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Analysis of Highrise Structures in Different Soil Types and Seismic Zones

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Abstract:

In the present paper, time history, response spectrum and p-delta analyses will be carried out using Etabs software to study the effects of different soil types and seismic zones for a high-rise building of G+ 30 storey. . In this work, total 12 models will be analyzed for various soils types and seismic zones are systematically compared and discussed for a seismic performance of multistory building. The obtained results are then analyzed and compared to determine the most suitable condition for the construction of given high-rise building to have maximum service life.

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I. INTRODUCTION

1.1 GENERAL

High rise buildings are the structures more than 23m (75ft) or 7-10 storey height. Due to increase in urban population cities are growing outwards which has made procuring basic facilities such as water supply, sewage collection and other basic needs difficult. So the alternative solution to this problem is to build high-rise structures within the city which are compact and concentrate the population of a large area into a single structure.

But construction of high-rise building is more complicated as the aspects to be considered are large. In which the soil type and seismic zone on which it is constructed plays an important role in determining the stability and height of the structure.

Vibrations which disturb the earth's crust caused by waves generated inside the earth are termed as earthquakes. It is caused due to the convergence or divergence of tectonic plates in the earth's crust. It is said that earthquakes are not fatal the life of human but structures which are not constructed in considering the earthquake forces do.

1.2 SEISMIC ZONES

With the help of the past seismic history, Bureau of Indian Standards has grouped the country into four seismic zones namely,

Zone II: Low intensity zone-It covers about **40.93% area** of the country. It consists of major parts of peninsular region and Karnataka Plateau.

Zone III: Moderate intensity zone-It covers about 30.79**% area** of the country. It consists of Kerala, Goa, Lakshadweep islands, remaining parts of Uttar Pradesh, Gujarat and West Bengal, Parts of Punjab, Rajasthan, Madhya Pradesh, Bihar, Jharkhand, Chhattisgarh, Maharashtra, Odisha, Andhra Pradesh, Tamil Nadu and Karnataka.

Zone IV: Severe intensity zone-It covers about**17.49% area** of the country. It consists of parts of Jammu and Kashmir, Himachal Pradesh, National Capital Territory (NCT) of Delhi, Sikkim, Northern Parts of Uttar Pradesh, Bihar, West Bengal, parts of Gujarat, small portions of Maharashtra near the coast and Rajasthan.

Zone V: Very severe intensity zone-It covers **10.79% area** of the country. It consists of the entire north-eastern India, parts of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Rann of Kutch in

Gujarat, part of North Bihar and Andaman & Nicobar Islands.

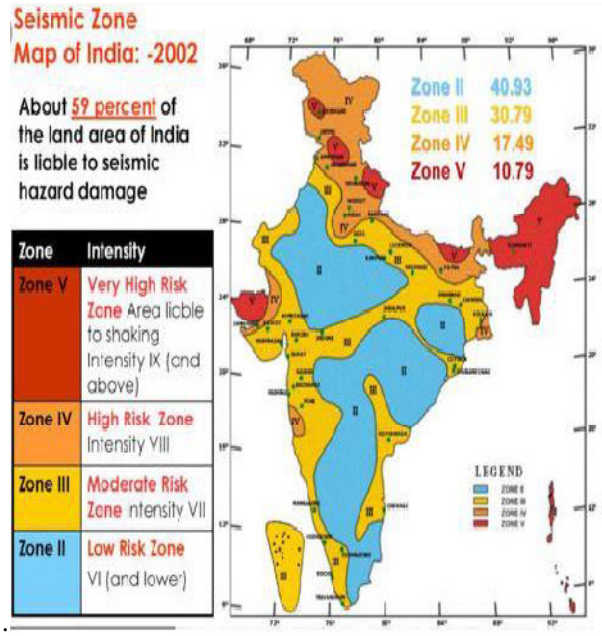

Fig 1: Seismic zones map of India

1.3 SOIL TYPES

The soil type on which the structure lies can affect the stability of structure during seismic activity. The soil condition of the field is essential in analysis of the structures. Soil condition is defined as The physical condition of the soil and its dynamic properties which are divided according to IS 1893 table 2 into

Type A: It is composed of Rock or hard soils. It consists of well graded gravel (GW) or well graded sand both with less than 5 percent passing 75mm sieve. Well graded gravel- sand mixtures with or without fines (GW-SW). Poorly- graded sand (SP) or clayey sand 3 (SC), all having N having above 30. Stiff to hard clays having N above 30, where N is corrected Standard Penetration test value.

Type B: It is composed of Medium or stiff soils. It consists of poorly graded sands or poorly graded sands or poorly graded sands with gravel (SP) with little or no fines having N between 10 and 30. Stiff to medium stiff fine- grained soils, like of low compressibility (CL) having N between 10 to 30.

Type C: It is composed of soft soils. All soft soils other than SP with N< 10. The various possible soils are ;
Silts of intermediate compressibility (MI). Silts of high compressibility (MH). Clays of intermediate compressibility (CI). Clays of high compressibility (CH). Silts and clays of intermediate to high compressibility (MI-MH or CI-CH). Silt with clay of intermediate compressibility (MI-CI). Silt with clay of high compressibility (MH-CH).

LITRATURE REVIEW

1. W. Bourouaiah**"Influence of the soil properties on the seismic response of structures".**(2019) The objective of the study is to model the interaction between Concrete wall & soil under seismic loading. The purpose of the study is to calibrate the effects of soil properties and the soil structure interaction on the seismic response of the structure. The obtained results show that soil properties have a great influence on seismic behavior of a structure.

2. Amer Hassan, Shilpa Pal "**Effect of soil condition on seismic response of isolated base buildings**" (2018) .In this study, analysis is carried out using Etabs-2015 software to study the influence of soil condition beneath the isolated base of G+12 story building. Various types of soils are systematically compared and discussed for a seismic performance of multi story buildings. The significant conclusion was that hard soil and medium soil are suitable for base isolation buildings. The value of base shear is directly proportional to soil flexibility and superstructure stiffness.

3. Arun Babu M, Ajisha R "**Analysis of Multi-storeyed Building in Different Seismic Zones with Different Soil Conditions**" (2018).This paper focuses on the effect of building in different seismic zones with different soil conditions for G+10 storey building. Here 3 dimensional model0ing and analysis of structure is going to do using the software by ETABS. The story displacement and base shear will help to compare the performance of all models and can identify which building has more performance against earthquake.

4. Bhalchandra P. Alone, Dr. Ganesh Awchat "**Study on seismic analysis of high-rise building by using software**" (2017).This paper addresses the Case study on seismic analysis of high rise building system (Ground+3 Basements+50) storey RCC by STAAD pro v8i with application of IS provisions. The main parameters considered in this study is to compare the seismic performance of different models based on storey drift, base shear, story deflection and time period.

5. ElyarZafarkhah, MortezaRaissiDehkordi "**Evaluation and numerical simulation of soil type effects on seismic soil structure interaction response of RC structures**" (2017) .The study is aimed at determining the effect of variation in soil type and structure height on soil-structure system responses. Different soil types and structure heights are considered, and the responses are analyzed with reference to changes in soil type and structure height. It was noted that, for sandy soils, the SSI impact is greater for looser sub-soils. For clayey soils, the medium clay has greater SSI effect. For low and medium rise buildings, the SSI effect is more profound as the structure becomes taller, but for high rise buildings, the SSI effect becomes significantly small with increasing height.

6. Gourav Sachdeva, Vinamra Bhushan Sharma "**Impact of Different Soils and Seismic Zones on Varying Height of Framed Structures**" (2017).To determine the impact of different soil and seismic zones on varying height of framed structure.Three different soils types was considered-soft, medium and hard. Stories i.e., G+4,G+5, G+6 & G+7 are taken of heights 15m,18m, 21m & 24m respectively are considered and analyzed for seismic zones II,III,IV & V. The paper concluded that in Seismic Zone - 2, 3 & 5 the values of maximum Shear forces & maximum bending moment are decreasing in hard soil strata in comparison to soft soil strata & found the least for the same.

7. DR. K. Chandrasekhar Reddy & G. Lalith Kumar "**Seismic Analysis of High-Rise Buildings (G+30) by Using ETABS**" (2017).To determining the effects of lateral loads on moments, shear force, axial force, base shear, maximum displacement and tensile forces on structural system are subjected and also comparing the results of seismic zones 2, 3, 4 and 5.Analysis of G+30 multi-story building in all seismic zones for wind and earthquake forces is carriedout.3D model is prepared for G+30 multi-story building using ETABS. It is found that the lateral displacements or drifts are more in zone 5 when compared to the zones 4, 3 & 2

8. Farzad Hatami, Hamed Nademi, Mohammad Rahaie "**Effects of Soil-Structure Interaction on the Seismic Response of Base Isolated in High-rise Buildings**" (2015).In this paper, a 10-story base isolated structure, designed and three different soil types are selected according to soil classifications in the code. This paper focuses on isolation systems which are widely used in high-rise buildings with the aims of reducing their seismic vulnerability against natural hazards.

9. M.Pavan Kumar, G.T.Naidu "**Effect of soil-structure interaction on high rise R.C regular frame structure with irregular bays subjected to seismic load**" (2015).To analyze the structure considering the foundation soil settlement for various seismic zones in India for G+30 storey building (II, III, IV&V). From the study it is observed that the percentage of displacement in x & y direction are increased with decreasing sub grade modulus at all seismic zones. It concluded that effect of soil – structure interaction has to consider especially for lower sub grade modulus of soil at higher seismic intensities.

10. Ketan Bajaj, Jitesh T Chavda, Bhavik M Vyas "**Seismic behavior of buildings on different types of soil**" (2013).In this study different soil strata are taken and corresponding base shear and lateral displacement is determined with variation in floors G+4, G+5, G+6 and 3, 4 and 5.Responses are obtained for different types of soil such as hard, medium and soft. It was noted that with the change in zone and soil the lateral load varies substantially. With the change in soil property from hard to medium and from hard to soft the lateral deflection has increased.

11. Narla Mohan &A.Mounika Vardhan "**Analysis of G+20 RC Building in different zones using Etabs"**(2017) The study is aimed at determining the behaviour of a multi storied R C building of irregular plan subjected to seismic load by the use of Response spectrum analysis. The present study is limited to reinforced concrete (RC) Rise-structure with FOUR different zones II, III, IV & V.
A high-rise building model is studied which consists of 20 storey's of constant storey height of 3m. Four models are considered to analyze with different bay lengths and for number of bays and the bay-width along two horizontal directions are kept constant in each model.

12. Shaik Fayaz Mrs. B.Ajitha **"Seismic Behavior of High Rise Building for Soft Soil in All Seismic Zones"** (2015) An analytical study on multi-Storey building of 30 stories was carried out for different seismic zones and soft soil types using different bracing systems.
The results indicate that to control drift, shear wall system is better than bracings system, normal HRB (moment resisting system). compared to Bracing system (i.e., X, inverted V and V) and Normal HRB (Moment resisting system). Inverted V-bracing system serves better to control drift above 28 storeys when compared to shear wall system.

13. Ms. Neha D.Khobragade**"Effect of Seismic Forces on Multi-Storey Building for Different Zones & Soil Condition"** (2016) This paper shows the effectof different seismic zone on the performance of G+10 multi-storeyed RC building. The models of building were developed to analyze and compare the effectof seismic forces on high-rise building by using STADD PRO software. It was noted that the maximum moment in X-direction , Z-direction and maximum Fy for Zone-V.

14. Shashidhar prasad KT, Dr M N Shivakumar. **"Analysis of G+15 Building in Different Seismic Zones Of India"** (2019). In this study, the behaviour of structure located in various seismic zones (Zone III, Zone IV and Zone V)the models of G+15 storey RC bare frame building is considered. These models are analyzed using ETABS software.To study the difference in behaviour of the models under three seismic zones and comparison is made on base shear, storey drift, storey displacement and storey stiffness.It was concluded that as the seismicity of the building increases care should be taken by the structural engineers to counter the seismic energy and to safe guard the building.

15. BurakYön, Mehmet EminÖncü **"Effects of seismic zones and site conditions on response of RC buildings"** (2015). The effect of seismic zones and local soil conditions given in Turkish Seismic Code are used to study nonlinear response of reinforced concrete buildings, assessed by using the distributed plastic hinge approach, is investigated in this paper.
Considering seismic zones and local soil conditions the Inter storey drifts, cross-sectional forces at the base of the building, and energy dissipation for selected hinges, were compared in this paper.

16. K. Shaiksha vali B. Ajitha **"Seismic Analysis in Tall Buildings for Hard Soil Type and Different Seismic Zones"** (2014). In this paper, An analytical study, on high-rise building of 35 stories, was carried considering different seismic zones and hard soil type.
The different bracing systems X-brace, Vbrace, inverted V or chevron brace and infills are introduced in these analytical models. These building models are analyzed, using SAP 2000 software.

17. Abhijeet Singh Tomar Dheeraj Sangtiani**"Study On The Behavior Of Building Under Different**

Soil Conditions" (2017). The behaviour of the building under soil condition as per the IS 1893:2002 (Part I), Using the ETABS 2016 v16.0.0. The analytical analysis was done under very severe seismic condition (zone 5) and static wind loads using IS 875:1989 (Part III). An attempt is made to compare the result from the same building subjected to change of soil condition.

It was observed that Base shear is more in the case of soft soil and less in the hard soil since because of liquefaction, shear strength is negligible in the case of the soft soil mostly.

Observations& Conclusion

1. By above collected journals we have made an effort to understand the effects of different seismic zones and soil types for a high rise structure.
2. As the seismicity of the building increases care should be taken by the structural engineers to counter the seismic energy and to safe guard the building.
3. With the change in soil property from hard to medium and from hard to soft the lateral deflection was increased.
4. In Seismic Zone - 2, 3 & 5 the values of maximum Shear forces & maximum bending moment are decreasing in hard soil strata when compared with soft soil strata & found the least for the same.
5. By referring to above collected journals we observe that most of the journals were based on modelling and analysis of either different seismic zones or soil types. But the combination of both seismic zones and soil types for a G+30 storey building using Etabswas not studied by any of the above mentioned journals.

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