Comparative Study of Static and Dynamic Seismic Analysis of High Rise Building in different seismic zones of India and different soil types by ETABS

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Abstract: Analysis of buildings for static forces is a routine affair these days because of availability of affordable computers and specialized programs which can be used for the analysis. On the other hand, dynamic analysis is a time consuming process and requires additional input related to mass of the structure, and an understanding of structural dynamic for interpretation of analytical results. Reinforced Concrete (RC) frame buildings are most common type of constructions in urban India, which are subjected to several types of forces during their lifetime, such as static forces due to dead and live loads and dynamic forces due to earthquake. Here the present study describes the effect of earthquake load which is one of the most important dynamic loads along with its consideration during the analysis of the structure. In the present study a high rise framed structure is selected. Linear seismic analysis is done for the building by static method (Equivalent Static Analysis Method) and dynamic method (Response Spectrum Method) using ETABS as per the IS-1893-2002-Part1 for earthquake forces in different seismic zones of India. And the soil types are also compared. A comparison is done between the static and dynamic analysis for a high rise RCC building for various parameters like lateral force , lateral displacement , storey shear , storey drift , absolute maximum bending moment, absolute maximum shear force ,

Keywords: lateral force, lateral displacements, storey shear, seismic zones, soil types, etc,.

I.INTRODUCTION

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

As the world move to the accomplishment of Performance Based Engineering philosophies in seismic design of Civil Engineering structures, new seismic design provisions require Structural Engineers to perform both static and dynamic analysis for the design of structures. While Linear Equivalent Static Analysis is performed for regular buildings up to 90m height in zone I and II, Dynamic Analysis should be performed for regular and irregular buildings in zone IV and V. Dynamic Analysis can take the form of a dynamic Time HiStorey Analysis or a linear Response Spectrum Analysis. All over world, there is high demand for construction of tall buildings due to increasing urbanization and spiraling population, and earthquakes have the potential for causing the greatest damages to tall structures. Since earthquake forces are random in nature and unpredictable, the engineering tools need to be sharpened for analyzing structures under the action of these forces. Structural analysis is mainly concerned with finding out the behavior of a structure when subjected to some action. This action can be in the form of load due to weight of things such as people, furniture, snow etc. or some other kind of excitation such as earthquake , shaking of the ground due to a blast nearby etc. In essence all these loads are dynamic including the self-weight of the structure because at some point in time these loads were not there. The distinction is made between the dynamic and static analysis on the basis of whether the applied action has enough acceleration in comparison to the structure's natural frequency. If a load is applied sufficiently slowly, the inertia forces (Newton’s second law of motion) can be ignored and the analysis can be simplified as static analysis. Structural dynamics, therefore, is a type of structural analysis which covers the behavior of structures subjected to dynamic (actions having high acceleration) loading. Dynamic loads include people, wind, waves, traffic, earthquake and blasts. Any structure can be subjected to dynamic loading. Dynamic analysis can be used to find dynamic displacements, time hiStory, and modal analysis.

SESIMIC ZONES OF INDIA

The term tremor can be utilized to depict any sort of seismic occasion which might be either common or started by people, which produces seismic waves. Tremors are caused regularly by burst of topographical deficiencies; yet they can likewise be activated by different occasions like volcanic action, mine impacts, avalanches and atomic tests. . The perceptions from a seismometer are utilized to quantify tremor. Seismic tremors more prominent than around 5 are for the most part given an account of the size of minute extent. Those littler than greatness 5, which are more in number, as detailed by the national seismological observatories are for the most part estimated on the nearby extent scale, which is otherwise called the Richter scale. There are numerous structures that have essential auxiliary framework, which don't meet the current seismic prerequisites and endure broad harm amid the quake. The structures at vizag were composed by essential auxiliary framework and the explanation for this is Rourkela lies in ZONE II of Seismic Zone Map of 2002 i.e. as per Seismic Zoning Map of IS: 1893-2002, which says the area is minimum plausible for earth shakes. The organization building is a four Storey building outlined without considering the plan components of IS: 1893-2002. At introduce time the techniques for seismic assessment of seismically lacking or quake harmed structures are not yet completely created. The structures which don't satisfy the prerequisites of seismic plan, may endure broad harm or crumple if shaken by an extreme ground movement. The seismic assessment mirrors the seismic limit of quake powerless structures for the future utilize. As indicated by the Seismic Zoning Map of IS: 1893-2002, India is separated into four zones based on seismic exercises. They are Zone II, Zone III, Zone IV and Zone V. Hyderabad lies in Zone II Cataclysmic events are inescapable and it isn't conceivable to deal with them.

INDIAN SEISMIC CODE IS 1893

"IS: 1893-2002 (Part-1) proposals for tremor safe outline of structures are starting unveiled in 1962 for the plan of structures in seismic tremor inclined territories. The code was updated for five times in 1966, 1970, 1975, 1984 and 2002 (Part-1) that, this ordinary is implied for the tremor safe plan of customary structures and for the quake safe outline of unique structures viz., dams, long traverse spans, major mechanical tasks and so forth, site particular explained examination should be attempted. The customary way to deal with insecure plan has been construct generally after giving a blend of quality and flexibility to oppose the compulsory burdens. The

Indian subcontinent has a background marked by destroying tremors. The real explanation behind the high recurrence and power of the seismic tremors is that the Indian plate is crashing into Asia at a rate of around 47 mm/year. Geological measurements of India demonstrate that just about 54% of the land is defenseless against quakes. As it were, the quake zoning guide of India partitions India into 4 seismic zones (Zone 2, 3, 4 and 5) dissimilar to its past variant, which comprised of five or six zones for the nation. As indicated by the present zoning map, Zone 5 expects the most abnormal amount of seismicity while Zone 2 is related with the least level of seismicity.

SOIL CLASSIFICATION IN INDIA

. The type of soil mainly constituting the foundation are categorized into three types (Table 1), namely

Type I - Rock or Hard Soil:

Well graded gravel and sand gravel and sand gravel mixtures with or without clay binder, and clayey sands poorly graded or sand clay mixtures (GB, CW, SB, SW, and SC) having N above 30, where N is the standard penetration value.

1) Well graded gravel (GW) or well graded sand (SW) both with less than 5% passing 75 m sieve (Fines);

2) Well graded Gravel- Sand mixtures with or without fines (GW-SW);

3) Poorly graded Sand (SP) or clayey sand (SC), all having N above 30;

4) Stiff to hard clays having N above 16, where N is the Standard Penetration Test value.

Type II - Medium Soil

All soils with N between 10 and 30, and poorly graded sands or gravelly sands with little or no fines (SP) with N>15

1.Poorly graded sands or Poorly graded sands with gravel (SP) with little or no fines having N between 10 and 30;

2) and stiff to medium stiff fine-grained soils, like Silts of Low compressibility (ML) or Clays of Low compressibility (CL) having N between 10 and 16.

Type III - Soft Soil

All soils other than SP with N

All soft soils other than SP with N < 10 The various possible soils are

1) Silts of Intermediate compressibility (MI);

2) Silts of High compressibility (MH);

3) Clays of Intermediate compressibility (CI);

4) Clays of High compressibility (CH);

5) Silts and Clays of Intermediate to High compressibility (MI-MH or CICH);

6) Silt with Clay of Intermediate compressibility (MI-CI);

7)Silt with Clay of High compressibility (MH-CH).

NEED FOR THE PRESENT STUDY

- The foundation of a building is the substructure through which the loads of the whole structure are transmitted to the soil. There are various types of soil present in India.
- The types of soil play a major role while designing a structure. Here the analysis and design of building is done by varying the type of soil. The difference in analysis of structure is studied.
- After that the seismic analysis for various zones are carried out for the same soil conditions and also by changing the model of building, the same are done. And the difference is studied.

OBJECTIVE OF THE STUDY

The present work aims at the study of following objectives:

- How the seismic evaluation of a building should be carried out.
- To study the behavior of a building under the action of seismic loads and wind loads.
- To compare various analysis results of building under zone II, III, IV and zone V using ETABS Software.
- The building model in the study has twenty storey's with constant storey height of 3m.five models are used to analyze with constant bay lengths and the number of Bays and the bay width along two horizontal directions are kept constant in each model for convenience.
- Different values of zone factor are taken and their corresponding effects are interpreted in the results.
- Different values of wind speeds are taken for wind analysis and their corresponding effects of building structure are interpreted in the results.

SCOPE OF THE STUDY

1. Based on project, study was undertaken with a view to determine the extent of possible changes in the seismic behaviour of RC Building Models.
2. RC framed buildings are firstly designed for gravity loads and then for seismic loads.
3. The study has been carried out by introducing symmetrical bare frame building models on different zones using equivalent static method and Response Spectrum Analysis.
4. 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.
5. The study emphasis and discusses the effect of seismic zone factor on the seismic performance of G+20 building structure.
6. The entire process of modelling, analysis and design of all the primary elements for all the models are carried by using ETABS 16 software

II. LITERATURE REVIEW

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Gauri G. Kakpure[1] and Ashok R. Mundhada[2] et all,. (2016) Reinforced Concrete (RC) building frames are most common types of constructions in urban India. These are subjected to several types of forces during their lifetime, such as static forces due to dead and live loads and dynamic forces due to earthquake. This authors presents a review of the previous work done on multi-storeyed buildings vis-à-vis earthquake analysis. It focuses on static and dynamic analysis of buildings.This authors presents a review of the comparison of static and dynamic analysis multistoried building. Design parameters such as Displacement, Bending moment, Base shear, Storey drift, Torsion, Axial Force were the focus of the study. It was found that, The difference of values of displacement between static and dynamic analysis is insignificant for lower stories but the difference is increased in higher stories and static analysis gives higher values than dynamic analysis. Static analysis is not sufficient for high rise buildings and it's necessary to provide dynamic analysis. Building with re-entrant corners experienced more lateral drift and reduction in base shear capacity compared to regular building When compared to irregular configuration the Storey drift value is more in the regular configuration. Storey drift is increased as height of building increased. Base shear value is more in the zone 5 and that in the soft soil in irregular configuration. Irregular shapes are severely affected during earthquakes especially in high seismic zones. The irregular shape building undergoes more deformation and hence regular shape building must be preferred. The results of equivalent static analysis are approximately uneconomical because values of displacement are higher than dynamic analysis.

Mr. Sunil S K[1], Mr. Dhananjay M[2], 3Mr. Jithendra S, 4Mr. Raghavendra H J, 5Mrs. Vindhya et all,. (2017) The frequent occurrence of earthquakes around the world has heightened the need for studying the seismic performance of existing structures according to code of practice. Seismic damages occurred in multi storied buildings shows if the structures are not well designed and constructed with an adequate strength, it leads to the complete collapse of the structures. To ensure safety against seismic forces of multi storied buildings need to study of seismic analysis to design seismic resistant structure. In every construction, it is necessary to consider the types of loading acting on structure. In general every building is designed for live load and dead loads (gravity loads), but in some circumstances it is mandatory to consider lateral loadings such as seismic loads and wind loads. The consideration is mainly depends on soil strata, zone where the building situated, height of the building. In the present dissertation work a multi storied residential building with G+5 is planned using Auto cad, that plan is modelled and analysed for hard soil strata and for Zone II as per IS: 1893-2000 using ETABS-2015, with obtained results, the structure is designed as per IS: 456-2000 and different members (slabs, beams, columns, footings) are drafted using Auto cad.From the data revealed by the manual as well as software analysis for the structures with seismic coefficient method using various loading combinations tried following conclusions are drawn: Seismic analysis was done by using ETABS software and successfully verified manually as per IS 1893-2002. There is a gradual increase in the value of lateral forces from bottom floor to top floor in both manual as well as software analysis Calculation of seismic weight by both manual analysis as well as software analysis gives exactly same result. The conventional method i.e. manual method of calculating unknown structural forces, moments etc. Would be long and tedious. Application of E -Tabs permits the user to analyze the structure within a short time as it is more user friendly both in the model development and in analysis. In the present study E-Tabs is been used for the analysis and design of earth quake resistant multi-storey building.

III.METHODOLOGY

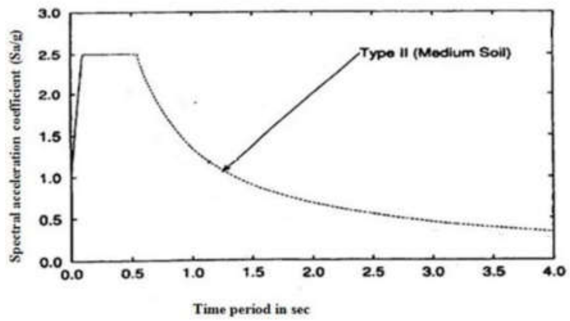
Methods of analysis of the structure:

EQUIVALENT STATIC ANALYSIS:

This approach defines a series of forces acting on building to represent the effect of earthquake ground motion, typically defined by a seismic design response spectrum. It assumes that the building responds in its fundamental mode. For this to be true, the building must be low-rise and must not twist significantly when the ground moves. The response is read from a design response spectrum, given the natural frequency of the building (either calculated or defined by the building code). The applicability of this method is extended in many building codes by applying factors to account for higher buildings with some higher modes, and for low levels of twisting. To account for effects due to "yielding" of the structure, many codes apply modification factors that reduce the design forces (e.g., force reduction factors).

RESPONSE SPECTRUM METHOD:

The representation of maximum response of idealized single degree freedom system having certain period and damping, during earthquake ground motions. This analysis is carried out according to the code IS 1893-2002 (part1). Here type of soil, seismic zone factor should be entered from IS 1893-2002(part1). The standard response spectra for type of soil considered is applied to building for the analysis in ETABS 2013 software. Following diagram shows the standard response spectrum for medium soil type and that can be given in the form of time period versus spectral acceleration coefficient (Sa/g).



This approach permits the multiple modes of response of a building to be taken in to account (in the frequency domain). This is required in many building codes for all except very simple or very complex structures. The response of a structure can be defined as a combination of many special shapes (modes) that in a vibrating string correspond to the "harmonic" computer analysis can be used to determine these modes for a structure. For each mode, a response is read from the design spectrum, based on the modal frequency and the modal mass, and they are then combined to provide an estimate of the total response of the structure. In this we have to calculate the magnitude of forces in all directions i.e. X, Y & Z and then see the effects on the building. Combination methods include the following:

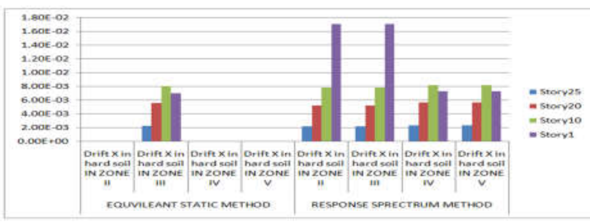
- absolute - peak values are added together
- square root of the sum of the squares (SRSS)
- complete quadratic combination (CQC) - a method that is an improvement on SRSS for closely spaced modes

The result of a response spectrum analysis using the response spectrum from a ground motion is typically different from that which would be calculated directly from a linear dynamic analysis using that ground motion directly, since phase information is lost in the process of generating the response spectrum.

IV.RESULTS

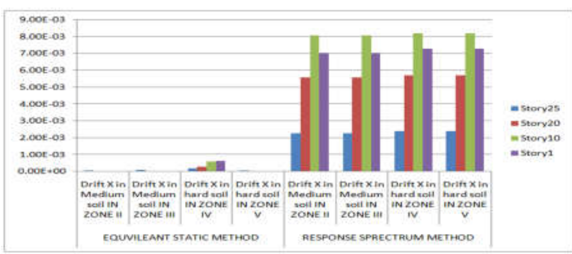
COMPARASION OF THE EQUVALENT STATIC METHOD AND RESPONSE SPECTRUM METHOD STORY DRIFT X DIRECTION IN HARD SOIL

Story	EQUVILEANT STATIC METHOD				RESPONSE SPRECTRUM METHOD			
	Drift X in hard soil IN ZONE II	Drift X in hard soil IN ZONE III	Drift X in hard soil IN ZONE IV	Drift X in hard soil IN ZONE V	Drift X in hard soil IN ZONE II	Drift X in hard soil IN ZONE III	Drift X in hard soil IN ZONE IV	Drift X in hard soil IN ZONE V
Story25	5.20E-05	0.00228	5.20E-05	5.20E-05	0.00216	0.00216	0.00238	0.00238
Story20	6.22E-08	0.005577	6.34E-08	6.34E-08	0.00527	0.00527	0.00571	0.00571
Story10	9.66E-08	0.008063	1.01E-07	1.01E-07	0.00779	0.00779	0.00818	0.00818
Story1	8.00E-06	0.007026	6.00E-06	6.00E-06	0.01705	0.01705	0.00728	0.00728



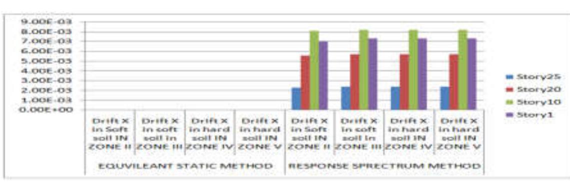
STORY DRIFT X DIRECTION IN MEDIUM SOIL

Story	EQUVILEANT STATIC METHOD				RESPONSE SPRECTRUM METHOD			
	Drift X in Medium soil IN ZONE II	Drift X in Medium soil IN ZONE III	Drift X in hard soil IN ZONE IV	Drift X in hard soil IN ZONE V	Drift X in Medium soil IN ZONE II	Drift X in Medium soil IN ZONE III	Drift X in hard soil IN ZONE IV	Drift X in hard soil IN ZONE V
Story25	5.20E-05	7.90E-05	0.000188	0.000052	0.00228	0.00228	0.00238	0.00238
Story20	6.22E-08	9.43E-08	0.00029	6.34E-08	0.00558	0.00558	0.00571	0.00571
Story10	9.66E-08	1.47E-07	0.000585	1.01E-07	0.00806	0.00806	0.00818	0.00818
Story1	8.00E-06	9.00E-06	0.000627	0.000006	0.00703	0.00703	0.00728	0.00728



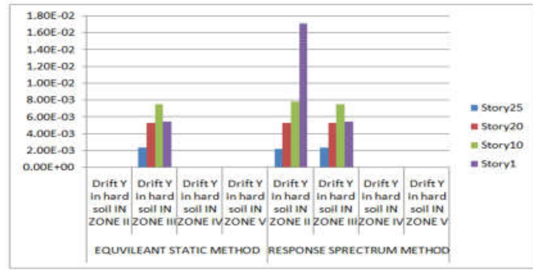
STORY DRIFT X DIRECTION IN SOFT SOIL

Story	EQUVILEANT STATIC METHOD				RESPONSE SPRECTRUM METHOD			
	Drift X in Soft soil IN ZONE II	Drift X in soft soil in ZONE III	Drift X in hard soil IN ZONE IV	Drift X in hard soil IN ZONE V	Drift X in Soft soil IN ZONE II	Drift X in soft soil in ZONE III	Drift X in hard soil IN ZONE IV	Drift X in hard soil IN ZONE V
Story25	5.20E-05	5.20E-05	5.20E-05	5.20E-05	0.00228	0.00238	0.00238	0.00238
Story20	6.22E-08	6.34E-08	6.34E-08	6.34E-08	0.00558	0.00571	0.00571	0.00571
Story10	9.66E-08	1.01E-07	1.01E-07	1.01E-07	0.00806	0.00818	0.00818	0.00818
Story1	8.00E-06	6.00E-06	6.00E-06	6.00E-06	0.00703	0.00728	0.00728	0.00728



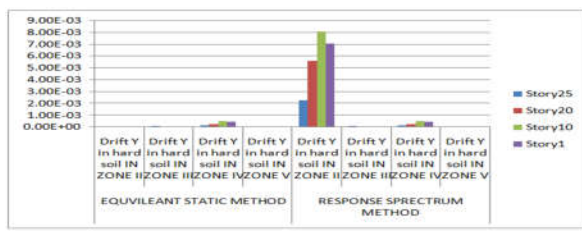
STORY DRIFT Y DIRECTION IN HARD SOIL

Story	EQUVILEANT STATIC METHOD				RESPONSE SPRECTRUM METHOD			
	Drift Y in hard soil IN ZONE II	Drift Y in hard soil IN ZONE III	Drift Y in hard soil IN ZONE IV	Drift Y in hard soil IN ZONE V	Drift Y in hard soil IN ZONE II	Drift Y in hard soil IN ZONE III	Drift Y in hard soil IN ZONE IV	Drift Y in hard soil IN ZONE V
Story25	5.90E-05	0.002312	6.00E-05	6.00E-05	0.00216	0.002312	6.00E-05	6.00E-05
Story20	6.51E-08	0.005282	6.61E-08	6.61E-08	0.00527	0.005282	6.61E-08	6.61E-08
Story10	1.03E-07	0.007502	1.08E-07	1.08E-07	0.00779	0.007502	1.08E-07	1.08E-07
Story1	9.00E-06	0.005448	7.00E-06	7.00E-06	0.01705	0.005448	7.00E-06	7.00E-06



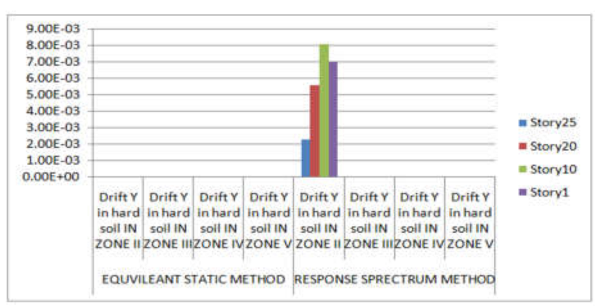
STORY DRIFT Y DIRECTION IN MEDIUM SOIL

Story	EQUVILEANT STATIC METHOD				RESPONSE SPRECTRUM METHOD			
	Drift Y in hard soil IN ZONE II	Drift Y in hard soil IN ZONE III	Drift Y in hard soil IN ZONE IV	Drift Y in hard soil IN ZONE V	Drift Y in hard soil IN ZONE II	Drift Y in hard soil IN ZONE III	Drift Y in hard soil IN ZONE IV	Drift Y in hard soil IN ZONE V
Story25	5.90E-05	8.90E-05	0.000169	0.00006	0.00228	8.90E-05	0.000169	0.00006
Story20	6.51E-08	9.88E-08	0.00024	6.61E-08	0.00558	9.88E-08	0.00024	6.61E-08
Story10	1.03E-07	1.55E-07	0.000492	1.08E-07	0.00806	1.55E-07	0.000492	1.08E-07
Story1	9.00E-06	1.00E-05	0.000456	0.000007	0.00703	1.00E-05	0.000456	0.000007



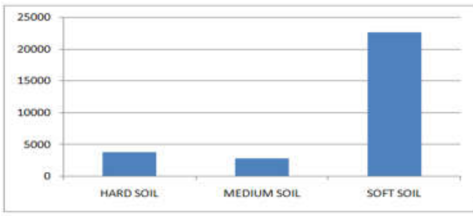
STORY DRIFT Y DIRECTION IN SOFT SOIL

Story	EQUVILEANT STATIC METHOD				RESPONSE SPRECTRUM METHOD			
	Drift Y in hard soil IN ZONE II	Drift Y in hard soil IN ZONE III	Drift Y in hard soil IN ZONE IV	Drift Y in hard soil IN ZONE V	Drift Y in hard soil IN ZONE II	Drift Y in hard soil IN ZONE III	Drift Y in hard soil IN ZONE IV	Drift Y in hard soil IN ZONE V
Story25	5.90E-05	6.00E-05	6.00E-05	6.00E-05	0.00228	6.00E-05	6.00E-05	6.00E-05
Story20	6.51E-08	6.61E-08	6.61E-08	6.61E-08	0.00558	6.61E-08	6.61E-08	6.61E-08
Story10	1.03E-07	1.08E-07	1.08E-07	1.08E-07	0.00806	1.08E-07	1.08E-07	1.08E-07
Story1	9.00E-06	7.00E-06	7.00E-06	7.00E-06	0.00703	7.00E-06	7.00E-06	7.00E-06



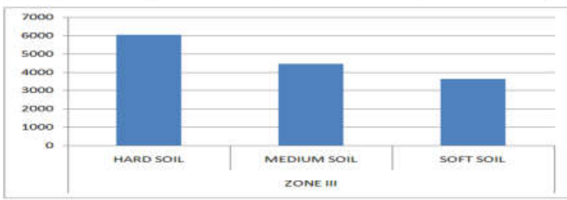
BASE SHEAR IN ZONE II

	ZONE II		
soil type	HARD SOIL	MEDIUM SOIL	SOFT SOIL
BASE SHEAR	3764.88	2768.37	**22550.1**



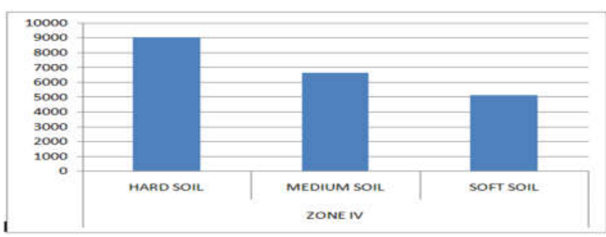
BASE SHEAR IN ZONE III

	ZONE II		
soil type	HARD SOIL	MEDIUM SOIL	SOFT SOIL
BASE SHEAR	3764.88	2768.37	**22550.1**



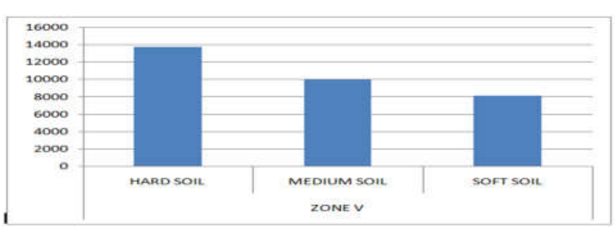
BASE SHEAR IN ZONE IV

	ZONE IV		
soil type	HARD SOIL	MEDIUM SOIL	SOFT SOIL
BASE SHEAR	9035.712	6647.37	5142.02



BASE SHEAR IN ZONE V

	ZONE IV		
soil type	HARD SOIL	MEDIUM SOIL	SOFT SOIL
BASE SHEAR	9035.712	6647.37	5142.02



IV.CONCLUSIONS

- This paper presents a review of the comparison of static and dynamic analysis multi-storeyed building. Design parameters such as Displacement, Bending moment, Storey drift, Torsion, Axial Force were the focus of the study. It was found that The difference of values of displacement between static and dynamic analysis is insignificant for lower stories but the difference is increased in higher stories and static analysis gives higher values than dynamic analysis.
- Static analysis is not sufficient for high rise buildings and it's necessary to provide dynamic analysis.
- Building with re-entrant corners experienced more lateral drift and reduction in base shear capacity compared to regular building
- When compared to the response spectrum analysis and Equivalent static method the drift value in the hard soil is increased from storey 1 and observed less drift as storey 25 , and zone II , III are having high drift values as compared to the Zone IV and Zone V.
- Storey drift is increased as height of building increased.
- Base shear values reduce in the soft soil but slightly increased in the medium soil and observed that the base shear is high in the hard soil due to less foundation depth.
- the Base shear in the different seismic zones from II to V the values are observed that it is high in hard strata and economical in the medium soil conditions thus the medium soil conditions are suitable for construction of high rise structures in high seismic zones .
- The results of equivalent static analysis are approximately uneconomical because values of displacement are higher than dynamic analysis.

REFERENCES

- IS 1893 (Part 1): (2002), "Criteria for Earthquake Resistant Design of Structures Part 1 General Provisions and Buildings", Bureau of Indian Standards.
- CSI Computers and Structures INC. "Introductory Tutorial for E-TABS: Linear and Nonlinear Static and Dynamic Analysis and

Design of Three- Dimensional Structures" 2011

- CSI (2009). "E-TABS: Static and Dynamic Finite Element Analysis of Structures" Nonlinear Version 14, Computers and Structures.
- B.C. Punmia, A.K. Jain, 2006, "R.C.C Designs", Laxmi publications New Delhi.
- IS-456 2000plain and reinforced concrete code of practice.
- P. Agarwal, M. Shrikhande, Earthquake resistance design of structures, PHI learning Pvt. 2012.
- Theory of Structures by Ramamrutham for literature review on kani′s method
- Reinforced and slab. concrete Structures by A.K. Jain and B.C. Punmia for design of beams, columns