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Effect of Seismic Zone and Soil Type on Linear Time History Behavior of RC Framed Building

K. Siva Kiran, D.V. Siva Sankara Reddy, H. Teja Kiran Kumar, V. Rajendra Kumar

Abstract*: In view of structural engineering, the in assessment of seismic vulnerability of structure plays an important role in the analysis and design of structure. A variety of methods are in practice to carry out lateral load analysis on structure due to earthquakes. In this respect, time history analysis is a method to analyze a structure subjected to a specific earthquake ground motion. The seismic response of a structure majorly depends on type of soil and seismicity of location of structure.In this context an attempt is made to study the Linear Time History behavior of a G+5 RC framed building subjected to Bhuj earthquake ground motion considering the effect of soil type and seismic zone factor in accordance with IS-1893-2016 (part-1). A G+5 RC framed residential apartment building is modeled in ETABS 2015 software and analysis is carried out using time history function subjecting to Bhuj earthquake ground motion data for different values of seismic zone factor and soil types. Responses such as base shear storey shear distribution and peak roof displacement are reported for different zone factors and soil type and tabulated the analytical study depicts that, with increase in seismicity of location of the structure, both base shear and peak roof displacement are been increased. Also, with increase in flexibility of soil, both base shear and peak roof displacement are been increased.

Index Choice: Seismic zone; Soil type; Time history; Base shear; Roof displacement.

I. INTRODUCTION

General

Lateral load analysis on high rise framed buildings is one of the most interesting areas of structural engineering and grabs the concentration of structural engineer especially in case of some iconic structures. The lateral load analysis on structures is majorly carried out for wind and seismic forces. The design lateral forces on building due to wind increases in magnitude with increase in height of the building, these forces on building pushes and displaces the storey diaphragms with respect to vertical centroidal axis of the building which thereby produces a base shear at the base level.

Unlike wind forces, seismic forces on building are due to occurrence of earthquake. An Earthquake is a sudden tremor or movement of Earth's crust, which originates naturally at or below the surface. The word natural is important here, since it excludes shock waves caused by nuclear tests, man- made explosions etc. About 90% of all earthquakes results from tectonic events, primarily movements on the faults. The remaining is related to volcanism, collapse of subterranean cavities or man- made effects. Tectonic earthquakes are triggered when the accumulated strain exceeds shearing strength of rocks. The earthquake waves propagate the strain energy released at the focus and when reaches the base of a structure vibrates it vigorously inducing amplified amplitudes in free vibration modes of the structure.

These amplified modes of the structure corresponding to a critical damping value together produce design lateral forces at each storey level on the building to which it has to be analyzed. The design lateral seismic forces on building are the fictitious forces obtained as mass times the acceleration associated with the base excitation; this includes the dynamic behavior of the structure. Whereas, in case of static analysis, the design base shear obtained as a function of seismic weight of the structure is distributed to each storey in proportion to its height from the base.

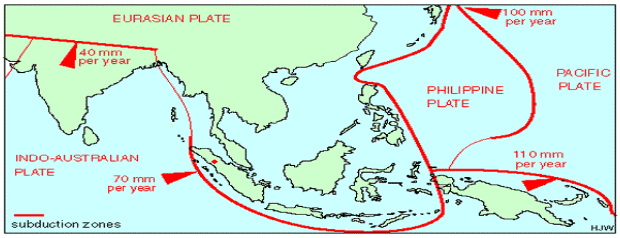

Fig.1: Movement of tectonic plates per year

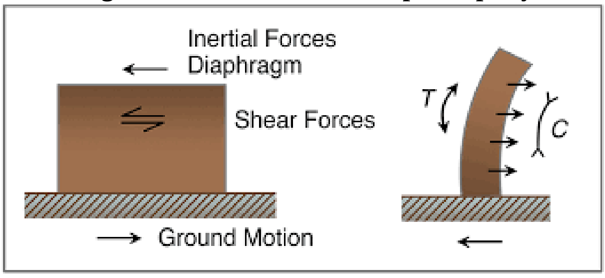

Fig.2: Reaction forces on building subjected to ground motion

Seismology is the study of the generation, propagation and recording of elastic waves in the earth and the sources that produce them. Seismology plays an important role in view of a structural engineer to 1. Study the subsoil behavior at the location of the structure 2. Know about past earthquake history of the site and predict the seismicity of the location 3. Evaluate the design forces on building for previous peak ground motion data based on seismicity and sub soil condition.

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K.Siva Kiran, Assistant Professor, Department of Civil Engineering, Kallam Haranadhareddy Institute of Technology, Guntur (A.P), India.

D.V.Siva Sankara Reddy, Assistant Professor, Department of Civil Engineering, Kallam Haranadha reddy Institute of Technology, Guntur, (A.P), India.

H.Teja Kiran Kumar, Assistant Professor, Department of Civil Engineering, Kallam Haranadha reddy Institute of Technology, Guntur, (A.P), India.

V.Rajendra Kumar, Assistant Professor, Department of Civil Engineering, Kallam Haranadha reddy Institute of Technology, Guntur, (A.P), India.

Different methods of seismic analysis of structure available in practice are as follows,
1. Equivalent static analysis
2. Non linear static analysis
3. Linear Dynamic analysis
4. Response Spectrum method
5. Non linear dynamic analysis
6. Time History method

Time History Method

Analysis of a structure applying data over increments of time steps as a function of acceleration, momentum or displacement. This method is most useful for very long or very tall structures (flexible structures). Eigen values generated for the structure based on response to time history are considered to be more realistic compared to response spectrum analysis. The solutions based on time history analysis are as accurate as close the spacing of time steps. The reduction of seismic forces on structures using this method depends on soil properties, type of structure and available data.

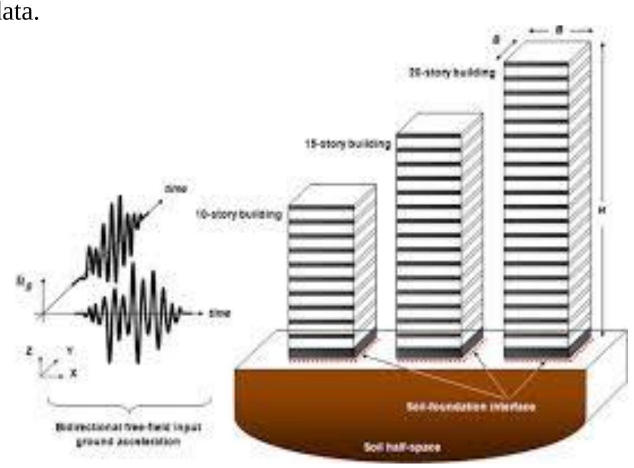

Fig.3: Response of a structure to ground motion

Bhuj Earthquake

The highest magnitude recorded earthquake in India that took place in the state of Gujarat on 26th January 2001 is subsequently referred to as bhuj earthquake or Kutch earthquake. The earthquake was named after the epicenter of the earthquake, i.e., a district in Gujarat called Bhuj. The earthquake ranks as one of the most destructive events recorded so far in India in terms of death toll, damage to infrastructure and devastation in the last 50 years .The magnitude of Bhuj earthquake recorded 6.9 on Richter scale and 7.79 on MS scale. The horizontal component of this earthquake is considered in this present work which is shown in Figure.

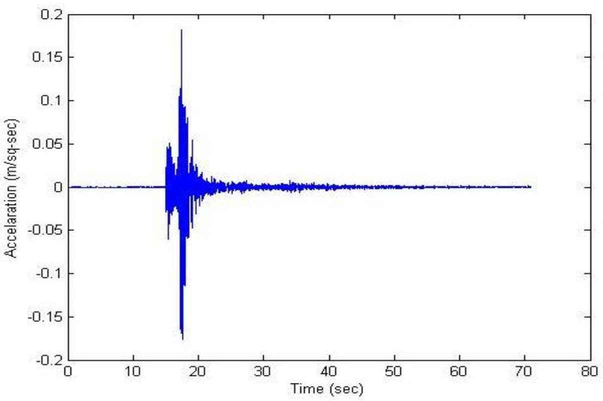

Fig.4: Ground Motion Data for Bhuj Earthquake

Introduction on Etabs

ETABS is extended three dimensional analysis of building system. ETABS is a completely integrated system. Embedded beneath the simple intuitive user interface are very powerful numerical methods, design procedures and international design codes. All working from a single comprehensive data base. This integration means that to create only one model of the floor systems and the vertical and lateral framing systems to analyze, design, and detail entire building. Everything you need integrated into one versatile analysis and design package with one windows –based graphical user interface. No external modulus is required. The effects on one part of the structure from changes in another part are instantaneous and automatic. The integrated components include: ETABS is a sophisticated, yet easy to use, special purpose analysis and design program developed specifically for building systems. ETABS features an intuitive and powerful graphical interface coupled with unmatched modeling, analytical, design, and detailing procedures, all integrated using a common database. Although quick and easy for simple structures, ETABS can also handle the largest and most complex building models, including a wide range of nonlinear behaviors necessary for performance based design, making it the tool of choice for structural engineers in the building industry.

II. METHODOLOGY CARRIED OUT IN ETABS

A G+5 RC framed residential apartment building is modeled in ETABS 2015 software developed based on a floor plan as shown in Fig-5. The sectional properties of different elements of the model are listed in Table-1. The properties of materials like concrete and steel used in the project work are listed in Table-2.

Fig.5: Floor plan for residential apartment building

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Structural Element	Sectional Property	Grade of Material
Main beams	300mm x 450mm	M25
Secondary beams	250mm x 300mm	M25
Column type-1	300mm x 450mm	M30
Column type-2	300mm x 300mm	M30
Outer wall	230 mm thick	M25
Partition wall	150mm thick	M25
Slab	190mm thick including floor finish	M25

Table 1: Sectional properties of different structural elements

Description of material	Grade of material used
Concrete	M20, M25
Steel	Fe415

Table 2: Properties of construction materials

Sl. No	Load particular	Description	Intensity	Reference
1	Dead load			IS 875:1987 (part-1)
	Outer wall	20x0.23x2.55	11.73kN/m	
	Partition wall	20x0.15x2.55	7.65kN/m	
2	Live load	Adopted		IS 875:1987 (part-2)
	Imposed live load on floor slab		3.5 kN/m2	
	Imposed live load on corridor slab		2.5 kN/m2	
	Imposed load on lift slab		5 kN/m2	

Table 3: Load particulars on different structural elements

The model is prepared with different load assignments on different structural elements as specified in Table-3 and a mass source of dead load plus 50 percent of imposed live load is as recommended by IS 1893:2016 is created for lateral load analysis due to seismic forces. A time history function with Bhuj earthquake ground motion data is assigned in both X and Y directions of the building initially with a scale factor given by

$$Scale\ factor = \frac{Ig}{R} \quad (1)$$

Where
I = Importance factor
g = Acceleration due to gravity, i.e., 9.81 m/sec2
R = Response reduction factor

Along with time history function, equivalent static force load case is also assigned to the structure in both X and Y directions and the model is run for the cases shown in Fig-10. After the analysis is run, the scale factor obtained by the ratio of average base shear of the structure due to time history load case to that of equivalent static force case in each direction of the model is calculated and by replacing the scale factor provided in time history analysis, the model is analyzed for the load cases again. This process is repeated until the base shear due to time history case come in range to that of equivalent static case.

III. RESULTS DISCUSSION

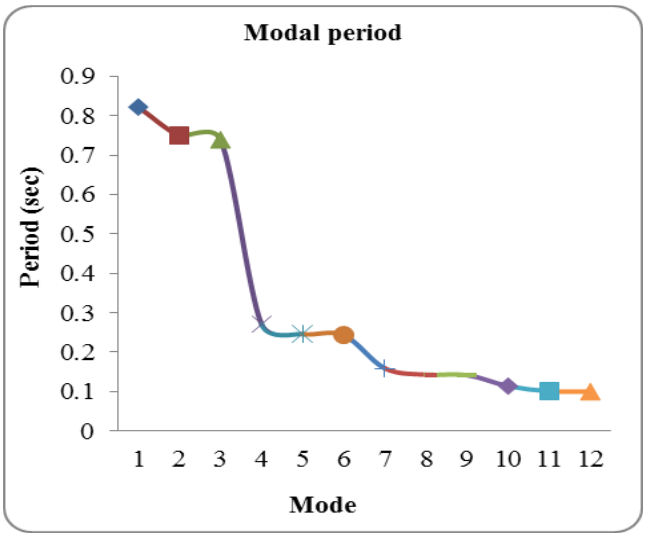

Fig.6: Periods of different modes of the structure

Spectral Response of the Structure to Bhuj Earthquake

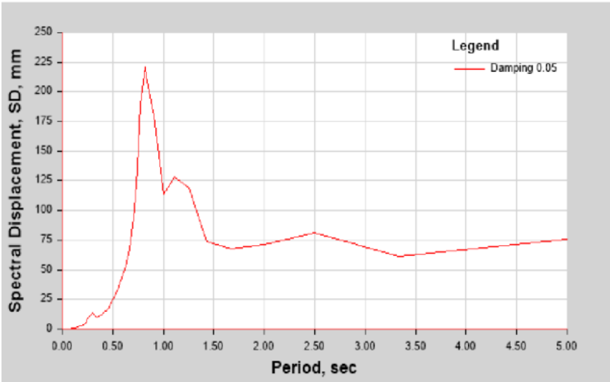

Fig.7: Spectral displacement response spectra

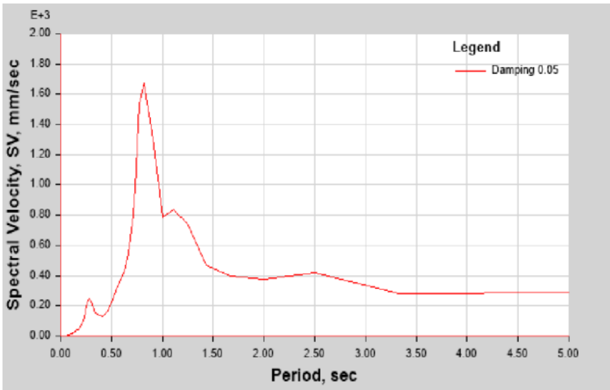

Fig.8: Spectral velocity response spectra

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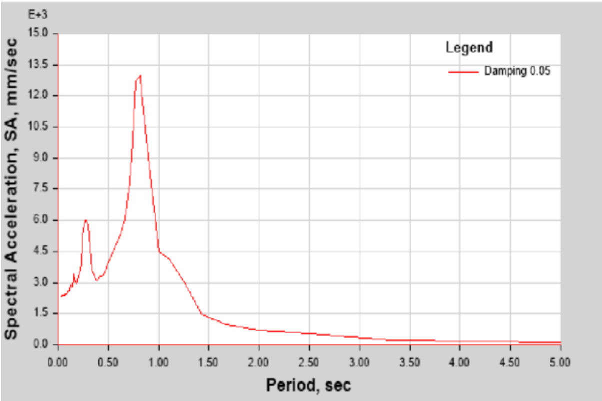

Fig.9: Spectral acceleration response spectra

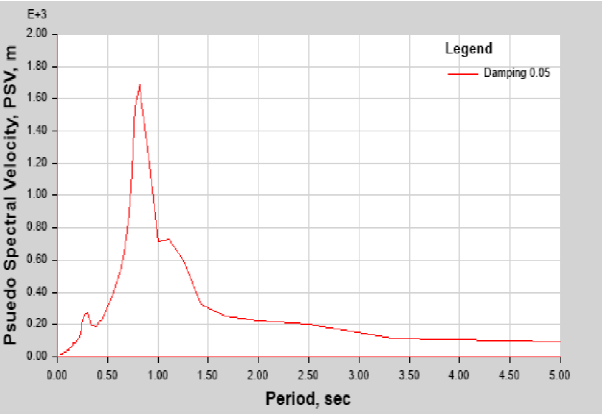

Fig.10: Pseudo spectral velocity response spectra

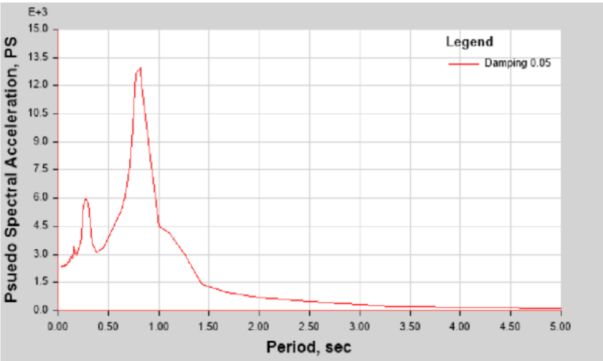

Fig.11: Pseudo spectral acceleration response spectra

Design Acceleration Spectrum for Bhuj Earthquake

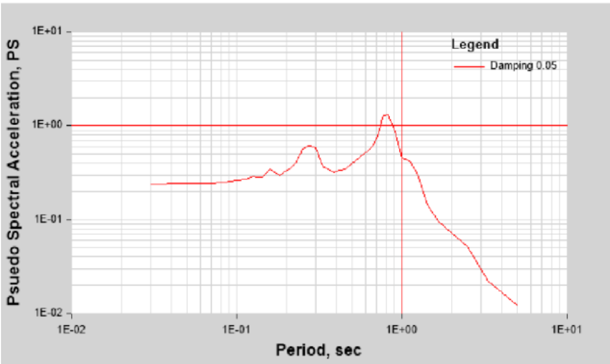

Fig-12 Design acceleration response spectra for Bhuj earthquake

Storey Shear Distribution Due To Time History Analysis

Storey shear distribution in X-direction

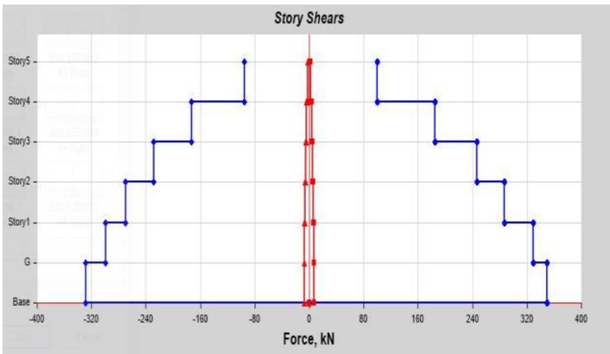

Fig.13: Storey shear for soil type-I and seismic zone I, II

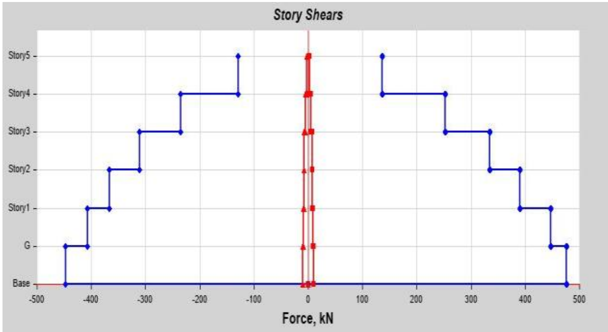

Fig.17: Storey shear for soil type-II and seismic zone I, II

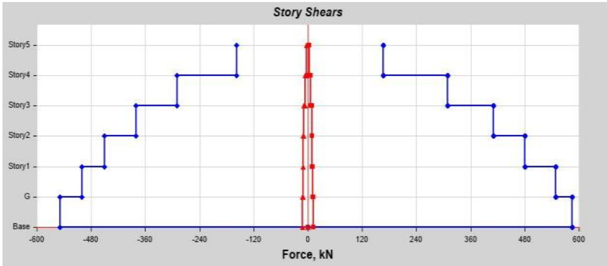

Fig.21: Storey shear for soil type-III and seismic zone I, II

Storey shear distribution in Y-direction

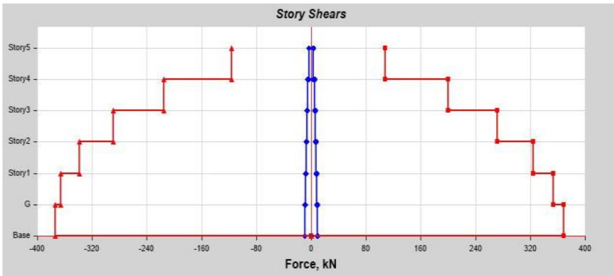

Fig.25: Storey shear for soil type-I and seismic zone I, II

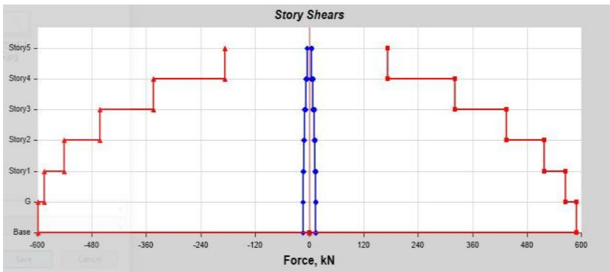

Fig.29: Storey shear for soil type-II and seismic zone I, II

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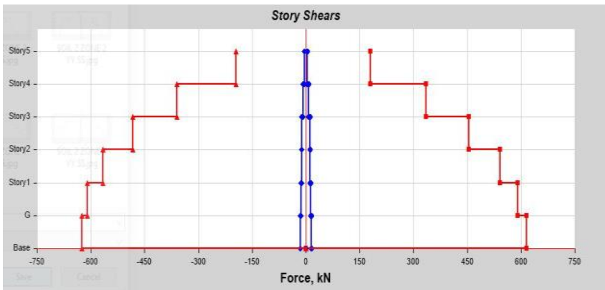

Fig.33: Storey shear for soil type-III and seismic zone I, II

Variation of Base Shear and Roof Displacement

Variation in X-direction

Soil type	Seismic zone	Roof displacement (mm)	Base shear (kN)
Hard	I & II	5.26	349.82
	III	8.42	559.76
	IV	12.63	839.62
	V	18.94	1259.39
Medium	I & II	7.15	475.78
	III	11.44	761.24
	IV	17.17	1141.85
	V	25.76	1712.81
Soft	I & II	8.78	584.23
	III	14.05	934.74
	IV	21.08	1402.13
	V	31.63	2103.22

Table 7: Variation of structural base shear and roof displacement in X-direction

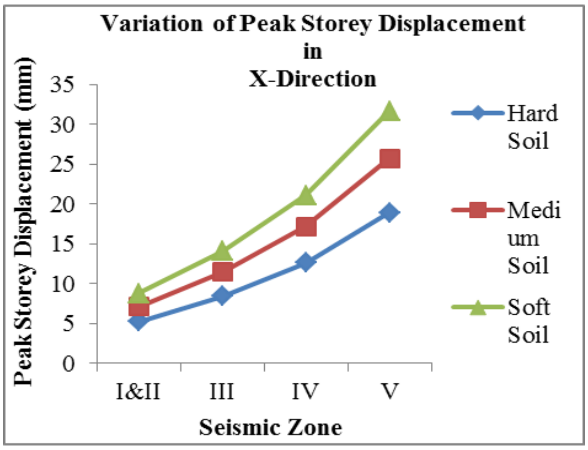

Fig.37: Variation of roof displacement in X-direction

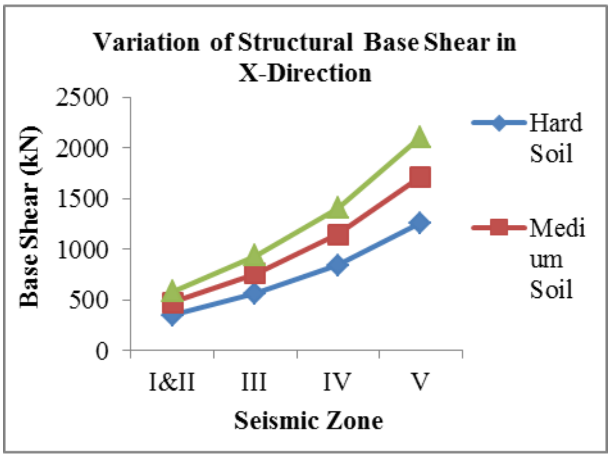

Fig.38: Variation of structural base shear in X-direction

Variation in Y-direction

Soil type	Seismic zone	Roof displacement (mm)	Base shear (kN)
Hard	I & II	5.15	373.49
	III	8.24	597.60
	IV	12.36	896.39
	V	18.54	1344.57
Medium	I & II	7.00	507.97
	III	11.21	812.73
	IV	16.81	1219.09
	V	25.26	1828.65
Soft	I & II	8.61	624.26
	III	13.76	998.01
	IV	20.65	1496.97
	V	30.97	2245.46

Table 8: Variation of structural base shear and roof displacement in Y-direction

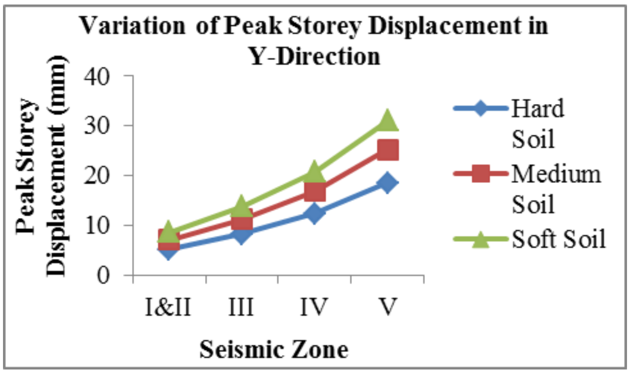

Fig.39: Variation of roof displacement in Y-direction

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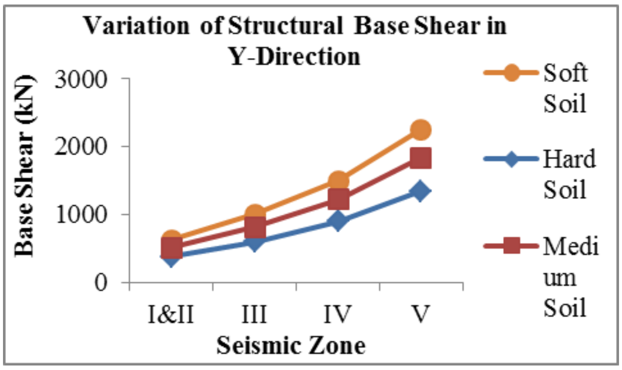

Fig.40: Variation of structural base shear in Y-direction

IV. CONCLUSION

1. The time period of the structure corresponding to its principal mode is found to be 0.822 seconds.
2. The top peak storey (roof) displacement and structural base shear of the building for a particular zone is increased by about 67% with increase in flexibility of the soil (i.e., hard soil to soft soil).
3. The top storey (roof) displacement and structural base shear of the building is linearly increased with increase in seismicity (i.e., zone factor) of building location with a particular soil type.
4. The top storey (roof) displacement and base shear of the building for a particular zone for soil type 3 is increased by 67% when compared to soil type 1 and found to be constant at each zone.
5. Both the top storey (roof) displacement and base shear of the building for a particular zone for soil type 1and 2 is increased by 36% and found to be constant at each zone.
6. Different plots showing the response spectra of Bhuj earthquake obtained in ETABS are presented in figures.
7. The design acceleration spectral curve has an uneven peak between 0.6 second and 1 second band on X-axis. It depicts that, all structures having their natural period between 0.6 to 1.0 second range May Subject to maximum responses.
8. The increase in flexibility of the soil (Hard soil to soft soil) transfers most of the energy of earthquake wave propagation to the structure and there by increases the structural base shears.
9. The increase in flexibility of soil increases the period of vibration of the structure and there by increases the roof displacement response.

REFERENCES

1. Pankaj Agarwal, Manish Shrikhande (2007), Earthquake Resistant Design of Structures' Prentice-Hall of India Limited Private Limited, New Delhi.
2. Anil K. Chopra (2002), Dynamics of Structures: theory and Applications to Earthquake Engineering, Prentice-Hall of India Limited Private Limited, New Delhi,
3. IS 1893 (part1): 2016, "Criteria for earthquake Resistant Design of Structures-Part1: general Provisions and Buildings", Bureau of Indian Standards, New Delhi.
4. Anil K.Chopra and Rakesh K.Goel (2001).' A Modal Pushover Analysis Procedure to Estimate Seismic Demands for Buildings: Theory and Preliminary Evaluation', peer reports, peer.berkeley.edu publications.
5. S.Rajasekaran(2009),'Structural Dynamics of Earthquake Engineering Theory and Application using MATHEMATICA and MATLAB', CRC Press Publisher.
6. K.SivaKiran (2017) "Study on Effect of seismic zone and soil type on Dynamic Behavior of RC framed building.
7. T.K.Data (2010), 'Seismic Analysis of Structures ', John Wiley &Sons (Asia) Pte Ltd.
8. Mario Paz and William Leigh (2003), 'Structural Dynamics: Theory and Computation', Kluwer Academic Publishers.
9. S.Mahesh, B.Panduranga Rao,"Comparision of analysis and design of regular and irregular configuration of multi storey building in various seismic zones and various types of soils using ETABS", an International Journal of Mechanical and Civil Engineering, volume 11,Issue 6 ver.IPP 45-52,Nov-Dec.2014.
10. P.V.Patel (2003)"Dynamic Analysis of Buildings as per IS:1893",the Journal of Engineering and Technology,16(4),PP 10-15.
11. Dr.S.SureshBabu (2015)"Study he performed linear static analysis and dynamic analysis on multistoried buildings with plan irregularities" an International Journal on Engineering and innovative Technology (IJEIT),volume 3,April 2015.
12. Srikanth and V.Ramesh (2013)"Comparatives study of seismic response for seismic coefficient and response spectrum method".
13. Awkar J.C. and Lui E.M, "Seismic analysis and response of multi storey building semi rigid frames", Journal of Engineering Structures, volume 21, Issue 5,page no:425-442,1997.
14. Md.Kabir ,DebasishSen(2015),"Seismic vulnerability and response of regular and irregular shaped multi storey building of identical weight in context of Bangladesh" shapes" International journal of Innovative Research in advance Engineering (IJIRAE)(August 2015).
15. Mohammed Rizwan Sultan (2015)'Dynamic analysis of multi storey building of different shapes', International Journal Innovative Research in advanced Engineering(IJIRAE),Issue 8,volume 2(August 2015).
16. Kulkarni J.G., Kore P.N., S.B. Tanawade, "Analysis of multi storey building frames subjected to Gravity and seismic loads with varying Inertia" ,International Journal of Engineering and Innovative Technology (IJEIT), volume 2,Issue 10,April 2013.

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