Live Load comprises of those loads whose positions or magnitude or both may change with respect to time. Live load is expressed as a uniformly distributed load. In our country, floors of various types of building have been categorized into different classes and live loads corresponding to them have been specified in the code IS: 875- 1987 (part 2).

1.9 LATERAL LOAD

While carrying out structural analyses and design, Some of the important lateral loads for structure are earthquake load and wind load.

1.9.1 WIND LOAD

The common lateral loading is wind load. Wind loads increases with the height of the building Stresses increase with height of a building, building against wind loads stiffening is increasingly important, since the height of the building increases. In fact, the design of tall buildings is strongly influenced by wind bracing requirements. Architects have often this structural requirement as a forceful aesthetic expression of building facades used in several buildings. The predominant effect of the wind speed at the wind pressure has already been mentioned. Other important factors that affect the wind pressure, are:

• Height above ground
• Exposure classification of the site
• Enclosure classification of the building

The forces influenced by the winds on the structure increases dramatically with the increased building height. Building which has 10 stories and of typical proportion, the design is rarely influenced by wind load. Wind induces a random time-dependent load. Because of winds fluctuating component (gustiness), buildings experiences dynamic oscillations. These oscillations are neglected in short rigid buildings, hence can be satisfactorily considered as having an equivalent static pressure. A structure may be considered as short and rigid if its natural time period is not greater than one second because of the gustiness of wind, more flexible systems such as tall buildings go through dynamic response. Wind Load is calculated according to IS: 875(Part-3) – 1987.

1.9.2 EARTHQUAKE LOAD

Earthquake loads are another lateral live load. A severe earthquake is one of the most terrifying natural events a person can experience. Regardless of where it occurs, it makes instant headlines all over the world. In the past, earthquakes killed a large number of people. They are very complex, unsafe and possibly more harmful than wind loads. It is lucky that they do not occur frequently. The earthquake creates ground movements that can be categorized as "shaking", "rattle" and "rolling". Each structure in an earthquake zone must be able to withstand all three loads of varying intensity. Although the ground can move in any direction under a structure, the structural analysis usually only considers the horizontal components of this movement to be critical. The vertical component of the earthquake is assumed to have a load bearing structure that supports suitably calculated design loads for vertical dead and live loads. The side resistance systems for earthquake loads are similar to those of wind loads. Both are designed to be applied horizontally to the structure. The minor earthquakes occur relatively frequently, the moderate are more frequent and heavier are rare.

1.10 LOAD RESISTING SYSTEM

Since the structures are exposed to two types of loads, i.e. Vertical loads due to the gravity, Further lateral load from earthquake and wind. The auxiliary arrangement of the building must be suitable for the type of loads. The basic layout of the building consists of two segments.

1.10.1 GRAVITY LOAD RESISTING SYSTEM
This structural load resisting system consists of columns, girders, slabs, beams which acts fundamentally to bolster the vertical or gravity loads.

1.10.2 LATERAL LOAD RESISTING SYSTEM
This structural load resisting system comprises of bracings, columns, shear walls, and so forth which essentially acts to resist the horizontal loads.

1.11 LATERAL LOAD RESISTING SYSTEM

1.11.1 MOMENT RESISTING FRAME
These frames infer their horizontal load resistance from the rigidity of associations between column and beams.

1.11.2 SHEAR WALL STRUCTURE SYSTEM
Shear wall is slender vertical cantilever opposite the horizontal load with or without frames. The shearing wall is primarily opposed to the horizontal load during bending with almost no shear deformation.

1.11.3 BRACED FRAME SYSTEM
There are two sort of braced frame system,

1.11.4 CONCENTRICALLY BRACED FRAME SYSTEM
Concentrically supported frames consist of column columns and columns that are connected to fixed connections. The elements are arranged in the form of a vertical truss. They counteract horizontal force by traversing activity. They have a higher elastic stiffness, but lower Ductility.

1.11.5 ECCENTRICALLY BRACED FRAME
Eccentrically braced frame is a kind of steel frame system including beams, Columns and struts, these elements being arranged in a manner in which at least one end of each bracket is connected to segment of the beam referred to as a connection. They resist lateral load of Frames and trusses and develop ductility through bending and shear strength.

1.11.6 CORE AND OUTRIGGER SYSTEM
The Outrigger construction system consists of two systems, the core and perimeter system. The lateral stiffness of a multi-storey building can be considerably reduced by the binding of the periphery Columns to the central core by deep girders. In the steel buildings, core is either formed vertical cross beam or shear wall and outrigger consists of horizontal truss. Outrigger mobilizes whereby the axial stiffness of the columns acts against the lateral load and at the same time the Bending moment in columns and beams.

1.11.7 TUBULAR SYSTEM
This is the most efficient way to get the lateral stiffness of the tall building, in this system; laterally load-bearing material is attached to the perimeter of the building. The result system is called tubular construction. Various tubular systems are framed tube, tube -in tube, Bundle tube and multi cell tube.

1.12 TYPES OF BRACING SYSTEM
1).Diagonal bracing system
2) X-bracing system
3) K-bracing system
4).Inverted V bracing system
5).V-bracing system

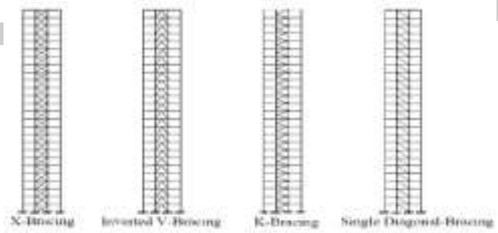


Fig1.2: Types of Bracing System

2. METHODOLOGY

2.1 ETABS
ETABS is sophisticated engineering software developed for a special application program designed specifically for the building system. This software is developed by United States this software works on principle of finite element analysis, from this software time-consuming for the design of the structure will be less. ETABS is abbreviated1as an extended three-dimensional analysis of the building system. ETABS can work with the most comprehensive and complex building models, including a wide range of nonlinear behaviors. In this day and age, the most important weapon for the designers is no other than ETABS. Using ETABS, the structures can be analyzed in various analytical methods, which are response spectrum method, a time history analysis, an equivalent static Method, and a pushover analysis.

2.2 STEPS FOR MODELING OF BUILDING IN ETABS.
Step 1: Define story data like floor height. Number of floors
Step 2: Select code settings from options and define material properties from the define menu.
Step 3: Define the frame section from the definition menu of columns, beams, beams, etc.
Step 4: Define the slab section

Step 5: Draw Building Element from Drawing Menu
Step 6: Specify the support condition
Step 7: Define combination of load case and load
Step 8: Load assignment
Step 9: Define batch source
Step 10: Check the model from the analysis model
Step 11: Set the model from the analysis model
Step 12: Select analysis options and run analysis

2.3 METHODOLOGY

2.3.1 GENERAL

In the present work, the methods used for the analysis of building are Response Spectrum Method1and Equivalent Static Method. In practice the analysis by Response spectrum analysis is required for plan with irregularities or elevation irregularities for tall building. Equivalent static method is used for regular, simple and low to medium height buildings.

2.3.2 EQUIVALENT STATIC FORCE ANALYSIS

The equivalent lateral force for an earthquake is a unique concept used in the earthquake Engineering. The concept is attractive because it converts dynamic analysis into partial dynamic and partial static analysis to find the maximum displacement (or stress) induced by the earthquake excitation in the structure. For the seismically resistant construction of structures, only these maximum voltages are of interest, not the time history of stresses. The equivalent side force for an earthquake is defined as a set of lateral static forces that produce the same peak response of the structure as obtained by the dynamic analysis of the structure under the same earthquake. This equivalence is limited only to a single vibration form of the structure. Inherently, the equivalent static transverse force analysis is based on the following assumptions,

Assume that the structure is rigid.

Ensure the perfect fixity between structure and foundation.

During the ground motion, each point of the structure undergoes the same accelerations.

1. Dominant effect of earthquakes is equivalent to horizontal forces of different sizes across the height.
2. Approximately the total horizontal force (base shear) on the structure.

However, during an earthquake structure does not remain rigid, it deflects, and thus base shear is he height.

2.3.3 DYNAMIC ANALYSIS METHOD

A dynamic analysis has to be carried out in order to obtain structural seismic force and its distribution at different heights along the building height and the different lateral load resisting elements for the following buildings:

1. **Regular structures:** Structures with a height of more than 40 m in zones 4 and 5 and

Their structure with a height of more than 90 m in zones 2 and 3.

2. **Irregular structures:** All framed structures of more than 12 m in zones 4 and 5 and

Those higher than 40 m in zones 2 and 3. The model analysis is carried out by a dynamic approach for structures with a certain arrangement, which are sufficient to the type of irregularities, building configuration. Buildings in relation to irregularities as described in IS-Code: 1893-2002. Dynamic analysis, executed by TIME HISTORY APPROACH or by RESPONSE SPECTRUM APPROACH,

2.3.3.1 RESPONSE SPECTRUM METHOD:

The response spectrum analysis=is a linear dynamic analysis method that measures every natural mode of vibration to the maximum seismic response of an elastic structure. The response spectrum is a graph of the maximum amplitude (velocity shift or acceleration) versus time for many linear oscillators with a single degree of freedom to generate the components of the earth's motion. This graph can be used to select the response of any free oscillator by natural frequency. Such use is in the evaluation of the building's peak response to an earthquake. Response spectra are one of seismic engineering for analyzing the performance of structures during earthquakes. The natural frequency of the structure and the building's peak response can be determined by reading the value from the fundamental response spectrum of the frequency. In seismic area, most building standards use this value to calculate the force that the structure must design.

1. Response Spectrum method is based on1the assumption of linear elastic structural behavior.
2. This method consists of calculating the maximum displacement and the maximum force of the elements in each mode, using smooth design spectra, which is the average value of the multiple seismic moments.
3. In order to perform response spectrum method, important parameter response spectrum in terms of expected earthquake intensity in the considered zone and the supporting base soil behavior have to be considered.
4. One of the other parameter response spectrum related to the computation process is the modal analysis in which the response spectrum analysis computes the structure's response through considering the significant modes. Mode contribution to the structure's response and flexural deformation is mainly dependent on the structure's height. For low to mid-rise structures, the response spectrum three modes are sufficient to capture accurate results where the higher modes contributions diminish very quickly. However, more than three modes have to be considered for high-rise structures. These number response spectra of the requested mode can be chosen such that their combined participating masses are at least 90% of the total of effective masses in the structure.
5. Scaling the1response spectrum curve to consider the over strength and global ductility capacity of lateral force-resisting systems is another important parameter during dynamic response spectrum analysis.

2.3.3.2 TIME HISTORY METHOD

The time history method is a nonlinear dynamic analysis method. This is a structural analysis method when the evaluated structural response is nonlinear. The Time history analysis is performed by stepwise analyzing the dynamic response of the structure to specified loads that change with time. Here, the mathematical model has the tendency of the acceleration of the earthquake records which represents the predicted earthquake at the base of the building.

2.4 RESCALING THE DESIGN5BASE SHEAR OBTAINED FROM RS ANALYSIS IN ACCORDANCE WITH THE ONES OBTAINED WITH THE STATIC ANALYSIS:

1. If the base shear force determined by analysis of the dynamic response spectrum is less than the value specified in the static procedure, it is necessary to scale to the static base shear force determined by the lateral force method. Likewise, if the dynamic base shear obtained from the dynamic response spectrum analysis has a value larger than the static base share, this can be reduced.
2. Following the code requirements, rescaling the dynamic base shear through a magnification factor induces same base as the one obtained employing the static analysis. It has to be noted that maintaining the code level of base force to be same for the static and dynamic analysis does not necessarily lead to similar distribution of storey shear forces using the static and the dynamic response spectrum procedures.

2.5 LOAD COMBINATIONS

Load Combinations is done to get the server condition that the structures have to encounter during its design service life. Indian standard has suggested load combinations for safe design of the structure. The various loads are combined with the stipulation in IS: 875 (Part 5)-1987; whichever combination produce the most unfavorable effect in the building may be adopted

2.6 DESIGN SEISMIC BASE SHEAR

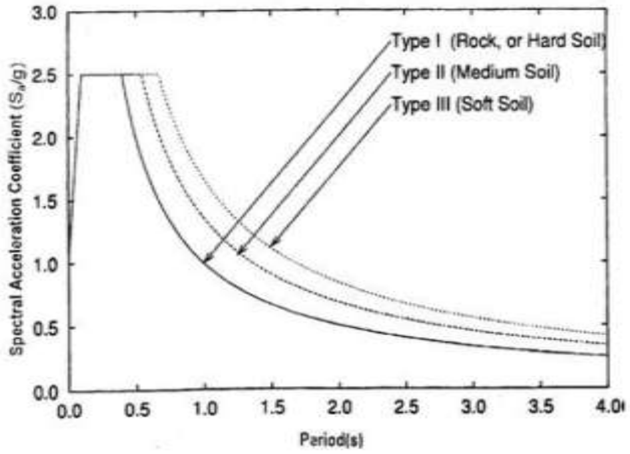
In any direction, total design lateral force (VB) or design seismic base shears can be found by,
(VB = Ah X W)
VB = design seismic base shear
W , seismic weight of structure
Ah is the Design horizontal seismic coefficient
Ah have to be find out by the below expression:
, $A_h = \frac{Z*I}{2*R} * \frac{Sa}{G}$
According to clause 6.4, IS 1893-2002 (Part 1)
The design horizontal seismic co-efficient (Ah) for a structure $=A_h = \frac{Z*I}{2*R} * \frac{Sa}{G}$
Where,
Z= Zone factor obtained from Table 2 of I.S1893-2002.

Table2.2: Zone factor

Seismic Zone	II	III	IV	V
Seismic intensity	Low	Moderate	Severe	Very severe
Z	0.10	0.16	0.24	0.36

I= Importance factor obtained from Table 6 of I.S1893-2002.
R= Response reduction factor from Table 7 of I.S1893-2002.
(Sa/g) = Average response acceleration co-efficient from fig.2 of I.S1893-2002.
, $T = 0.075 * h^{0.75}$
I = I indicates the importance factor and it rely on the functional importance of the building. It is distinguished by hazard effect and failure, post earthquake functional necessities, economic value and historical importance. 1.5 is regarded for the important buildings like schools, hospitals, monumental structures so on. And the remaining buildings I is considered as 1. R = It is response reduction factor which rely on detected seismic impairment performance of building, distinguished as brittle or ductile distortion of building. The values for R are mentioned in IS: 1893,

Table 7. The R value is in-between 3 and 5, for detailing of ductile reinforcement. Sa/g = coefficient for average response acceleration according to IS 1893:2002 clause 6.4.5 as shown in the following figure and it is depend on the natural periods and damping of the building. The zone factor value in the above table is given for Maximum Considered Earthquake (MCE) and building service life in a zone. For the factor Design Basis Earthquake (DBE) in order to decrease the maximum Considered Earthquake (MCE) zone factor, factor 2 is considered in the denominator of Z.



3.2: Response Spectra for Rock & Soil Sites for 5% damping

2.7 DESIGN BASE SHEAR DISTRIBUTION (VB)

Design base shear VB decided above can distribute crosswise over building tallness.
Using the following equation

$Q_i = \frac{wi*hi^2}{\sum_{j=1}^{n} wj*hj^2}$ hi: ith floor height measured from base

Wi : seismic weight
Qi : design lateral force
n = number of stories.

2.8 FUNDAMENTAL8NATURAL TIME PERIOD7OF THE STRUCTURE

For a moment resisting frame structure without brick infill panels, approximate fundamental natural period of vibration (Ta) in seconds, can be assessed by the empirical formula For RC framing structure, ($Ta= 0.075h^{0.75}$)
For steel framing building, ($Ta= 0.085h^{0.75}$)
Where
h = Height of building.
Where, H = Building height, in m (excluding the basement height, basement walls are bridged with ground floor deck or connected in between columns. Yet, when they are not fastened, it comprises the basement storey,).
D = Base dimensions of structure at plinth level (in m) along lateral force considered direction.

2.9 SEISMIC WEIGHT

Seismic weight of the building the seismic intensity of the entire building is the sum of the seismic intensity of all floors. It is necessary to distribute each weight supported between the floors so that it is inversely proportional to the distance from the floor to the top and bottom of the floor. Seismic weight of floors the seismic weight of each floor is the total dead load plus a reasonable load. For various load classes according to IS 875 (part 2), the seismic forces against the total dead load and the proportion of the applied load shall be calculated as shown in Table 8. Regarding the calculation of the structural seismic forces of the structure, it is not necessary to consider the applicable roof load. When calculating the seismic weight of each floor, the weight of the pillars and walls of each storey must be evenly distributed over the floors above and below the storey.

2.10 BUILDING MODELING

In this building model, 30 floors RC braced framed structure with Floating column are analyzed, the typical height of the storey is considered as 3m. The elevation and plan of the structure is as shown in the figure below.

2.10.1 GEOMETRY OF THE PROPOSED BUILDING MODEL

In this chapter, 5x5 Bay 30 storey steel structure is modeled by using ETABS software. The structure is symmetrical in plan and elevation. Winds loading are considered as per IS 875 (Part3):1987 and Earthquake loading are considered as per IS1893 (Part 1): 2002. Parameters such as displacement and storey drift are evaluated.

No of stories	No of base in x direction	Bay width in x direction	No of bays in y direction	Bay width in y direction	Storey height
31	8	5m	8	5m	3m

The plan of the building

1. Number of storeys – G+30
2. The structural building is a RC frame building
3. Height of the building - 90m
4. Typical height of the building – 3m

5. Thickness of the wall – 0.3m
6. Grade of concrete – M25
7. Grade of steel – 415 N/mm^2
8. Thickness of slab – 175mm
9. Sizes of Column – 0.45X0.45m , 0.6X0.6m
10. Size of Beam – 0.3X0.45m
11. SDL – 1.5 KN/m^2
12. LL – 2.5 KN/m^2
13. Zone of the building - II (0.36)
14. Importance factor – 1
15. Response Reduction factor – 5
16. Time period Ta = 2.19sec

The building is analyzed by response spectrum method and time history analysis. The damping factor is assumed to be 5%

2.10.2 MATERIAL PROPERTIES

The materials used in this building model is reinforced concrete with M25 grade and Fe-415 steel then the stress-strain relationship is used as per IS 456-2000. The material property of M25 grade concrete and steel Fe-415 such as Shear modulus, Poisson's ratio, Modulus of elasticity, Density, etc are defined as below. Concrete: Grade M-25, Shear Modulus 9316.95 Mpa, Poisson's Ratio 0.2, Modulus of elasticity 22360.68 Mpa, Density 2458.538 Kg/m3. Steel: Fe 415, Shear Modulus 76884615 Mpa, Poisson's Ratio 0.3, Modulus of elasticity 25000000 Mpa, Density 7849.047 Kg/m3.

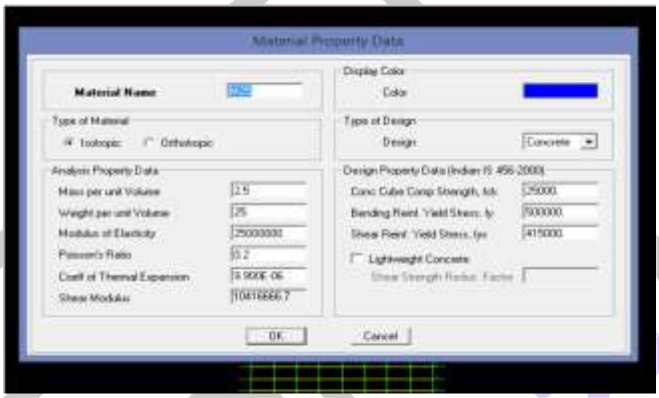


Fig2.1: Material property of M25 grade concrete

Fig2.2: Material property of steel

2.10.3 STORY DATA

The story data of the building model is considered as of G+30 floors of 3m height (each story) The detail of each story is shown in the below snap. Including that the below diagram represents about master story, similar story, spice height etc.

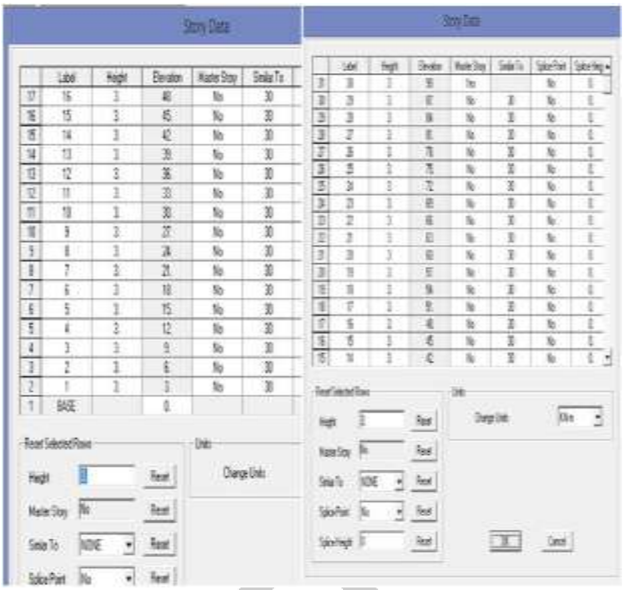


Fig2.3: Details of Story Data

2.10.4 SECTION PROPERTIES

2.10.4.1 FRAME SECTIONS

The Frame sections used in this model are defined as below; the beam of size of 300x450 and column of 450x450 and 600x600 have used in this practice. The properties of the beam like dimensions, depth, width etc are given in the rectangular section division and then the reinforcement details of the same beam is selected as below snap.

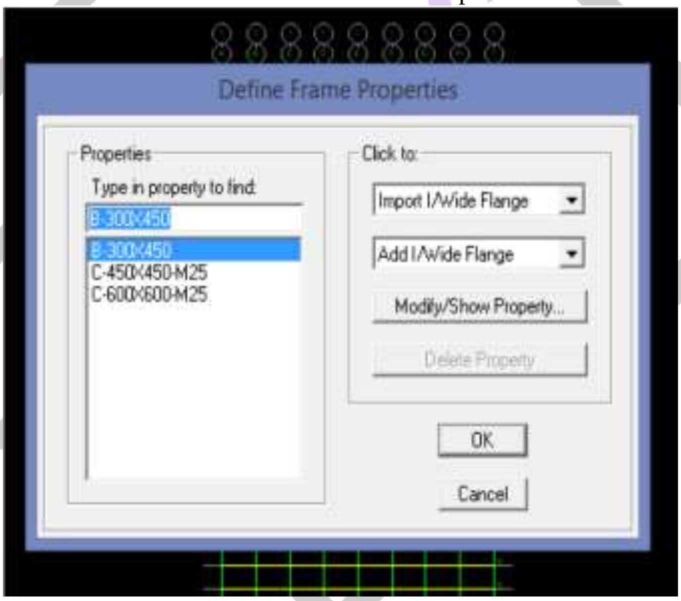


Fig2.4: Details of Frame Sections

The properties of the column section such as depth, width, name of the column which is given in material selection division are as in the diagram showing below, Similarly its and reinforced details are; Cover of the reinforcement for column is taken as 50mm, and number of bars, bar size are selected as default.

2.10.4.2 WALL/SLAB/DECK SECTIONS

For the proposed building model the slab section is used of 175mm thick and grade of concrete used is M-25.

Fig2.5: Proposed slab Section Details

Once the material and sections have defined, it is time to draw them, To draw the frame section and wall/slab/deck sections there are quick tools as well draw tool, by using those we will draw the beams, columns and slabs.

2.10.5 LOAD CASES

In this stage we assigned Static load cases and their referral code for the proposed building. At first, we defined load patterns. In Define Load Patterns tab we provide load name then we provide type of load and select the code in case of lateral load calculation which will be calculated by E-tabs. Dead Load with Self Weight multiplier is default load and no need to define it again. We defined Live load, Super Dead Load, Wind Load and Seismic Load.

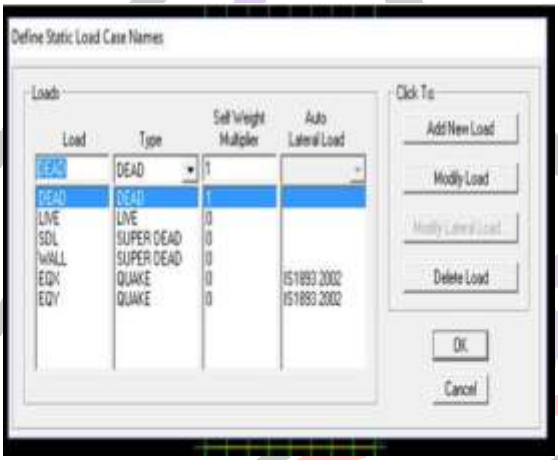


Fig2.6: Details of load cases

2.10.6 LOAD COMBINATIONS

Load combinations such as Dead load + Live load and multiplier of that are taken as below diagram.

Fig2.7: Details of seismic load combinations

2.10.7 MASS SOURCE DATA

While modeling mass source data is the term which is very essential consideration for analysis, which is take as, For dynamic seismic analysis of building, we have to define the mass source. According to the IS:1893, we have to consider entire dead load of the building and 25% of the live load if Live Load is within 3kN/m2 otherwise take 50% of the Live Load. We have defined the mass source of1the building by specifying the load patterns. We gave a multiplier of 1.0 for both Dead Load & Super Imposed Dead Load and multiplier of 0.25 for Live Load.

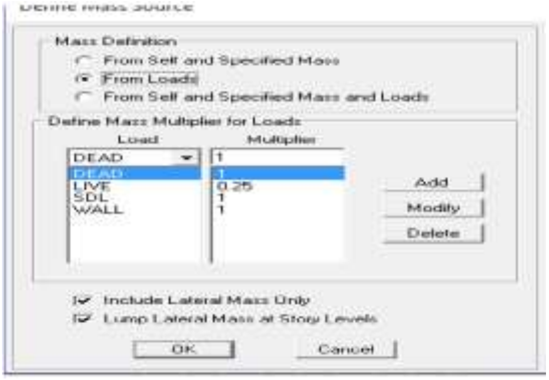


Fig2.8: Details of Mass Source Data

2.10.8 RUN THE ANALYSIS

Once the model has developed we need to check the model and analysis will get over by run the model. After analyzing we will get the value of Maximum shear force, bending moment and deformed shape for the purpose of design.

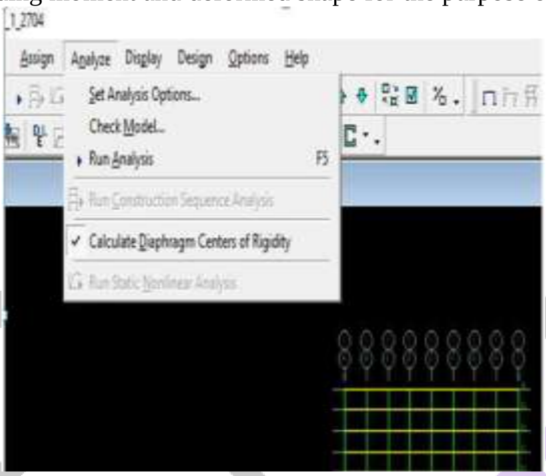


Fig2.9: Analyzing the Model

2.10.9 ANALYSIS OF THE MODEL

The deformed shape of the model shown in figure below, which represents the maximum shear force and bending moment.

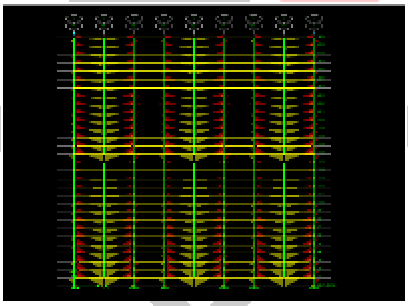


Fig2.10: Deformed Shape of the Model

2.10.10 SHEAR FORCE AND BENDING MOMENT DIAGRAM

We can see the display of bending moment diagram as well as shear force diagram as below;

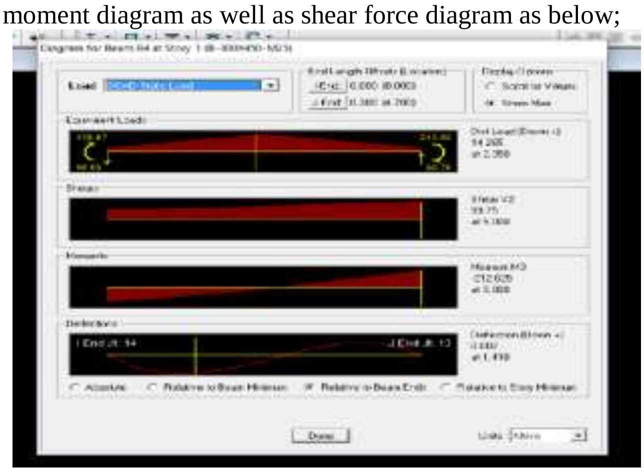


Fig2.11: Shear Force and Bending Moment Diagram

2.11 TYPES OF MODELS

The following Models are considered for the present project work

1) Model 1 with column present all over the Building.
2) Model 2 with floating column
3) Model 3 floating column with inverted V Bracing
4) Model 4 with floating column with different location
5) Model 5 floating column with inverted V Bracing

Model – 1 with column present all over the building

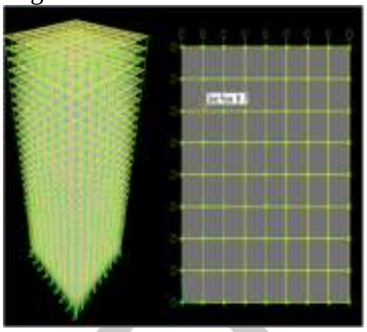


Fig2.12: Plan and 3D view2of0the Regular model

Model – 2 with floating column

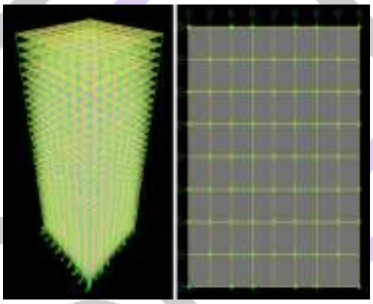


Fig2.13: Plan and 3D view2of0the building model with Floating Column

Model – 3 floating column with inverted V Bracing

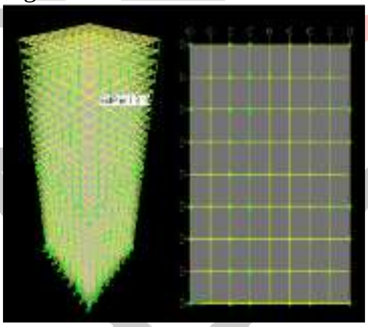


Fig2.14: Plan and 3D view of0the building model with Floating Column and Bracing System

Model – 4 floating column with different location

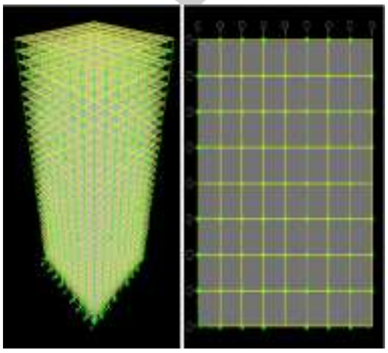


Fig2.15: Plan and 3D view of0the building model with different Floating Column Location.

Model – 5 floating column with inverted V bracing

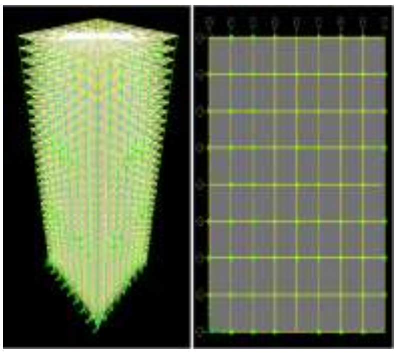


Fig2.17: Plan and 3D view of0the building model with Bracing System

Elevation of the Model

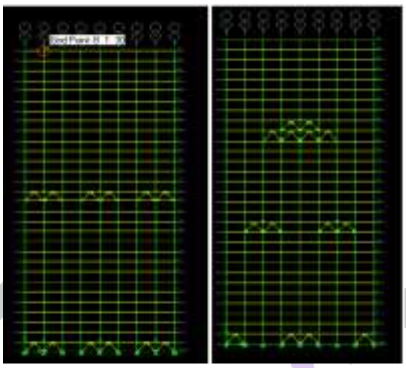


Fig 2.17: Elevations of the structural Model with Bracing System with Floating column

3. RESULTS AND DISCUSSION

3.1 RESULTS AND DISCUSSIONS

After the analysis part, the responses are extracted for OMRF from Etabs 9.7.4 version. As discussed earlier the study of model with and without floating column has been carried out for several load cases and load combination and also for lateral load resisting systems. The responses of the structure for different parameters are noted as;

Member specification for model

Member	Specification
Beam	(300x450) mm
Column	(450x450) mm (600x600) mm

3.2 EQUIVALENT STATIC ANALYSIS

ESA is abbreviated as equivalent static analysis which is used to convert the complex dynamic analysis to the simple static one. This system is well suited for regular balanced structure. The overall weight of the building is calculated based on floor weight. These floor loads involves self -weight of the structural member, live load, and other super dead loads. These loads are sum up later. The seismic loads are then calculated based on floor weight and horizontal seismic co-efficient. This horizontal coefficient is based on zone of the earthquake in which building lies, response reduction factor for OMRF and SMRF, Importance factor depending upon residential building or other type of building. The Displacement, Drift, Time Period and base shear are computed and extracted in further details of the project.

3.3 DISPLACEMENT

Joint Displacement or lateral displacement of the building is an important parameter we have to consider in design of a multi storey building. According to the Indian Codes the maximum displacement of the building should be within 1/500 times the building height in case of wind load and should be 1/250 times the building height in case of earthquake load. The displacement of the structure in X- direction and Y- direction for different models is resulted as in following table for equivalent static analysis;

Table 3.1: Displacement of the structure in X- direction and Y- direction for different Models by using Equivalent Static Analysis

EQX and EQY DISPLACEMENT

STOREY	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5
30	431	456	413	470	391
29	428	452	409	465	387
28	422	446	403	458	381
27	415	438	395	450	373
26	406	429	386	440	364
25	396	418	376	428	353
24	385	406	364	415	341
23	372	393	351	401	328
22	359	378	336	385	316
21	344	363	321	368	308
20	328	346	304	350	303
19	311	329	287	332	289
18	294	311	270	313	272
17	276	292	252	294	254
16	257	271	236	275	234
15	238	250	231	254	215
14	222	233	218	237	199
13	206	216	203	219	183
12	189	199	186	201	171
11	173	182	169	182	164
10	156	164	152	164	151
9	139	146	134	146	135
8	121	129	117	128	118
7	104	111	99	111	101
6	87	93	82	93	83
5	70	75	64	75	65
4	53	57	47	57	48
3	36	40	30	39	31
2	20	23	14	22	15
1	7	8	2	8	3
0	0	0	0	0	0

The table showing displacement of the structure in X- direction and Y-direction for different models is resulted as in following table for response spectrum analysis;

Table 3.2: Displacement of the structure in X- direction and Y direction for different models by using Response Spectrum Analysis

SPECX and SPECY DISPLACEMENT

STOREY	MODEL 1 -RSA	MODEL 2 -RSA	MODEL 3-RSA	MODEL 4-RSA	MODEL 5-RSA
30	351	372	338	383	318
29	349	369	335	380	315
28	345	365	331	375	311
27	341	360	326	369	305
26	335	353	319	362	299
25	328	346	312	354	292
24	321	338	304	346	284
23	312	329	295	336	275
22	302	319	285	325	267
21	292	308	274	312	261
20	281	296	262	299	258
19	269	284	250	286	248
18	256	270	237	272	235
17	242	256	223	258	221
16	228	240	212	243	207
15	214	223	207	227	192
14	201	210	197	213	179
13	188	196	185	199	167
12	174	182	171	184	157
11	160	168	157	168	151
10	145	153	142	153	140
9	131	137	127	137	127
8	115	122	111	121	111
7	100	106	95	105	96
6	84	89	79	89	80
5	68	73	62	72	63
4	52	56	46	55	47
3	36	39	29	38	30
2	20	23	14	22	15
1	7	8	2	7	3
0	0	0	0	0	0

The graph showing the result for displacement in X- direction and Y- direction for equivalent static analysis

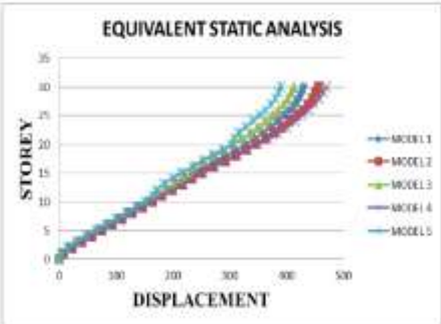


Fig3.1: The graphical representation of displacement Vs Storey by using Equivalent Static Analysis

The below graph showing the result for displacement in X- direction and Y- direction for Response Spectrum Analysis

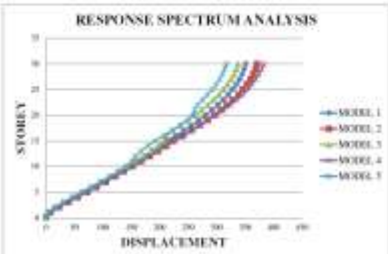


Fig3.2: The graphical representation of displacement Vs Storey by using Response **Spectrum Analysis**

The0displacement of the Regular model is very high compared to other structural models. In this configuration model 5 shows lowest displacement, where as model 4 shows highest displacement.

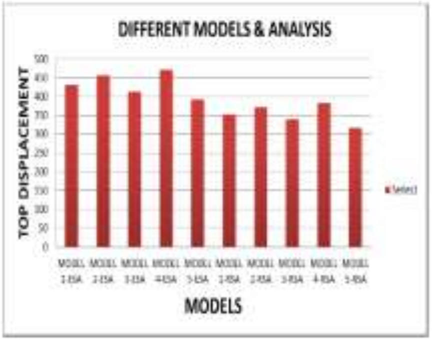


Fig3.3: Comparing the results of Displacement for both Equivalent Static Analysis and Response Spectrum Analysis

3.4 DRIFT

Storey drift is the difference between displacements of two stories to the story height. Drift is characterized by lateral displacement. Storey drift is the drift of a level of a multi storey building from the lower level. Thus, greater the drift, greater probability of damage. According to the Indian code, Story drift in any story should not exceed 0.004 times the height of the story. We also have to check the story drift for all combinations. The drift of the structure in X- direction and Y- direction for different models is resulted as in following table for equivalent static analysis;

Table 3.3: Maximum Drift of the structure in X- direction and Y-direction for different models by using Equivalent Static Analysis

DRIFT - EQX and EQY

STOREY	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5
30	0.001245	0.001468	0.001223	0.001737	0.001437
29	0.001792	0.002014	0.001904	0.002279	0.001984
28	0.002549	0.002572	0.002527	0.002838	0.002542
27	0.002874	0.003096	0.003052	0.003364	0.003066
26	0.003361	0.003584	0.003539	0.003854	0.003551
25	0.00381	0.004033	0.003989	0.00431	0.003987
24	0.004222	0.004447	0.004403	0.004748	0.004317
23	0.004599	0.004825	0.004781	0.005262	0.004204
22	0.004942	0.005168	0.005125	0.005834	0.002627
21	0.005251	0.005479	0.005435	0.00605	0.001547
20	0.005529	0.00576	0.007708	0.005927	0.004614
19	0.005776	0.006021	0.005929	0.006159	0.00578
18	0.005993	0.00631	0.00598	0.006378	0.006156
17	0.006185	0.006923	0.005177	0.006577	0.006371
16	0.006341	0.007189	0.001013	0.006745	0.006486
15	0.005377	0.005606	0.004135	0.005799	0.005398
14	0.005456	0.005661	0.005129	0.005926	0.005138
13	0.005535	0.005731	0.005516	0.006143	0.00418
12	0.005601	0.005799	0.005688	0.006182	0.002344
11	0.005654	0.005853	0.005777	0.005963	0.004187
10	0.005693	0.005893	0.00585	0.005962	0.005313
9	0.005718	0.005921	0.00586	0.005977	0.005709
8	0.00573	0.005936	0.005875	0.005991	0.00585
7	0.005728	0.005938	0.005875	0.005982	0.005896
6	0.005711	0.005927	0.005854	0.005986	0.005894
5	0.005666	0.005894	0.005793	0.00595	0.005822
4	0.005559	0.005815	0.005631	0.005861	0.005691
3	0.00528	0.005614	0.005186	0.005624	0.005257
2	0.004586	0.005068	0.003914	0.004962	0.004009
1	0.002269	0.002842	0.000823	0.002533	0.001646
0	0	0	0	0	0

The table showing drift of the structure5in X- direction and Y-direction for different models is resulted as in following table for response spectrum analysis;

Table3.4: Maximum Drift of the structure in X- direction and Y-direction for different models by using Response Spectrum Analysis

DRIFT- SPECX and SPECY

STOREY	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5
30	0.000968	0.001128	0.001107	0.001343	0.001105
29	0.001428	0.001579	0.001569	0.001793	0.001555
28	0.001889	0.002037	0.002036	0.002255	0.002008
27	0.002304	0.002452	0.002453	0.002674	0.002414
26	0.002667	0.002818	0.002817	0.003046	0.002769
25	0.002988	0.003143	0.003137	0.003379	0.003077
24	0.003281	0.00344	0.003429	0.003699	0.003307
23	0.003561	0.003722	0.003707	0.00409	0.003212
22	0.003834	0.003997	0.003979	0.004546	0.00200
21	0.004099	0.004264	0.004244	0.004725	0.001195
20	0.004352	0.00452	0.004493	0.004682	0.003628
19	0.004587	0.004767	0.004704	0.004904	0.004788
18	0.00488	0.005042	0.00478	0.005121	0.004925
17	0.004906	0.005587	0.004162	0.005327	0.005131
16	0.005182	0.005836	0.001471	0.005521	0.005367
15	0.004447	0.004635	0.00325	0.00428	0.004426
14	0.004568	0.004737	0.00433	0.004962	0.004294
13	0.004702	0.004865	0.004722	0.005216	0.003498
12	0.004831	0.004995	0.004938	0.00533	0.002003
11	0.00495	0.005115	0.005084	0.005217	0.003683
10	0.005055	0.005223	0.005196	0.005286	0.004735
9	0.005148	0.005318	0.00529	0.00537	0.00515
8	0.005232	0.005403	0.005376	0.005453	0.005339
7	0.005308	0.005481	0.005517	0.005603	0.005447
6	0.005374	0.00555	0.005542	0.005652	0.00552
5	0.005416	0.005602	0.00546	0.005643	0.005554
4	0.00539	0.005604	0.005081	0.005476	0.005486
3	0.005181	0.005476	0.003863	0.004875	0.005127
2	0.004459	0.00499	0.000817	0.002907	0.003942
1	0.002256	0.002617	0.000823	0.002533	0.001019
0	0	0	0	0	0

The graphical representation of the drift is drawn as shown as;

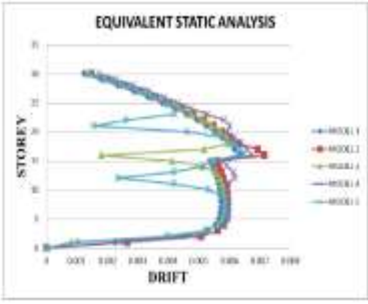


Fig3.4: The graphical representation of drift Vs storey by using Equivalent Static Analysis

The intern storey drift ratio is more in model 2 as compared to other models.

The graphical representation of Response Spectra Analysis is drawn as in the following figure;

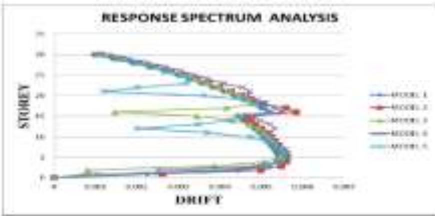


Fig3.5: The graphical representation of Drift Vs storey by using Response Spectra Analysis

Comparing the results of drifts for both ESA and RSA is represented in the following graphical representation;

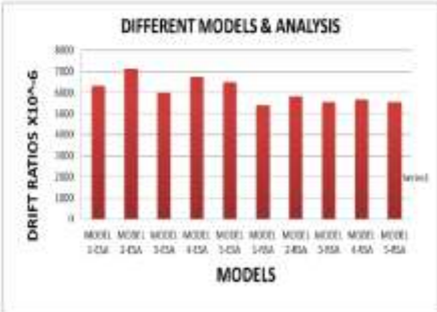


Fig3.6: Comparing the results of drifts for both Equivalent Static Analysis and Response Spectrum Analysis

3.5 TIME PERIOD

The parameter time period for different models with different bracing system by using Equivalent static analysis in X direction and Y direction is represented as;

Table 3.5: Time Period for different Models with different Bracing System by using Equivalent Static Analysis in X direction and Y direction

	TIME PERIOD				
MODE	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5
1	6.24	6.41	6.07	6.47	5.95
2	6.24	6.41	6.07	6.46	5.94
3	5.69	5.85	5.43	5.79	5.17
4	2.16	2.20	2.11	2.22	2.02
5	2.16	2.20	2.11	2.22	2.02
6	1.98	2.03	1.93	2.04	1.79
7	1.24	1.26	1.17	1.27	1.19
8	1.24	1.26	1.17	1.27	1.19
9	1.15	1.18	1.10	1.17	1.08
10	0.88	0.89	0.86	0.89	0.81
11	0.88	0.89	0.86	0.89	0.81
12	0.82	0.83	0.80	0.83	0.73

The parameter time period for different models with different bracing system by using Response Spectra Analysis in X direction and Y direction is represented as;

Table 3.6: Time Period for different Models with different Bracing System by using Response Spectrum Analysis in direction X direction and Y direction

	TIME PERIOD				
MODE	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5
1	6.24	6.41	6.07	6.47	5.95
2	6.24	6.41	6.07	6.46	5.94
3	5.69	5.85	5.43	5.79	5.17
4	2.16	2.20	2.11	2.22	2.02
5	2.16	2.20	2.11	2.22	2.02
6	1.98	2.03	1.93	2.04	1.79
7	1.24	1.26	1.17	1.27	1.19
8	1.24	1.26	1.17	1.27	1.19
9	1.15	1.18	1.08	1.17	1.08
10	0.88	0.89	0.86	0.89	0.81
11	0.88	0.89	0.86	0.89	0.81
12	0.82	0.83	0.80	0.83	0.73

The graphical representation of the Time Period Vs Mode Shapes by using Equivalent static analysis is drawn as shown as;

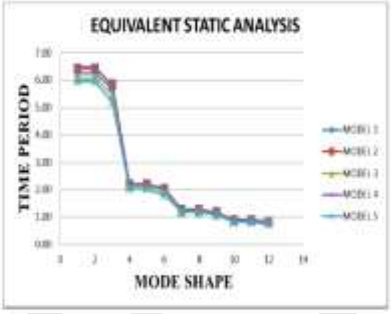


Fig3.7: The Graphical Representation of the Time Period Vs Mode Shapes by using Equivalent static analysis

The graphical representation of the Time Period Vs Mode Shapes by using Response Spectrum Analysis is drawn as shown as;

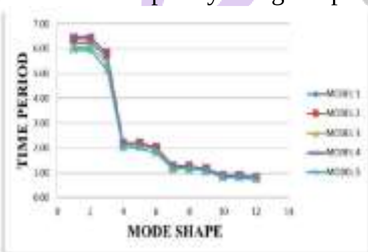


Fig3.8: The graphical representation of Time Period Vs Mode Shape by using Response Spectrum Analysis

3.6 STUDY OF BASE SHEAR

The table below shows different base shear values for 30 storey different models

Table 3.7: The Base Shear for different Models for 30 storeys

30 STOREY				
MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5
15786.01	15779.74	15800.96	15776.3	15809.59

Fig3.9: The graphical representation of Base Shear for Different Models

The base shear value directly depends on the weight of the building, the regular model is having less loads compared to other models. The model 5 is having highest base shear value compared to other models.

4. CONCLUSION

4.1CONCLUSION

- The results obtained from dynamic analysis will be practical and gives the lesser deformations compared to linear static analysis.
- The values obtained from static analysis are too impractical, the ESA will gives the more lateral resistant design, there by considering heavy design of structure. Which will increase the self weight and also the construction cost.
- The Intern Storey drift values will increases as we move down stories and after few levels it will vary inversely.

- The dynamic analysis shows much practical result compared to static analysis. The Model 4 being highest in both static, dynamic and lowest being 5. There is a considerable reduction of approximately 20% for response spectrum analysis compared to static analysis.
- The Time period and base shear value will not vary much compared to static and dynamic analysis, since these values are dependent on building parameter not on earthquake behaviour.
- The model 4 is showing better ductile property which the model 5 can be considered as brittle. Since the natural time period of the regular system is not matching with the time period obtained from analysis, we can conclude that the time period depends not only on the total height, but also on the mass, configuration and others.
- Base shear value is less in the regular model compared to bracing systems. Since base shear depends on the load. The regular model posses less load, so the building exhibits lowest value of base shear.

4.2 Scope for Future Study

- The project can be continued by further studies as stated below:
- • The steel structure can be replaced with concrete to check the seismic performance of steel Building.
- • Different forms of bracings can be used to alter the behavior.
- • The time history analysis can be performed to check the exact behavior.

REFERENCES

[1] Niroomandi, Maheri and Mahini (2010) “Retrofitted on eight-storey frame strengthened previously with a Steel Bracing system with web- bonded CFRP”.
[2] Dr.R.B. Khadiranaikar and Yallappa halli (2014) ISSN2278-0181 “Seismic performance of RC frame with steel bracing’’.
[3] Kulkarni J.G. and Kore P.N. and Tanawade S.B. (IJERA) ISSN 2248-9622 Vol 3, Issue 4 Jul-Aug 2013 “Seismic Response of reinforced concrete Frames”.
[4] Kavya N Dr. K. Manjunatha and Sachin P Dyavappanavar (IRJET) Vol 2- Sep 2015 “Seismic Evaluation of Multi storey RC Building With and without Floating Column”.
[5] Anitha M and Divya K.K.(IRJET) Vol 2 Sep-2015 “Study on Seismic behavior of Knee Braced Steel Frames”.
[6] Gourav Kumar and Megha Kalra (IJATES) Vol 04 Feb 2016 “Review paper on seismic analysis of RCC Frame Structures with floating columns”.
[7] Nikhil Bandval (2014) “Architectural complexity and various irregularities like Floating column at various level and location are analyzed”.
[8] Mundada (2014) “Analysis of structure with Floating column and without Floating column and Floating column with Struts”.
[9] Malaviya (2014) “Cost Analysis of structure having Floating column and without Floating column structure”.
[10] Rohilla (2015) “Behavior and Advantages of Floating column” Etab software is used in this dissertation”.
[11] IS 456(2000), “Plain and Reinforced Concrete- Code of Practice”, Bureau of Indian Standards, New Delhi.
[12] IS: 875 (Part 1) - 1987: Dead Loads – Unit Weights of Building materials and stored materials
[13] IS: 875 (Part 2) - 1987: Imposed Loads
[14] IS: 875 (Part 3) - 1987: Wind Loads
[15] BIS: 1893 (PART 1)-2002 “Criteria For Earthquake Design Of Structures: General provisions and buildings”(Fifth revision), Bureau of Indian Standards , New Delhi