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ANALYSIS AND DESIGN OF G+6 BUILDING IN DIFFERENT SEISMIC ZONES BY USING SOFTWARE

Shubham Borkar[1], Dr. G.D. Awchat[2]

[1]*PG Student. Department of Civil Engineering, Guru Nanak Institute of Technology, Nagpur, India*
[2]*Associate and Professor, Dean R & D, Department of Civil Engineering, Guru Nanak Institute of Technology, Nagpur, India*

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Abstract - *The principle objective of this project is to analyze and design of G + 6 building in different seismic zones and in different soil types by using ETABS. In this project, all the four zones and three types of soils have been taken under consideration. ETABS (Extended Three Dimensional Analysis of Building System) is a software that is incorporated with all the major analysis engines that are static, dynamic, Linear and non-linear and especially this Software is used to analyze and design the buildings. The present work is to study the behaviour of a G+6 building subjected to earthquake load by adopting Response spectrum analysis. We analyzed G + 6 storey building for all possible load combinations [Dead, Live &Seismic loads]. Seismic loads were taken as per IS 1893: 2002.*

Our final work was the analysis of G + 6 building under various load combination. We considered a commercial building as specified in the plan. The height from the ground floor to sixth floor is 3.0 m. The structure was subjected to self-weight, dead load, live load and seismic loads under the load case details of ETABS. Seismic load calculations were done with the following IS 1893-2000 (part-1). The materials were specified and cross-sections of the beam and column members were assigned. The supports at the base of the structure were also specified as fixed.

Key Words*: *ETABS, G+6, Soils, Zones, Analysis, Design.

1. INTRODUCTION

The Design of buildings wherein there is no damage during the strong but rare earthquake is called earthquake-proof design. The engineers do not attempt to make earthquake-proof buildings that will not get damaged even during the rare but strong earthquake. Such buildings will be too robust and also too expensive. The aim of the earthquake resistant design is to have structures that will behave elastically and survive without collapse under major earthquakes that might occur during the life of the structure. To avoid collapse during a major earthquake, structural members must be ductile enough to absorb and dissipate energy by post-elastic deformation.

Many researchers have been conducted on this topic and still, it is continuing because more we try to learn more we can minimize the damages and save the lives. According to studies that have been made on the seismology about 90% earthquake happens due to tectonics. If we come to civil engineering an engineer's job is to provide maximum safety in the structures designed and maintain the economy.

Prior to the analysis and design of any structure, necessary information regarding supporting soil has to be collected by means of geotechnical investigation. A geotechnical site investigation is a process of collecting information and evaluating the conditions of the site for the purpose of designing and constructing the foundation for a structure. Structural engineers are facing the challenges of striving for most efficient and economical design with accuracy in solution while ensuring that the final design of a building and the building must be serviceable for its intended function over its design lifetime. Now a day's various software packages are available in the market for analyzing and designing practically all types of structures viz. RISA, STAADPRO, ETABS, STRUDL, MIDAS, SAP and RAM, etc.

The latest version of the seismic zoning map of India given in the earthquake resistant design code of India [IS 1893 (Part1) 2002] assigns four levels of seismicity for India in terms of zone factors. In other words, the earthquake-zoning map of India divides India into 4 seismic zones (Zone 2, 3, 4 and 5) unlike its previous version, which consisted of five or six zones for the country. According to the present zoning map, Zone 5 expects the highest level of seismicity whereas Zone 2 is associated with the lowest level of seismicity.

Zone 5 covers the areas with the highest risks zone that suffers earthquakes of intensity MSK IX or greater. The IS code assigns zone factor of 0.36 for Zone 5. Structural designers use this factor for earthquake resistant design of structures in Zone 5. The zone factor of 0.36 is indicative of effective (zero periods) level earthquake in this zone. It is referred to as the Very High Damage Risk Zone. The region of Kashmir, the western and central Himalayas, North and Middle Bihar, the North-East Indian region and the Rann of Kutch fall in this zone.

Zone 4 is called the High Damage Risk Zone and covers areas liable to MSK VIII. The IS code assigns zone factor of 0.24 for Zone 4. The Indo-Gangetic basin and the capital of the country (Delhi), Jammu and Kashmir fall in Zone 4. In Maharashtra, the Patan area (Koyananager) is also in zone no 4. In Bihar, the northern part of the state like- Raksaul, near the border of India and Nepal, is also in zone no 4.

Zone 3, the Andaman and Nicobar Islands, parts of Kashmir, Western Himalayas fall under this zone. This zone is classified as Moderate Damage Risk Zone, which is liable to MSK VII. The IS code assigns zone factor of 0.16 for Zone 3.

Zone 2 is liable to MSK VI or less and is classified as the Low Damage Risk Zone. The IS code assigns zone factor of (maximum horizontal acceleration that can be experienced by a structure in this zone is 10% of gravitational acceleration) for Zone 2.

1.1 Introduction to ETABS software

In this report, we are mainly concerned with the analysis of the G+6 Building subjected to loads. The methods that we would be presenting in this report for analysis of structure were done with the help of software (ETABS).

ETABS is software created by computer and structural Inc (CSI), it is a structural and earthquake engineering Software Company, the tallest building in the world Burj khalifa is also designed and analyzed in this software.

We have chosen ETABS because of THE following advantages:

- Easy to use interface,
- ConfIrmation with the Indian Standard Codes
- Versatile nature of solving any type of problem,
- Accuracy of the solution.

ETABS features a state-of-the-art user interface, visualization tools, powerful analysis and design engines with advanced finite element and dynamic analysis capabilities. From model generation, analysis and design to visualization and result verification, ETABS is the professional's choice for steel, concrete, timber, aluminum and cold-formed steel design of low and high-rise buildings, culverts, petrochemical plants, tunnels, bridges, piles and much more.

1.2 Aim and objective of the present project

Following specific objectives are decided for the present study

- To study the behaviour of a building under the action of seismic loads.
- How the seismic evaluation of a building should be carried out.
- To compare various analysis results of building under zone II, III, IV, and V using ETAB Software.
- To calculate the types of loads acting on such kinds of buildings.
- To study the seismic analysis technique, like, response spectrum analysis, and its application by using the software.
- Different values of zone factor are taken and their corresponding effects are interpreted in the results.
- The main objective of this study is to analyze and design a G+6 building using ETABS software.
- To analyze the building as per code IS 1893:2000(part I) criteria for earthquake resistance Structure.
- To develop, design and analysis model of the high rise structure using ETABS.
- Building structures should be able to resist major earthquakes without collapse.

1.3 Scope of work

- The study views to determine the extent of possible changes in the seismic behavior of RC building models.
- RC framed buildings are firstly designed for gravity loads and then for seismic loads.
- There has been a considerable increase in the number of buildings. Thus the effects of lateral load like earthquake forces are attaining increasing importance and almost every designer is faced with the problem of providing adequate strength and stability against the lateral load.
- The study highlights the effect of seismic zone factor in different zones that is in zone II, Zone III, Zone IV and Zone V which is considered in the seismic performance evaluation of buildings.
- The entire process of modeling, analysis, and design of all the primary elements for all the models are carried by using ETABS software.

2. LITERATURE REVIEW

IS 456:2000 [22], this standard is basically used for the plain and reinforced structure. It deals with the design of building according to their requirements. In this code, it has been assumed that the design of plan and reinforced cement concrete work is entrusted to a qualified engineer and that the execution of cement concrete work is carried out under the direction of a qualified and experienced supervisor.

Bruce R.Ellingwood (2001) [7] studied the prospect and future improvement in earthquake resistant and design procedure based on the more rational probability-based treatment of uncertainty are examined.

IS 1893(part1):2002 [21] this standard deals with assessment of seismic loads on various structures and earthquake resistant design of buildings, its basic provision are applicable for building; elevated structures; industrial and stack like structures; bridges; concrete masonry and earth dams; embankments and retaining walls and other structures.

S.K. Ahirwar, S.K.Jain and M.M.Pande(2008): Estimated earthquake loads on multi-story R.C. Framed buildings as per IS:1893-1984 and IS:1893-2002 recommendations. They considered three, five, seven and nine storey buildings and each was analyzed individually. For each building, a set of five individual sequences was decided in the process. The methods of analysis adopted were the Seismic Coefficient method, Response Spectrum method, and Modal Analysis method. Seismic responses viz. storey shear, base shear

Geotechnical Earthquake Engineering (Steven L. Kramer), (2013) deals with the basic concept of earthquake engineering, geotechnical engineering, seismology, and structural engineering. This book deals with the type of damage done by earthquake, measurement of ground motion, hazard analysis and methods for analyzing the ground response during an earthquake.

Anil K. Chopra (2015) [17] this book includes the theory of structural dynamics and application of this theory to earthquake analysis, response and design of structures. This book concerned with the earthquake response and design of the multi-story building with dynamic analysis.

Inchara K P, Ashwini G (2016): The main objectives of this study were to study the performance and variation in steel percentage and quantities concrete in R.C framed irregular building in gravity load and different seismic zones. And to know the comparison of steel reinforcement percentage and quantities of concrete when the building is designed as per IS 456:2000 for gravity loads and when the building is designed as per IS 1893(Part 1):2002for earthquake forces in different seismic zones. In this study five (G+4) models were considered. All four models were modeled and analyzed for gravity loads and earthquake forces in different seismic zones. ETABS software was used for the analysis of the models. According to their research, it can be inferred that support reactions tended to increase as the zone varied from II to V, which in turn increased volume of concrete and weight of steel reinforcement in footings and in case of beams, percentage of steel reinforcement increased through zones II to V.

3. METHODOLOGY

As discussed in the previous chapters, a structure must be analyzed and designed to resist the lateral earthquake forces. In this chapter, the analysis and design procedure of the G+6 storey commercial building is discussed with the help of ETABS Software by response spectrum method. There are computational advantages in using the response spectrum method of seismic analysis for the prediction of displacements and member forces in structural systems. The method involves the calculation of only the maximum values of the displacements and member forces in each mode using smooth design spectra that is the average of several earthquake motions. In these different seismic zones and soil types are taken to get the results of building, how it reacts to different zones as well to different soil types.

3.1 PRELIMINARY DATA

A G+6 storey RC commercial building has been designed as an RCC framed structure with a reinforced concrete slab. This building is analyzed by using ETABS Software and the analysis part is done for the different zones of India and for different soil types. IS code 456-2000: Plain and Reinforced Concrete, IS code 875-1987(part 2): Live Load and IS code 1893-2002: Criteria for earthquake resistant design of structures are taken into consideration.

3.2 BUILDING CONFIGURATION

The building model has six storeys with a constant storey height of 3m. Different values of zone factors and different soil types are taken and their corresponding effects are interpreted in the results. Twelve models are made by taking different zones and soil types.

Table 1: Other relevant data

Sr. No.	GENERAL DATA	VALUES
1.	Grade of concrete	M25
2.	Grade of steel	Fe-415
3.	The density of reinforced concrete	25 KN/m^3
4.	The density of fly ash brick	20 KN/m^3
5.	Slab thickness	0.150 m

Table 2: Zone relevant data

Parameters	Zone - II	Zone - III	Zone-IV	Zone-V
Seismic zone factor	0.10	0.16	0.24	0.36
Response reduction factor	5	5	5	5
Importance factor	1	1	1	1
Soil type	1) soil type – I (Rock or Hard soil) 2) soil type – II (Medium soil) 3) soil type – III (Soft soil)			

Table 3: Loading data

Parameters	Zone - II	Zone-III	Zone-IV	Zone - V
Live load for parking	0.10	0.16	0.24	0.36
Live load for passages, corridors, lobby's	5	5	5	5
Live load for terrace	1	1	1	1
Floor finish(KN/m^2)	1	1	1	1

Table 4: Column and beam data

Beam's size	B-230X400 B-230X750
Column's size	C-230X750 C-230X1000

3.3 PLAN

This is the ground floor plan which is consisting of ramps, staircase and lift this is the parking area for the commercial building. The first floor to the fifth floor is the office area for the commercial building.

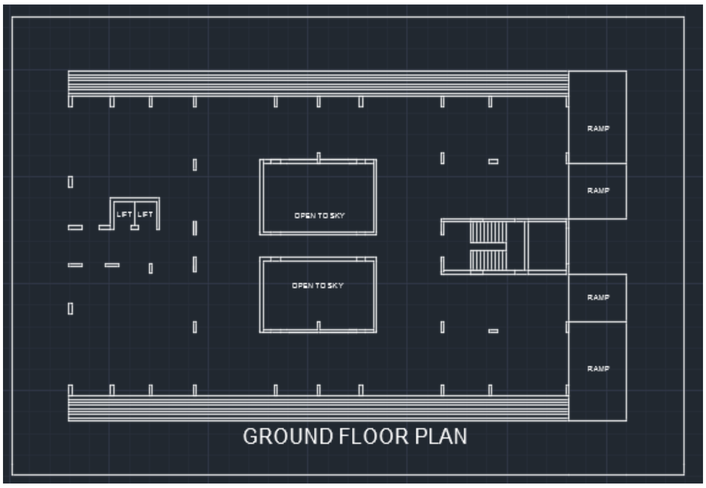

Figure 5.1: Ground floor plan

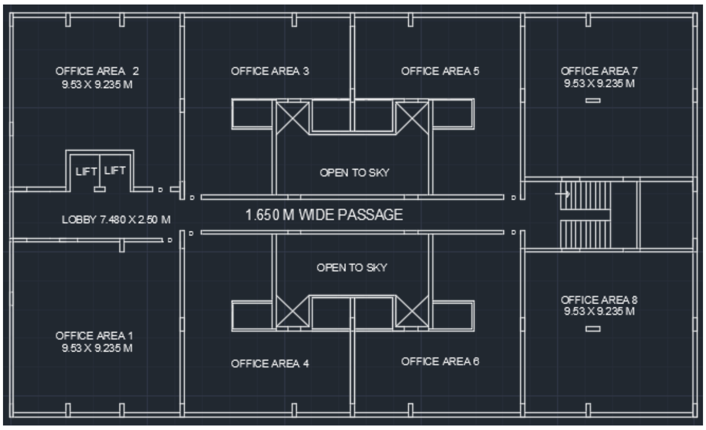

Figure 5.1: Ground floor plan

4. SEISMIC ANALYSIS AND DESIGN WITH ETABS SOFTWARE

ETABS software's working is divided into four parts name as modeling, defining, assigning and analysis. Then the modeling part is divided into three parts as model initialization, grid dimensions, and story dimensions. The defining part is divided into five parts as material properties, section properties, load patterns, diaphragms attachments, and response spectrum.

Step – 1: Modeling

Modeling is the first process in which all the modeling work is done by preparing the whole plan into a grid pattern so that the beams and columns should be placed easily. In this process the height of the structure is defined, Model initialization is the first step in modeling in this a new model is selected and display units, steel section database, steel design code, and concrete design code is selected and after this a window is open in which grid template is selected so that columns and beams are easily placed and in this storey floors and their height can be selected, Grid dimension in this step the grid data in x-direction and grid data in y-direction is put in meters so that the plan should be formed in a proper manner because of this the columns and beams should be placed easily in their proper position, Story dimensions In this step the story dimensions are putted according to the requirement. If a project is similar on each floor then set a story1 as the base story and remaining are like similar stories.

Step – 2: Defining

In this step all the material properties, section properties, slab properties, wall properties, load patterns, seismic zone factor, importance factor, response reduction factor, soil type, diaphragm, response spectrum functions, load case, and load combinations are defined, Material properties in this step the materials as concrete and rebar are defined as M25 and Fe-415, Section properties in this step size of columns and size of the beams are defined, Load pattern are defined and for earthquake zones the zone factor, response reduction factor, important factor, and type of soil are defines as well as diaphragm and response spectrum function values are defined for earthquake load cases.

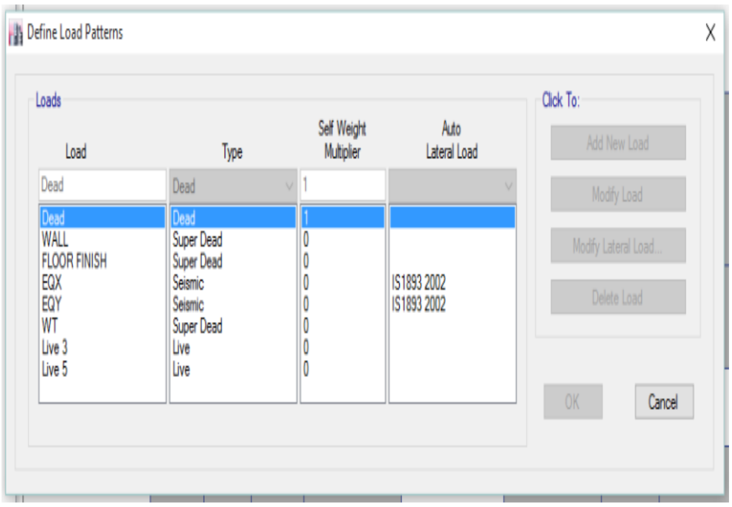

Figure 5.11: Define load patterns

Load cases and combinations are defined by load patterns and extra cases are also defined for earthquake response spectrum functions and from load cases load combinations are made.

Step – 3: Assigning

In this step all assigning part is done by assigning the columns, beams, slab, diaphragm and loads, 3D view of the structure after assigning all the assignments are shown below

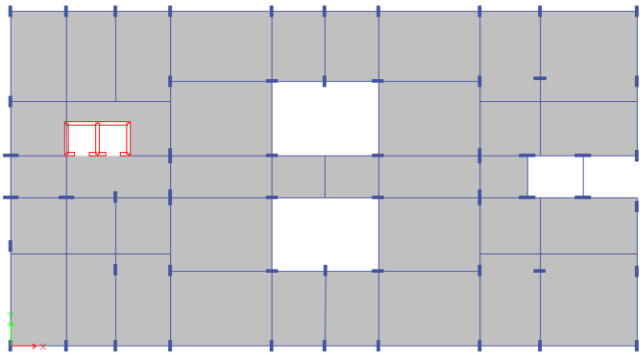

Figure 5.18: 2D structure with columns beams and slab

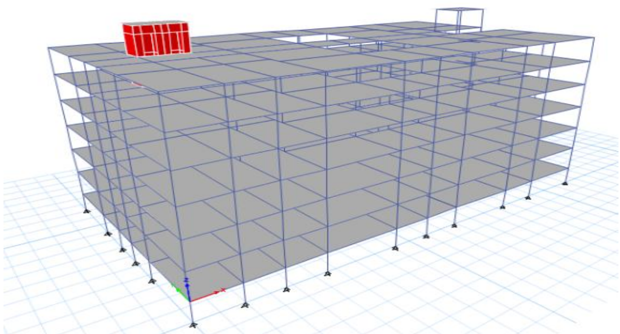

Figure 5.19: 3D structure

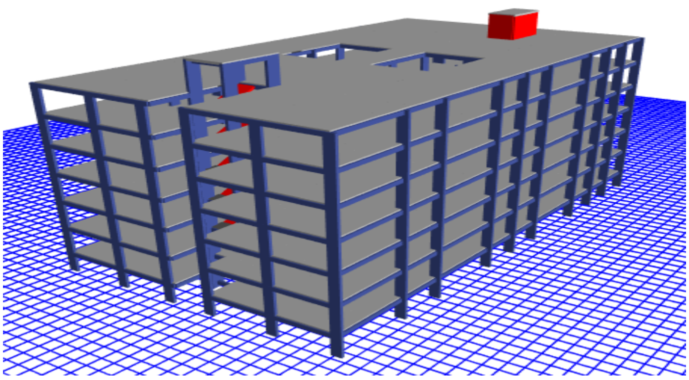

Figure 5.22: Rendered view of the structure

Step – 3: Analysis

- After completion of all the process runs the analysis by clicking to analyze then run analysis, I had done all the above steps by selecting different zones and different soil types, after that I get 12 models to consist of different zones and soils having different results.

5. RESULTS AND DISCUSSION

Base shear: Base shear is an estimate of the maximum expected lateral forces that will occur due to seismic ground motion at the base of a structure. In the below table the values of base reaction according to the response spectrum in different zones and different soils are given for x-direction and y-direction.

Table 1: The base reaction forces in the global x- direction

Sr. No.	SOIL TYPE ZONES	SOIL-I Base shear(KN)	SOIL- II Base shear(KN)	SOIL- III Base shear(KN)
1	ZONE – II	723.5497	1123.9395	1408.5387
2	ZONE- III	1066.1183	1489.8291	2526.7324
3	ZONE- IV	2510.6757	3402.1053	3792.616
4	ZONE- V	3727.7996	5069.8044	5688.924

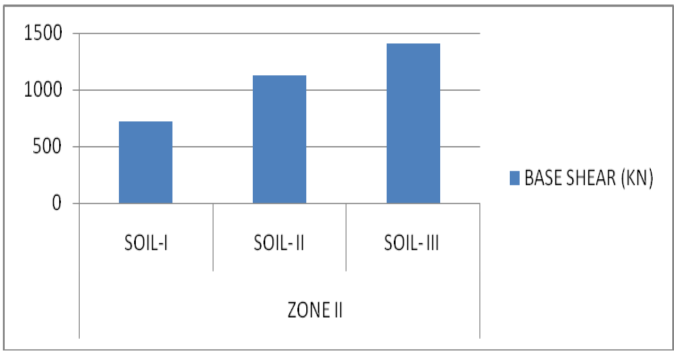

Fig-Base shear (KN) in the zone- II

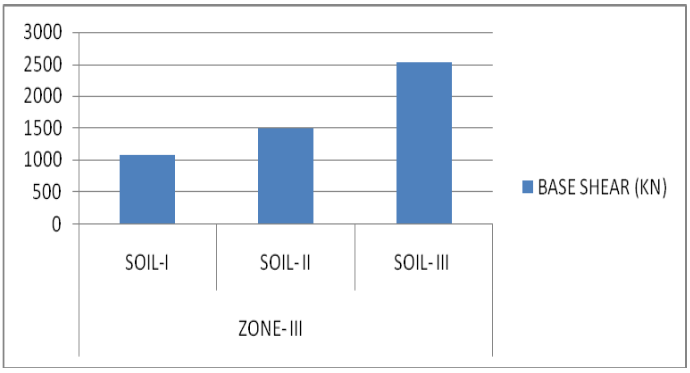

Fig- Base shear (KN) in the zone- III

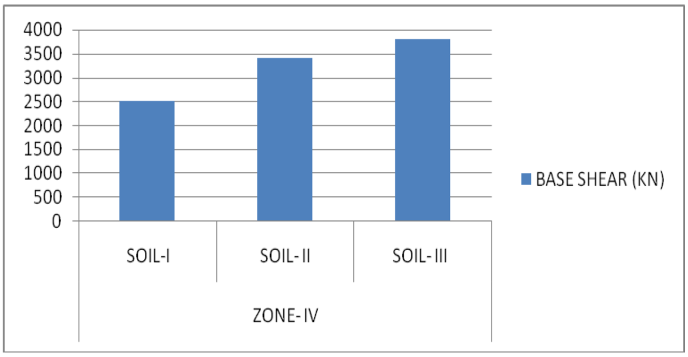

Fig- Base shear (KN) in the zone- IV

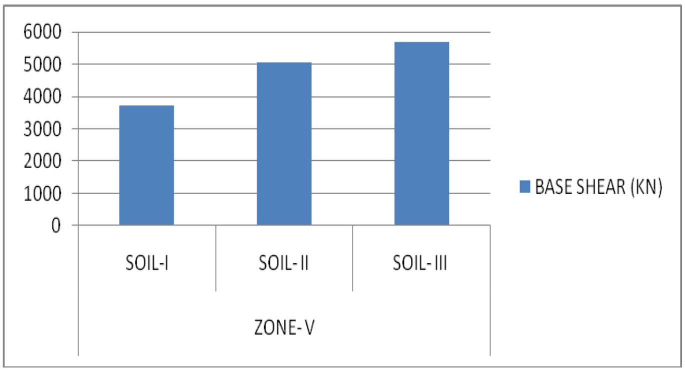

Fig- Base shear (KN) in the zone- V

Table 2: The base reaction forces in the global y-direction

Sr. No.	SOIL TYPE	SOIL-I	SOIL- II	SOIL- III
	ZONES	Base shear(KN)	Base shear(KN)	Base shear(KN)
1	ZONE - II	453.4649	751.9543	867.6803
2	ZONE- III	722.8684	989.9881	1716.9048
3	ZONE- IV	1663.3168	2185.0906	2559.4448
4	ZONE- V	2298.9123	3126.5207	3839.1834

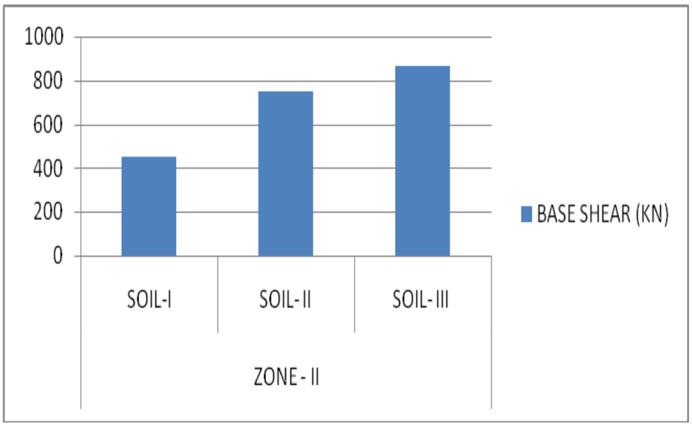

Fig- Base shear (KN) in the zone- II

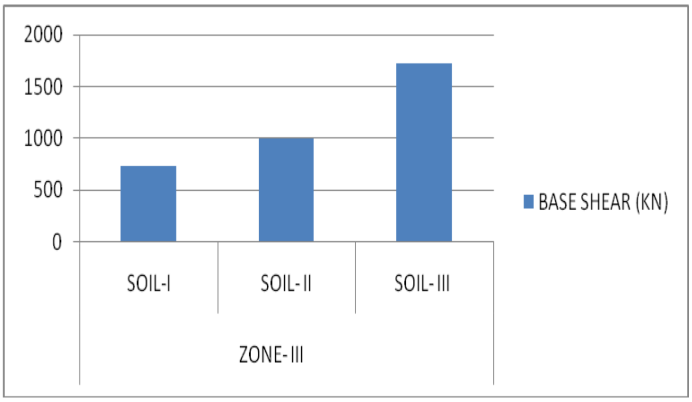

Fig- Base shear (KN) in the zone- III

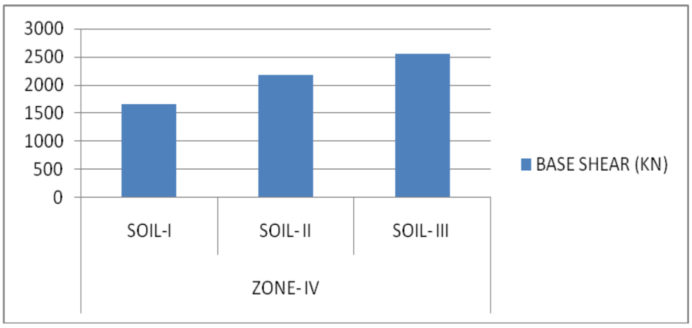

Fig- Base shear (KN) in the zone- IV

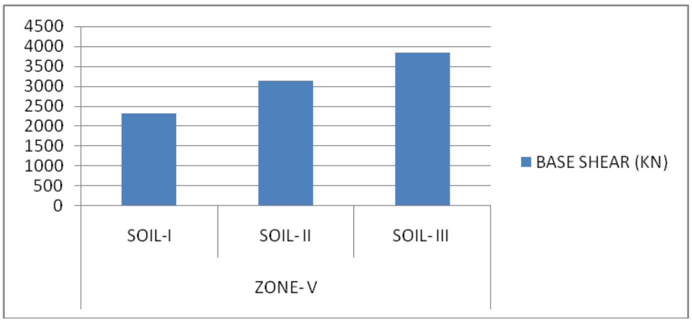

Fig- Base shear (KN) in the zone- V

Storey Drift: It is the difference of displacements between two consecutive stories divided by the height of that story. Story displacement is the absolute value of the displacement of the story under the action of the lateral forces.

TABLE 3: SOIL-I-1.5(DL+EQX-RS)

Sr. No.	ZONES			
	ZONE- II	ZONE- III	ZONE- IV	ZONE- V
1.	0.000213	0.000333	0.000624	0.000829
2.	0.000412	0.000582	0.000694	0.000842
3.	0.000421	0.000600	0.000830	0.000923
4.	0.000709	0.000940	0.001035	0.001442
5.	0.000209	0.000269	0.000591	0.000775
6.	0.000196	0.000249	0.000519	0.000655
7.	0.000127	0.000233	0.000410	0.000495

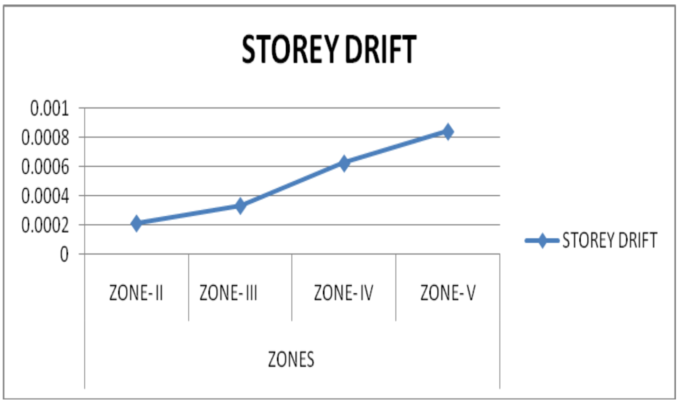

Fig-Storey drift for soil-I

TABLE 4: SOIL-II -1.5(DL+EQX-RS)

Sr. No.	ZONES			
	ZONE- II	ZONE- III	ZONE- IV	ZONE- V
1.	0.000311	0.000442	0.000789	0.000902
2.	0.000485	0.000600	0.000806	0.000984
3.	0.000519	0.000789	0.000875	0.001067
4.	0.000842	0.000987	0.001161	0.001548
5.	0.000276	0.000378	0.000794	0.001067
6.	0.000223	0.000257	0.000696	0.000829
7.	0.000162	0.000241	0.000543	0.000684

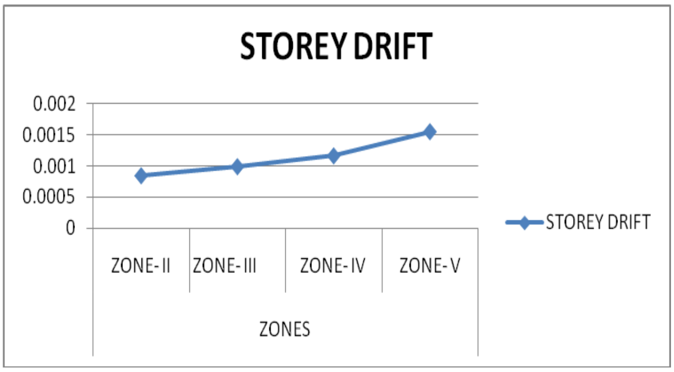

Fig- Storey drift for soil-II

TABLE 5: SOIL-III -1.5(DL+EQX-RS)

Sr. No.	ZONES			
	ZONE- II	ZONE- III	ZONE- IV	ZONE- V
1.	0.000345	0.000529	0.00879	0.001016
2.	0.000586	0.000732	0.000948	0.001275
3.	0.000576	0.000854	0.000982	0.001381
4.	0.000942	0.001011	0.001181	0.001595
5.	0.000538	0.000922	0.001028	0.001201
6.	0.000472	0.000665	0.000712	0.000975
7.	0.000358	0.000432	0.000501	0.000771

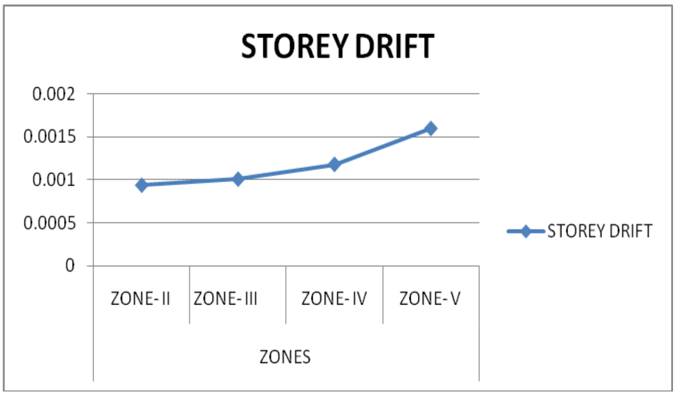

Fig- Storey drift for soil- III

TABLE 6: SOIL-I- 1.2(DL+LL+EQX-RS)

Sr. No.	ZONES			
	ZONE- II	ZONE- III	ZONE- IV	ZONE- V
1.	0.000200	0.00443	0.000572	0.000672
2.	0.000241	0.000585	0.000612	0.000751
3.	0.000373	0.000628	0.000674	0.000778
4.	0.000791	0.000874	0.000897	0.001021
5.	0.000443	0.000502	0.000637	0.000657
6.	0.000354	0.000443	0.000530	0.000563
7.	0.000222	0.000327	0.000356	0.000401

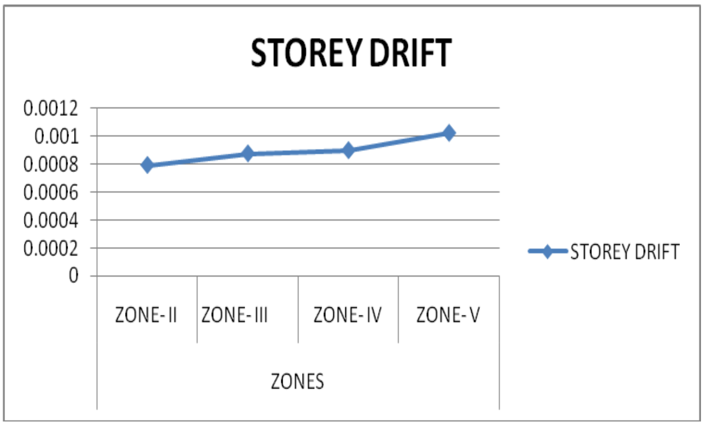

Fig- Storey drift for soil-I

TABLE 7: SOIL- II -1.2(DL+LL+EQX-RS)

Sr. No.	ZONES			
	ZONE- II	ZONE- III	ZONE- IV	ZONE- V
1.	0.000307	0.000458	0.000625	0.000693
2.	0.000336	0.000634	0.000671	0.000774
3.	0.000393	0.000651	0.000698	0.000786
4.	0.000822	0.000946	0.000943	0.001038
5.	0.000338	0.000359	0.000665	0.000862
6.	0.000218	0.000231	0.000584	0.000728
7.	0.000156	0.000193	0.000464	0.000552

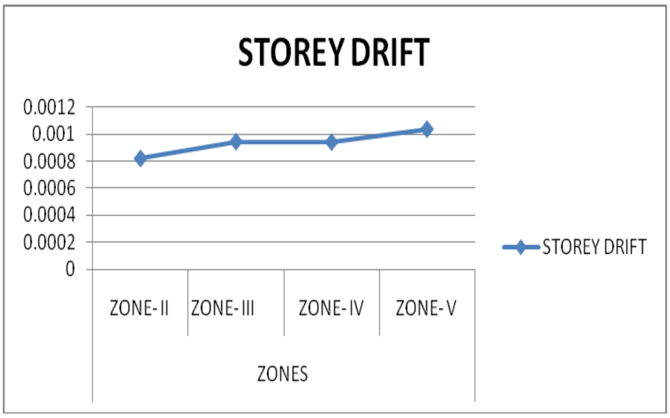

Fig- Storey drift for soil-II

TABLE 8: SOIL- III- 1.2(DL+LL+EQX-RS)

Sr. No.	ZONES			
	ZONE- II	ZONE- III	ZONE- IV	ZONE- V
1.	0.000452	0.000587	0.000849	0.00955
2.	0.000616	0.000676	0.000889	0.001028
3.	0.000656	0.000718	0.000962	0.001039
4.	0.000859	0.000981	0.000988	0.001056
5.	0.000351	0.000439	0.000678	0.000970
6.	0.000258	0.000274	0.000622	0.000819
7.	0.000167	0.000259	0.000481	0.000622

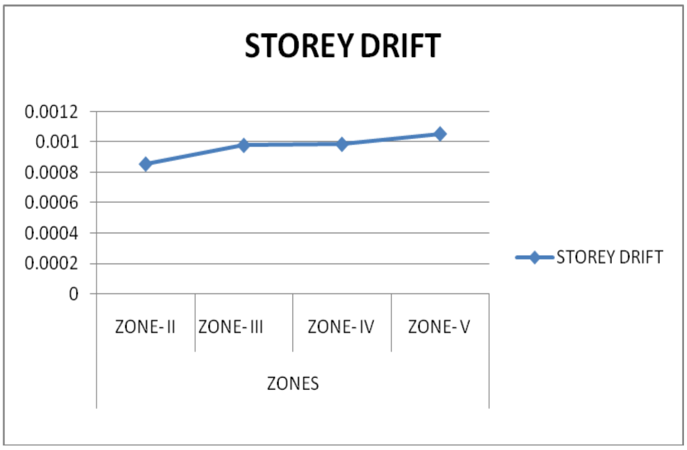

Fig- Storey drift for soil- III

TABLE 9: SOIL- I- (0.9DL+1.5EQX-RS)

Sr. No.	ZONES			
	ZONE- II	ZONE- III	ZONE- IV	ZONE- V
1.	0.000396	0.000665	0.000776	0.00851
2.	0.000471	0.000686	0.000822	0.000894
3.	0.000496	0.000720	0.000876	0.000912
4.	0.000653	0.000847	0.000952	0.001041
5.	0.000358	0.000682	0.000721	0.000786
6.	0.000215	0.000504	0.000553	0.000671
7.	0.000192	0.000250	0.000394	0.000511

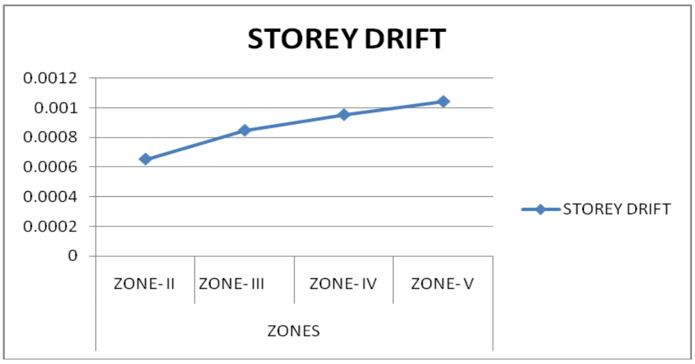

Fig- Storey drift for soil-I

TABLE 10: SOIL- II-(0.9DL+1.5EQX-RS)

Sr. No.	ZONES			
	ZONE- II	ZONE- III	ZONE- IV	ZONE- V
1.	0.000422	0.000744	0.000871	0.00932
2.	0.000497	0.000803	0.000884	0.001054
3.	0.000512	0.000879	0.000988	0.001134
4.	0.000627	0.000952	0.000994	0.001167
5.	0.000376	0.000691	0.000736	0.001018
6.	0.000238	0.000545	0.000677	0.000918
7.	0.000211	0.000419	0.000526	0.000699

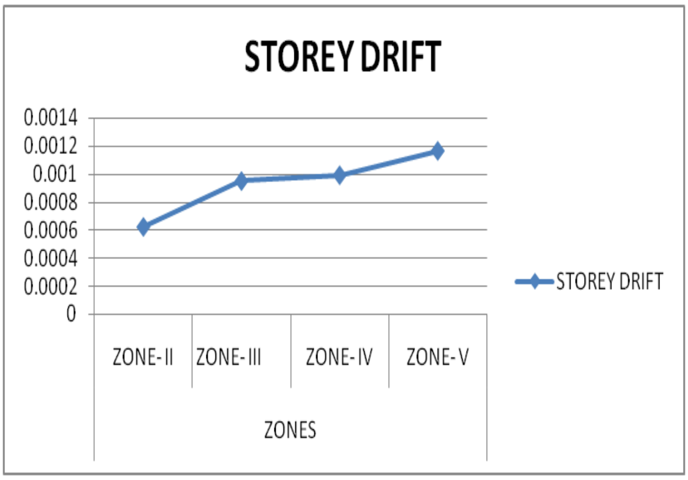

Fig- Storey drift for soil-II

TABLE 11: SOIL- III-(0.9DL+1.5EQX-RS)

Sr. No.	ZONES			
	ZONE- II	ZONE- III	ZONE- IV	ZONE- V
1.	0.000635	0.000782	0.00874	0.001032
2.	0.000704	0.000834	0.000894	0.001174
3.	0.000731	0.000852	0.000948	0.001281
4.	0.000752	0.000973	0.000984	0.001312
5.	0.000394	0.000714	0.000803	0.001213
6.	0.000331	0.000582	0.000764	0.001027
7.	0.000297	0.000356	0.000537	0.000787

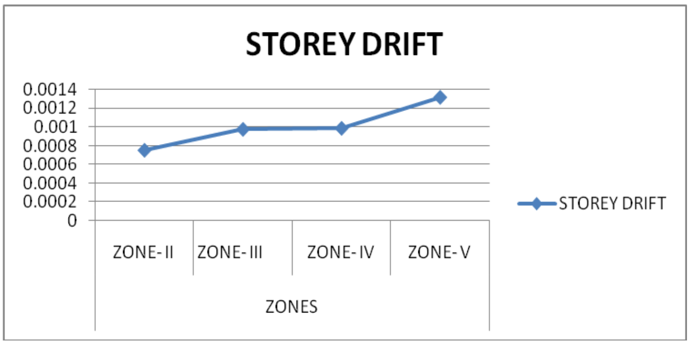

Fig- Storey drift for soil- III

3. CONCLUSIONS

The Following conclusions are made from the present study:

1) As from table 1, it can easily see that base shear varies from zone to zone and from soil to soil.
2) In table 1 the base reaction forces in the global x-direction are increasing from zone- II to zone- V, in zone-II the value is 723.5497 and in zone-V, the value is 3727.7996 means as the zone is increased the values also get increased.
3) In the figures of base shear, the values are changing according to the soil as in soil-I the values are low & in the soil-III the values are high, so from this it is understood that soil-I has a low base shear as compare to the soil-II & soil-III.
4) In table 2 the base shear values in the global y-direction are acting the same as in x-direction because in y-direction the values are high in zone-V as compare to zone-II & the soil-III values are high as compare to the soil-I & soil-II.
5) So as the zone is changed the zone factors are changed and because of this, the structure act's differently in different zones. As zone-II is low earthquake-prone zone so in this the base reactions are low and as zone-V is high earthquake-prone zone so in this the base reactions are high.
6) As the soil-I is the hard soil, so in this, the base reactions are low because the soil is hard and has more strength than the soil-I & soil-III.
7) The storey drift mainly occurred at the middle of the building, in this building the middle storey is the 4th storey and it has maximum storey drift.
8) In table 3 the storey drift values for soil-I & for the load combination 1.5(DL+EQX-RS) are there, from this table it is seen that the middle storey 4 has the maximum storey drift values, all storey drift values are in m.
9) The storey drift values increases with the increase of seismic zone factor, so as the zone is increased from zone-II to zone-V the values for zone-II storey 4th is 0.000709 and for zone-V, the value is 0.001442, so the storey drift values increased as the zone is increased.
10) In the below figure of table 3, it shows the increase in the storey drifts from zone to zone.
11) For all the load combinations the storey drift is increasing as the zone is increasing and in the middle storey 4th, the story drift is maximum.
12) As we change the soil the values also increased as in table 4 the storey drift values for soil-I in storey 4th is 0.000709 and in table 5 the storey drift values for soil-II for same load combination in storey 4th is 0.000842, so as the soil type is changed the storey drift changes.
13) Using this software ETABS, reduces the time for analysis and design work and gives high accuracy and due to this software, we can get the values of the structure easily and can get the values for any zone & any soil type.

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AUTHOR