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"Comparative Study on Seismic Analysis of R.C Structure with Fixed and Spring Base in Different Zones and Soil Types Considering Soil Structure Interaction"

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Abstract**—**The nonlinear behavior of soil leads to complexity of a structure during earthquake. In recent trend soil structure interaction is considered only in very few cases and the structure is analyzed under the assumption of fixed or hinged base. Indian Standard Code also do not provide method for seismic analysis based on soil structure interaction since it has complication in analysis procedure. The response of a structure during earthquake is heavily influenced by soil structure interaction. In this study the comparative study on seismic analysis of RC frame structure with fixed and spring base in different zones of India are done taking different soil types and considering soil structure interaction. Two modes of soil structure interaction are considered for the analysis, one is replacing soil by spring and second by considering the whole soil mass. For the analysis purpose SAP 2000 software is used. For soil structure interaction study soil types considered are hard, medium and soft soil. Parameters such as displacement, drift and base shear are considered to determine the influence of soil structure interaction.

Keywords*-Seismic Analysis, R.C Structure, Soil Structure Interactiion.*

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I. INTRODUCTION

During an earthquake the dynamic response of a structure is dependent on the following characteristics, the ground motion, properties of the surrounding soil medium and lastly the structure itself. The seismic wave transmits through the soil from the source of disturbance to the structure during an earthquake. This wave motion of soil vibrates the structure. Fixed base structures are structures located on rock. When earthquake is subjected to such structures the motion of rock is constrained due to the rocks high stiffness. It is different in case of structures located on soft soils as there is coupling of soil and structure when earthquake occurs. Soil structure interaction mainly has two methods Direct and Substructure method. In direct method the structure and soil are considered as a whole system where the soil and structure response is simultaneously found by analysing it in a single step. In case of substructure method the soil and the structure are considered as two different substructures where each substructures are analysed by the best technique possible. Usually the soil structure interaction is neglected and the dynamic response of structure is taken with the assumption of fixed or hinged base response in the framed buildings of seismic design. Based on this assumption the structures vibration period is calculated and evaluation of seismic load is carried out. However the soil undergoes settlements or deformations during actual seismic loading and also because of actual soil parameters the structures vibration period increases. The structure becomes more flexible and there is reduction in seismic loads due to increase in vibration period.

The natural calamities such as earthquakes, tsunamis, seiches, landslides, floods and fires causes severe damage and leads to sufferings of humans by structure collapse, cutting off transport systems ,trap or kill humans ,animals etc. Civil engineers as designers play a major role in minimising such natural disasters by designing structures properly. Besides vibration of structure in response to ground motion at its foundation earthquake also have many other effects which may even exceed that due to vibration. However we are unfortunate as the estimation procedures and steps for design are considered outside the scope of structural engineering. There are provisions of different seismic design codes for design of structure but these codes have no provision for other earthquake effects.

II. SOIL STRUCTURE INTERACTION

The response of a structure to the motion of foundation soils and the response of soil to the motion of structure may be defined as soil-structure interaction. Generally in soil-structure interaction the maximum base shear usually decreases, the system period is lengthened and the rocking components contribution of ground motion to the total response is increased. The maximum base shear is reduced from the results of scattering of waves from the foundation and from the vibration of structural radiation energy into the soil. The incident wave energy is absorbed due to soil-structure interaction when the soil around the foundation is exposed to small or moderate levels of non linear response thereby reducing the excitation of structure.

III. IMPORTANCE OF STUDY

The study of response of RC structure subjected to seismic loading with fixed and spring base is studied very little in the past. Structure in which the base is fixed is not usually preferred, the spring base model has been developed as a base for the present study to represent the soil structure interaction system. As the fixed base model gives almost perfect accuracy but during the study of soil structure interaction spring base is more accurate compared to fixed base. From the past failure of the structure, it is realised that to get optimum design of buildings, the design of building for earthquake loading requires an early enclosed collaboration between the architect and engineer. The base of the structure is an important characteristic that affects building response. In the present study a comparison of seismic analysis of RC structure with fixed and spring base in different zones of India and soil types are considered.

IV. Litreature Review

Mohammadreza Ostoadali Makhmalbaf et.al (2011) have carried out a study on displacements of building considering the effects of soil structure interaction. The classification of behaviour of structures with seismic loads on performance based design is expanding rapidly in the structural engineering field. This study consists of behaviour of building under seismic loads and the effects of interaction between the motion of soil surrounding the foundation to the structure and the motion of structure to the foundation soil. For modelling the structure manually, finite difference method was considered. The parameters considered for this study were embedment of structures foundation and their horizontal displacement on roof at the centreline, ratio of structural impedance to the soil, the height of structure to width and the horizontal displacement of ground in the level of foundation.

Hamid Reza Tabatabaifar et.al (2012) have carried out the level of performance of moment resisting building at which the foundation is based on different soil types under the effects of dynamic soil structure interaction. This study consists of two models having five and fifteen storeys respectively. These models were moment resisting building frames resting on three different soil types where analysis of time history considering inelastic procedure of design and behaviour of elastic perfect plastic of structural elements were carried out. For modelling and analysing the structure, finite difference method was considered using software FLAC 2D and comparison between the fixed base(no soil structure interaction) and spring base(having soil structure interaction) was done. The results of the inelastic behaviour of models from the non linear dynamic analysis having different records of earthquake were compared. The results showed that according to Australian Standards of soil types Ee and De the inter-storey drifts of the models increases substantially when soil structure interaction is considered. Therefore, when soil structure interaction is not considered for the design procedure there is no sufficient safety guarantee for the building frames based on soft soil.

Shiji P.V et. al (2013) have carried out an analytical study on the effect of soil structure interaction in seismic loads of framed structures. The dynamic response of the structure is considered under the assumption of a fixed or a hinged base response. In this paper, the interaction between the super-structure and sub-structure is analysed by modelling the soil as nonlinear spring and as elastic continuum. To study the effects of soil-structure interaction on the seismic response of framed structures, frames with 5, 10, 20 and 40 storeys have been considered with base supported as fixed with and without considering the soil structure interaction. The influence of soil structure interaction by considering soil as compression only spring and elastic continuum are presented in the form of fundamental period of vibration and base shear. SAP 2000 has been used for the analysis of structures. This paper concluded that the period of vibration increases for the modal analysis as compared to the calculated value as per IS 1893(Part I):2002, the period of vibration is more when considering soil as elastic continuum models than as non linear spring model, the influence of soil structure interaction is more significant in frames with higher number of storeys.

Dr. S. A. Halkude et. al (2014) have carried out an analytical study soil structure interaction effect on seismic response of R.C. frames with isolated footing. In this study the effect of soil on the performance of building frame is investigated. Two soil structure interaction modes are considered for the analysis, one is replacing soil by spring of equivalent stiffness and second by considering the whole soil mass. Model considered are 2 bay 2 storey (2x2x2), 2 bay 5 storey (2x2x5) and 2 bay 8 storey (2x2x8) are considered with fixed base and flexible base. SAP 2000 has been used for the analysis of structures. For soil structure interaction study three types of soil are considered i.e. Hard, Medium and Soft Soil. The dynamic analysis is carried out. Parameters such as natural time period, base shear, roof displacement, beam moment and column moment are considered for analysis. This paper concluded that soil structure interaction significantly affects on the response of the structure.

Mengke Li et. al (2014) have carried out an analytical study on the influence of soil structure interaction on seismic collapse resistance of super-tall buildings. Shanghai Tower with a total height of 632 m is taken as the research object; the substructure approach is used to simulatethe soil structure interaction effect on the seismic responses of Shanghai Tower. The refined finite element (FE) model of the superstructure of Shanghai Tower and the simplified analytical model of the foundation and adjacent soil are established. Subsequently, the collapse process of Shanghai Tower taking into account the soil structure interaction is predicted, as well as its final collapse mechanism. The influences of the soil structure interaction on the collapse resistance capacity and failure sequences are discussed. The results indicate that, when considering the soil structure interaction, the fundamental period of Shanghai Tower has been extended significantly, and the collapse margin ratio has been improved, with a corresponding decrease of the seismic demand. In addition, the soil structure interaction has some impact on the failure sequences of Shanghai Tower subjected to extreme earthquakes, but a negligible impact on the final failure modes.

Shreya Thusoo et. al (2015) have carried out an analytical study on response of buildings with soil-structure interaction with varying soil types. This paper studies the effect of Soil Structure Interaction on multi-storey buildings with varying under-laying soil types after proper validation of the effect of Soil Structure Interaction. Analysis for soft, stiff and very stiff base soils has been carried out, using ANSYS v14.5 software. The paper concluded that the deflection is less on hard or medium soil as compared to the buildings on soft soils, the spectral acceleration response pattern changes drastically as stiffness of base soil decreases and time period of all the responses increases while considering Soil-Structure Interaction effects.

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286 - 292

V. MODELLING

The present work consists of modelling and analysis of structures using SAP 2000. Here, analysis of structures are done for all zones and soil types considering fixed and spring supports. In this study two methods are considered for studying the behaviour of structures with and without spring supports, one is equivalent static method and the other is response spectrum method.

Reinforced Cement concrete multi-storey building plane frames were analyzed using Finite Element Analysis employing SAP 2000 with fixed and spring base condition and soil base condition in different zones of India.

Material Properties of RC Bare frame members are as follows:
Column size = 200 x 600 mm
Beam size = 200 x 450 mm
Grade of concrete = M30 (Assumed)
Grade of steel = Fe 415 (Assumed)
Slab thickness (Infill frame) = 125 mm
Floor finish = 2 kN/m2
Live Load = 3 kN/m2

Soil Models
Different types of soil taken for the analysis are,
a. Soft Soil
b. Medium Soil
c. Hard Soil

There are total 48 models for comparative study on seismic analysis of R.C structures with fixed and spring base in different zones and soil types.

VI. RESULTS

Behaviour of the seismic performance of RC structure with fixed and spring base in different zones and soil types considering soil structure interaction are studied. Significance and effect of different parameters are studied in detail.

a) Comparision of Displacement With Fixed and Spring Base In Different Zones of India By Equivalent Static Method

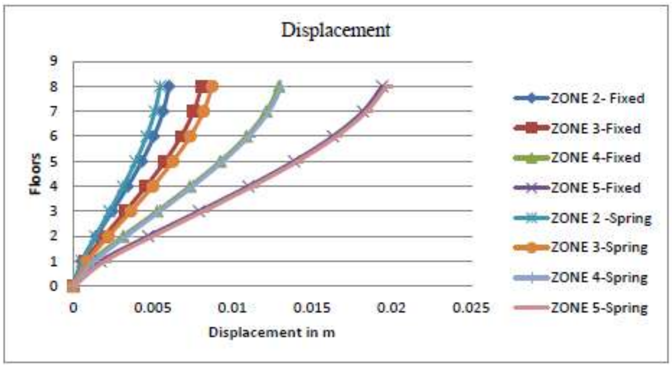

Fig 1: Comparison of Displacement with Fixed and Spring Base in Different Zones of India in X-Direction (Hard Soil)

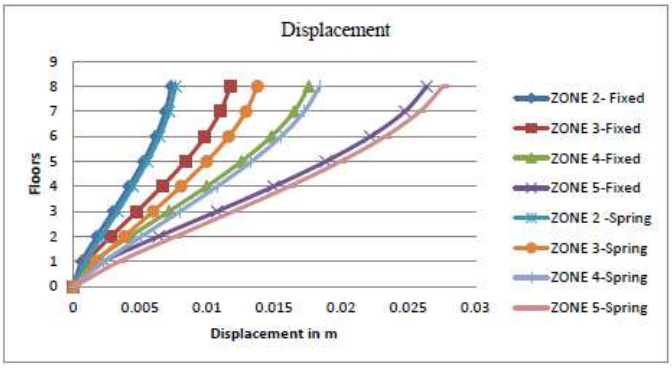

Fig 2: Comparison of Displacement With Fixed and Spring Base In Different Zones Of India In X-Direction (Medium Soil)

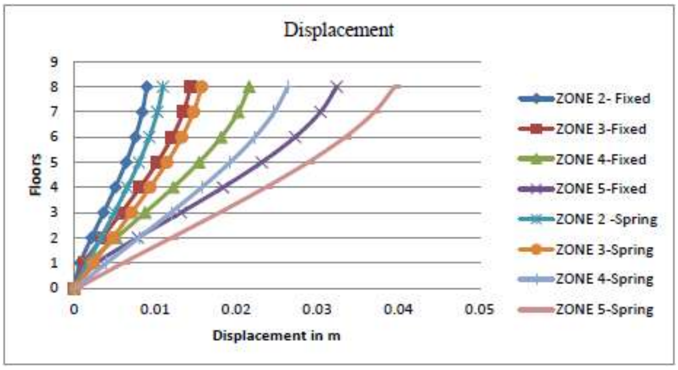

Fig 3: Comparison Of Displacement With Fixed and Spring Base In Different Zones Of India In X-Direction (Soft Soil)

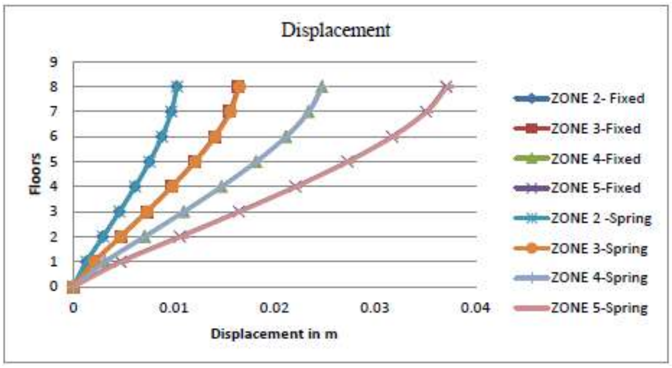

Fig 4: Comparison Of Displacement With Fixed and Spring Base In Different Zones Of India In Y-Direction (Hard Soil)

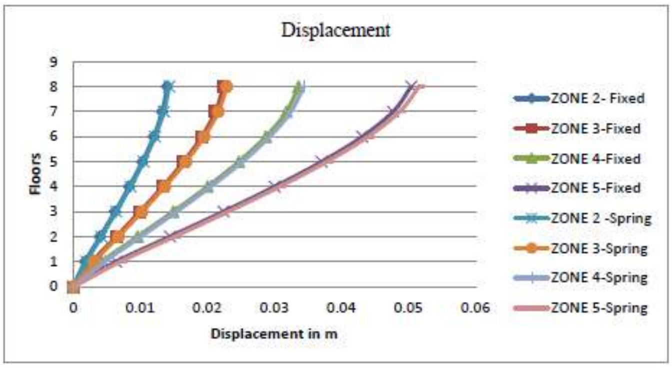

Fig 5: Comparison Of Displacement With Fixed and Spring Base In Different Zones Of India In Y-Direction (Medium Soil)

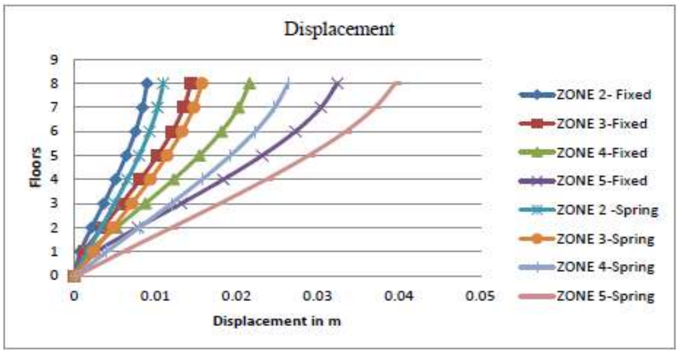

Fig 6: Comparison Of Displacement With Fixed and Spring Base In Different Zones Of India In Y-Direction (Soft Soil)

b) Comparision of Displacement with Fixed wnd Spring Base In Different Zones of India by Response Spectrum Method

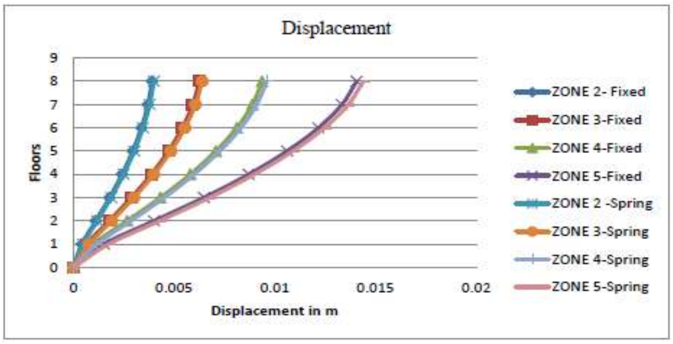

Fig 7: Comparison Of Displacement With Fixed and Spring Base In Different Zones Of India In X-Direction (Hard Soil)

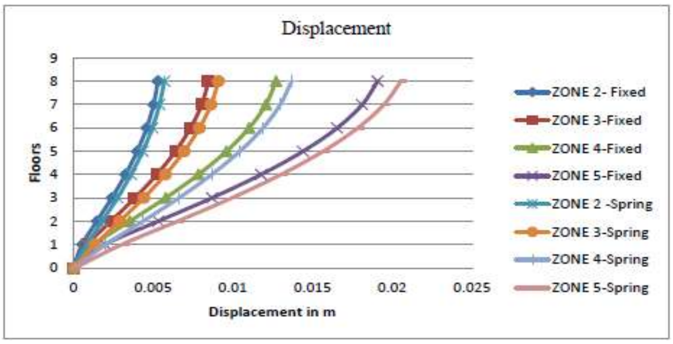

Fig 8: Comparison Of Displacement With Fixed and Spring Base In Different Zones Of India In X-Direction (Medium Soil)

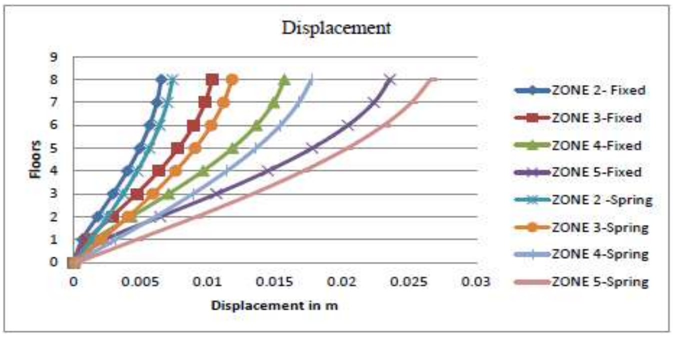

Fig 9: Comparison Of Displacement With Fixed and Spring Base In Different Zones Of India In X-Direction (Soft Soil)

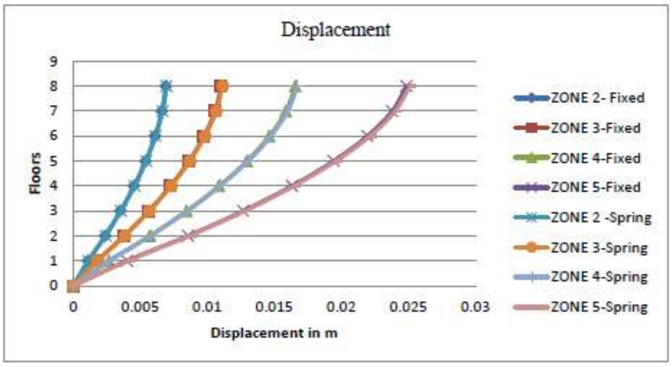

Fig 6.10: Comparison Of Displacement With Fixed and Spring Base In Different Zones Of India In Y-Direction (Hard Soil)

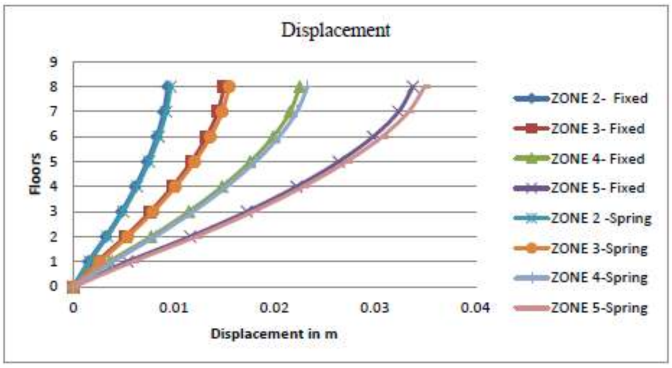

Fig 6.11: Comparison Of Displacement With Fixed and Spring Base In Different Zones Of India In Y-Direction (Medium Soil)

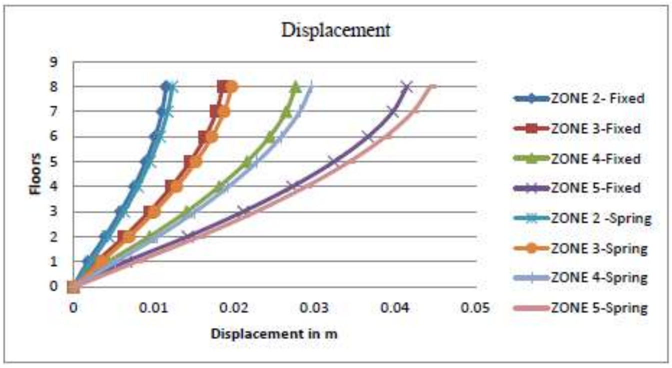

Fig 6.12: Comparison Of Displacement With Fixed and Spring Base In Different Zones Of India In Y-Direction (Soft Soil)

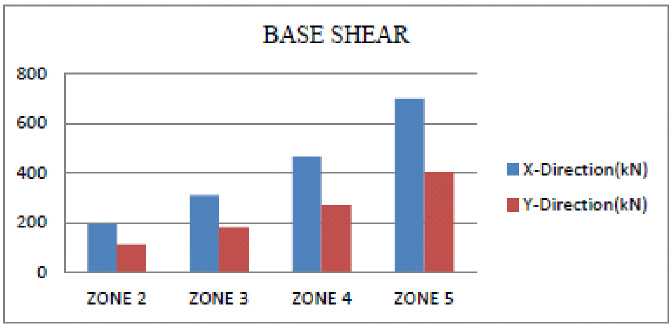

Fig 6.13: Comparison Of Base Shear With Fixed Base In Different Zones Of India (Hard Soil)

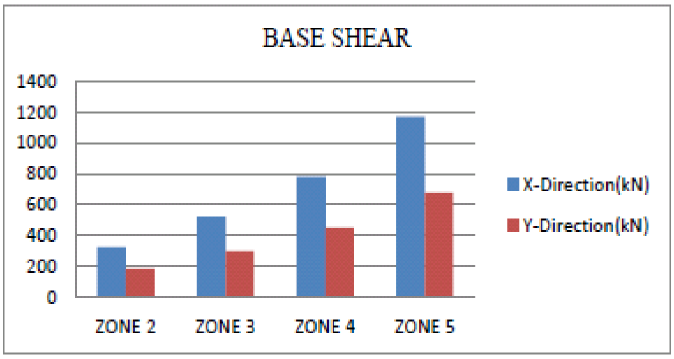

Fig 6.14: Comparison Of Base Shear With Fixed Base In Different Zones Of India (Medium Soil)

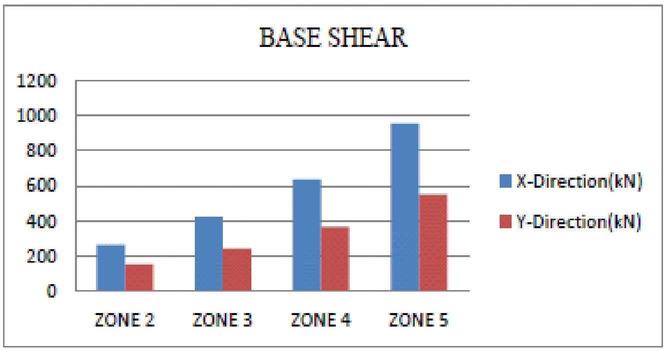

Fig 6.15: Comparison Of Base Shear With Fixed Base In Different Zones Of India (Soft Soil)

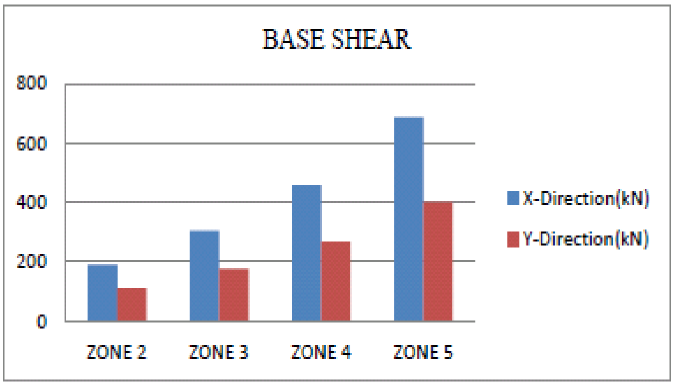

Fig 6.16: Comparison Of Base Shear With Spring Base In Different Zones Of India (Hard Soil)

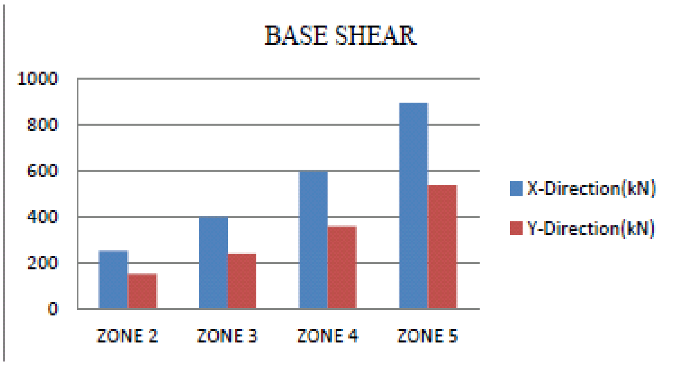

Fig 6.17: Comparison Of Base Shear With Spring Base In Different Zones Of India (Medium Soil)

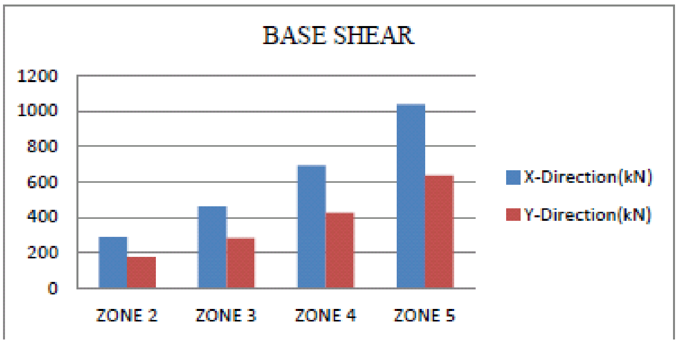

Fig 6.18: Comparison Of Base Shear With Spring Base In Different Zones Of India (Soft Soil)

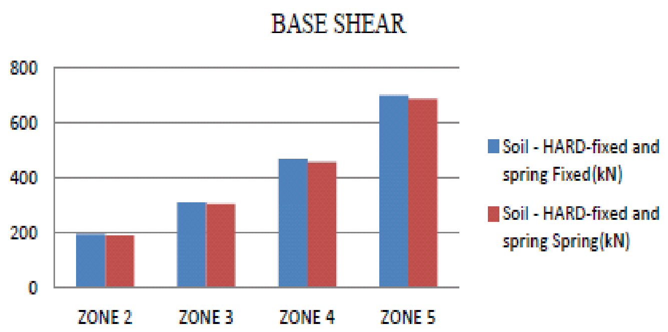

Fig 6.19: Comparison Of Base Shear Along X-direction With Fixed and Spring Base In Different Zones Of India (Hard Soil)

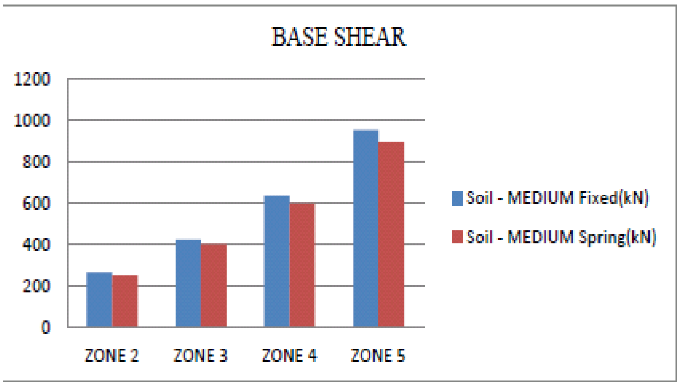

Fig 6.20: Comparison Of Base Shear Along X-direction With Fixed and Spring Base In Different Zones Of India (Medium Soil)

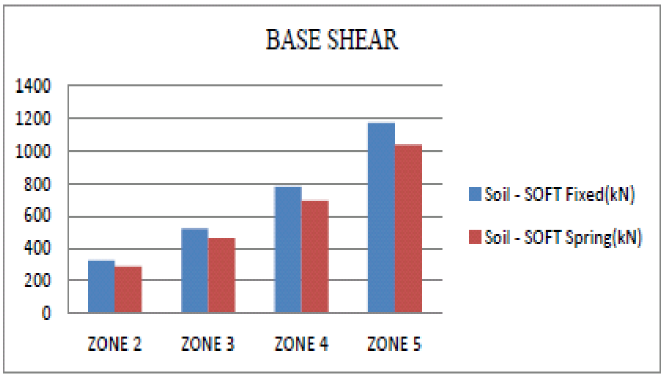

Fig 6.21: Comparison Of Base Shear Along X-direction With Fixed and Spring Base In Different Zones Of India (Soft Soil)

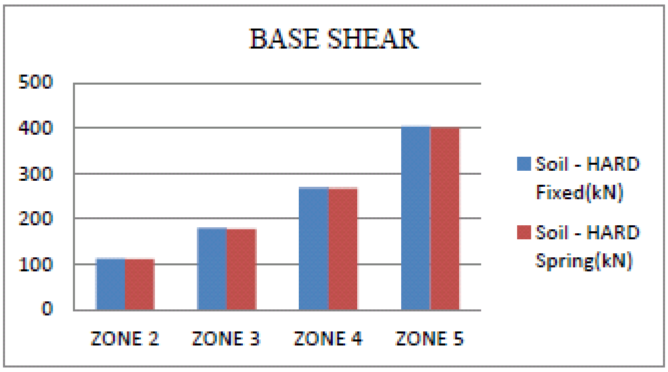

Fig 6.22: Comparison Of Base Shear Along Y-direction With Fixed and Spring Base In Different Zones Of India (Hard Soil)

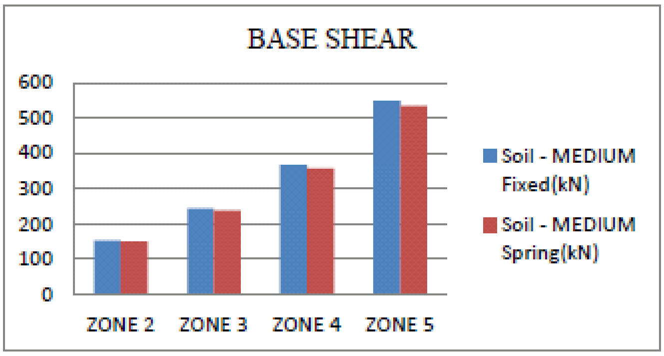

Fig 6.23: Comparison Of Base Shear Along Y-direction With Fixed and Spring Base In Different Zones Of India (Medium Soil)

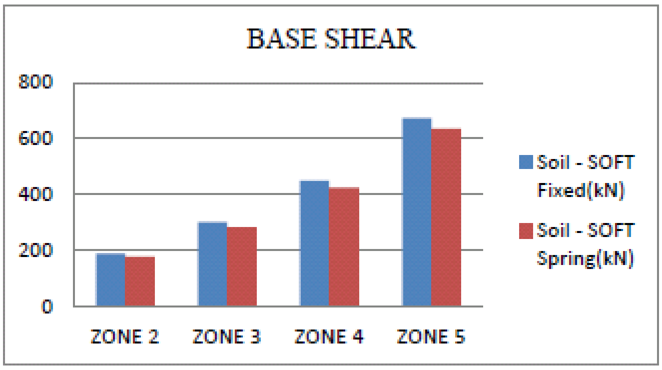

Fig 6.24: Comparison Of Base Shear Along Y-direction With Fixed and Spring Base In Different Zones Of India (Soft Soil)

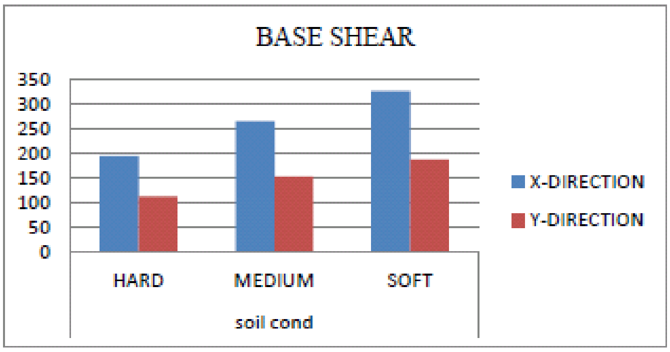

Fig 6.25: Comparison Of Base Shear with different Soil Condition in Zone 2 (Fixed Base)

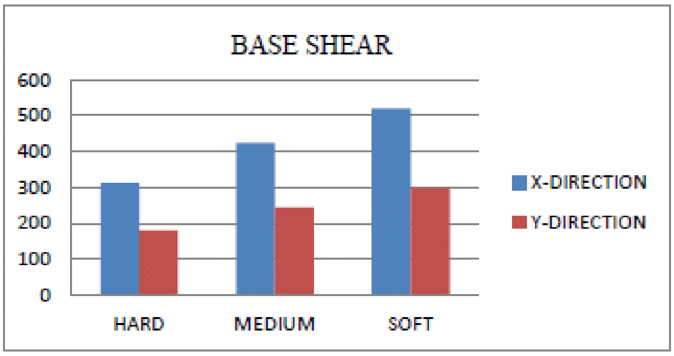

Fig 6.26: Comparison Of Base Shear with different Soil Condition in Zone 3 (Fixed Base)

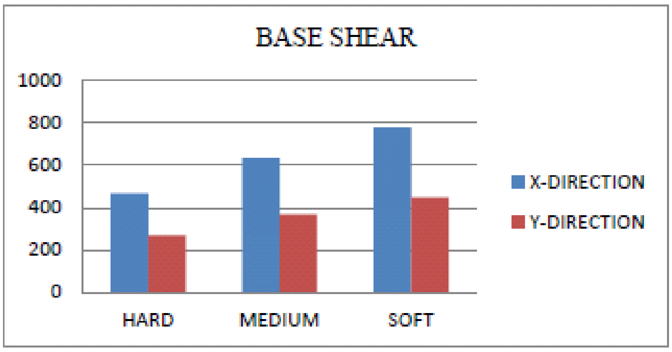

Fig 6.27: Comparison Of Base Shear with different Soil Condition in Zone 4 (Fixed Base)

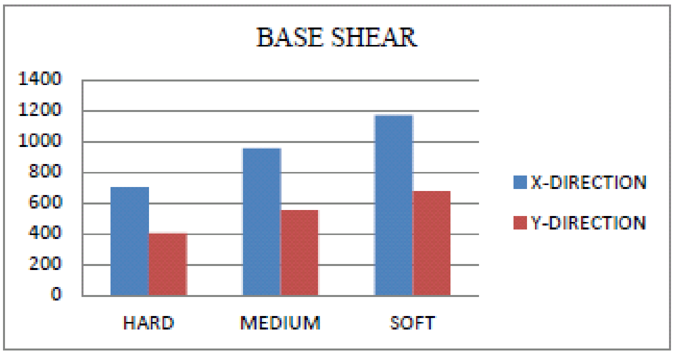

Fig 6.28: Comparison Of Base Shear with different Soil Condition in Zone 5 (Fixed Base)

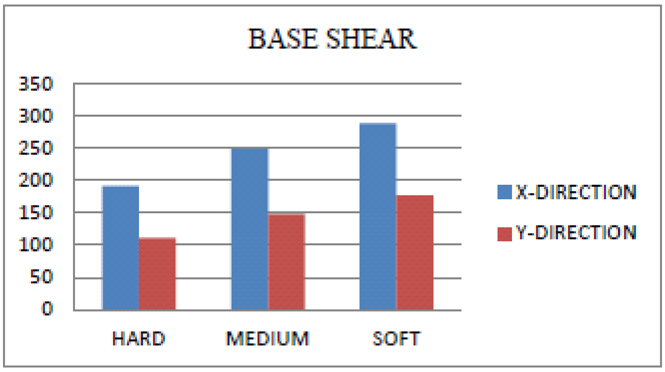

Fig 6.29: Comparison Of Base Shear with different Soil Condition in Zone 2 (Spring Base)

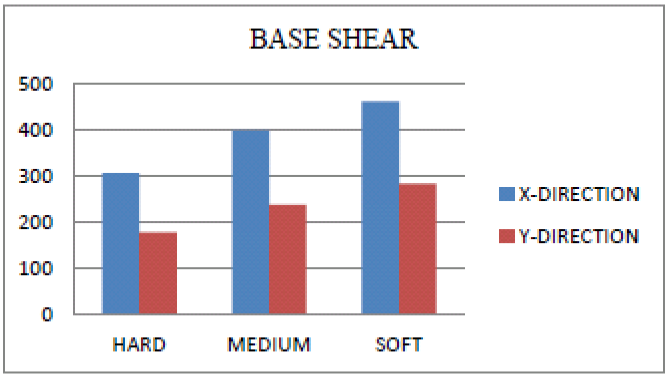

Fig 6.30: Comparison Of Base Shear with different Soil Condition in Zone 3 (Spring Base)

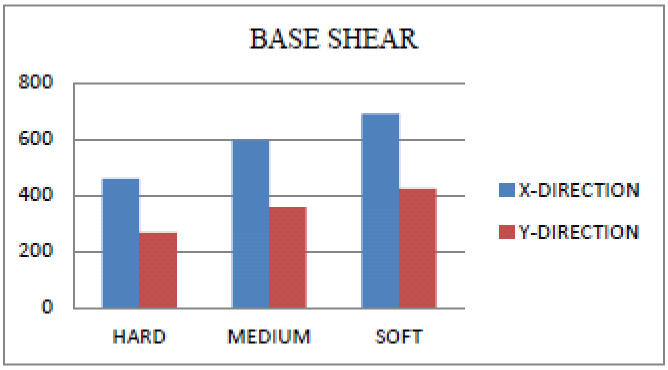

Fig 6.31: Comparison Of Base Shear with different Soil Condition in Zone 4 (Spring Base)

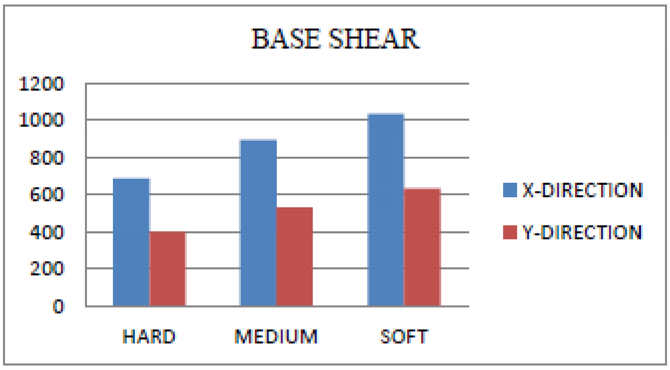

Fig 6.32: Comparison Of Base Shear with different Soil Condition in Zone 5 (Spring Base)

VII. CONCLUSION

The following conclusion can be drawn from the results of the present study:

i) SAP software has been proved to be an effective tool for the analysis of RC structure subjected to seismic loading.

ii) The comparison of displacement with fixed and spring base in different zones of India in X-direction and Y-direction for different soil conditions shows that there be an increase in displacement from zone 2 to zone 5 and after providing springs in base, displacement is increased, also with increase in storey height displacement increases.

iii) The comparison of base shear for fixed support and spring support in Different Zones of India in X and Y direction shows that there will be an increase in base shear by 70-75% from zone 2 to zone 5.

iv) The comparison of base shear for fixed support and spring support from hard to soft soil shows that there will be an increase in base shear by more than 30% and from hard to medium soil shows that there will be an increase in base shear by more than 20%.

v) The structure with spring base shows good result when compared with fixed base in different zones of India.

REFERENCES

[1] Dr.S.A.Halkude, Mr. M.G Kalyanshetti, Mr.S.H.Kalyani on "Soil-structure interaction effect on seismic response of R.C.Frames with isolated footing." International Journal of Engineering Research & Technology(IJERT) ISSN:2278-0181 Vol.3 Issue 1, January-2014.

[2] Hamid Reza Tabatabaiefar, Behzad Fatahi & Bijan Samali on "Effects of dynamic soil-structure interaction". Pacific conference on earthquake engineering (PCEE), 2011, pp. 1-8.

[3] IS 1893 (Part I): 2002 Criteria for Earthquake Resistant Design of Structures- Generalprovisions and Buildings , Bureau of Indian Standards, New Delhi.

[4] Mengke Li, Xiao Lu, Xinzheng Lu, Lieping Ye on "Influence of soil-structure interaction on seismic collapse resistance of super tall buildings."Journal of rock mechanics and geotechnical engineering, April-2014.

[5] Mohammadreza Ostaadali Makhmalbaf, Mahtab Alitalesh, Mohammed Amin, Tutunchian, on "Displacement of buildings considering the dynamic soil-structure interaction effects". Electronic journal of Geotechnical engineering (Ejge) volume 16 2011.

[6] Shiji P.V, Suresh, Glory Joseph on "Effect of soil-structure interaction in seismic loads of framed structures." International Journal of Scientific & Engineering Research Volume 4, Issue 5, May-2013.

[7] Shreya Thusoo, Karan Modii, Rajesh Kumar & Hitesh Mahadar on "Response of buildings with soil-structure interaction with varying soil types". International journal of Civil, Environmental, Structural, Construction and Architectural Engineering Vol:9, No. 4, 2015.