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Analysis and Comparison of High Rise Building (G+40) Subjected to Combined Effect of Earthquake and Wind Load using ETAB Software

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***Abstract*– A long-lasting high rise structure might be subject to one or more serious risks. According to the governing load situation, specifications have historically considered the various severe threats separately. As a result, it is difficult to predict how well high rise structures according to the present rules would withstand the combined threat of earthquake and wind. This paper presents Analysis and comparison of (G+40) high rise building subjected to combined effect of earthquake and wind load using ETAB software. Modern tall structures are more thin and flexible with minimal damping because they have effective structural systems and use high-strength materials, which results in a reduction in building height. These flexible structures are extremely sensitive to earthquake stress and wind excitation, which is uncomfortable for the building's inhabitants. As a result, several investigations and studies have been carried out in order to reduce such an excitation and enhance the resistance of tall buildings to wind loads and earthquake loads. Numerical results indicate that lateral force, storey shear, storey drift, storey displacement, overturning moment and contributions of each hazard circumstances are sensitive to damage severity.**

Key Words: Seismic effect, wind effect, story displacement and story drift.

I. INTRODUCTION

In the 1880s, the United States built its first high-rise skyscrapers. They arose in metropolitan region when rising land prices and high population densities prompted a need for building that grew vertically rather than horizontally, taking up less valuable land. Steel structure frame and glass external cladding allowed for the construction of commonplace in most countries' architectural landscape. High-rise building foundations are frequently made out of concrete piers, or caissons that are lowered into the earth to withstand very severe gravity loads. The best basis is solid rock, but even on relatively soft ground, there are techniques to distribute loads uniformly. The necessity for high-rise building to withstand lateral stresses imposed by wind and potential earthquake is, never the less, the most significant consideration in their construction. Steel and concrete frameworks are used in most high-rise structures.

High-rise structures are those that are latter 23 meters (75 feet) or have seven to ten stories. As the urban population grows, cities are expanding outwards, making essential services such as water supply, sewer collection, and other necessities more difficult to get. Therefore, an alternate answer to this problem is to develop vertically, that is, to construct high-rise buildings inside cities that are compact and concentrate the people of a wide area into a single structure.

II. LETERATURE REVIEW

Yashashri ankalkhope et.al (2021), They studied the analysis and design of a building using rectangular and circular column, they determine the parameters of all storey of a building moments, shear force, base reaction, storey stiffness, storey shear, overturning moment, storey displacement, storey drift and so on. Their study reveals that comparison of both analysis and design was carried out by software and manual calculation as per IS 456- 2000.

Gourav B N et al (2021), They studied the effects of soil type I for different seismic zones for a high rise building of (G+29) storeys using ETAB software and response spectrum analysis. The response spectrum is used to compare the behavior of the models in four seismic zones (Zones II, III, IV, and V), with base reaction, storey drift, time period and storey stiffness being used as criteria.

Nitin R Mule et.al (2020), Their study reveals that a multi hazard based methodology for assessing the damage risk of high rise buildings, When a multistory RC building is subjected to wind and earthquake hazards, variations in storey displacement at each floor occur, i.e. storey displacement does not increase with building height as compare to regular earthquake excitation. Building storey drift values with wind and seismic excitation grow with building height but drastically decrease at 14 storeys.

W Bourouaiah et al (2019), Their study reveals the research is to simulate the interaction between a concrete wall and the earth under seismic loading. Their study goal is to calibrate the impacts of soil characteristic's and soil-structure interaction on the structures seismic response. The findings reveal that soil conditions have a significant impact on a structures seismic behavior.

Shubham Borkar et.al (2019), They studied the analyse and design of (G+6) storey building in various seismic zones and soil types. Their study shows that because soil-I is a hard soil, the base reactions are low because the soil is harder and stronger than soil-II and soil-III. The storey drift values increase as the seismic zone factor increases.

Mindala Rohini et.al (2019), They carried out the seismic response of (G+15) storey residential building in zones III and V using response spectrum and time history methods in ETAB. The results show that zone V has a higher value of storey displacement than zone III. The storey shear is greatest at the ground in both response spectrum method and time history method. Zone V has a higher value than zone III.

Umamaheswara Rao Tallapalem et.al (2019), Their study reveals, when an earthquake hits a multi storey building in a populated region, it will inflict massive damage. In this work, (G+7) structure was modeled in Staad Pro and the earthquake analysis of the structure in different seismic zones (II, II, IV and V) of India was performed. The results show that base shear, displacements, support reactions, and steel quantities are zone factor dependent, hence these values are higher in zone V.

Jaiprakash et.al (2019), They studied the response spectrum method of analysis of a (G+30) storey reinforced concrete high rise building under wind and seismic loads. The results show that storey displacement is maximum at top storey and also observed that as the building height increase, lateral stiffness goes on decreases, storey drift is maximum at mid height of the building and goes on decreasing from mid height to roof level.

P Rajeswari et.al (2019), Their study reveals that an earthquake resistant construction by enterprise seismal investigation of the structure utilizing static equivalent technique of study.A (G+10) storey residential building plan is being proposed for this purpose. Displacement of building increases with increasing seismic zones and wind pressure. The majority of the storey drift occurred in the midsection of the building structure and it increases with increasing the seismic zone.

Nilesh F Ukey et.al (2019), Their study reveals that an overview of the effects of seismic and wind loading on (G+11) building. It concluded that seismic and wind stresses on multi storey buildings rise as building height increases. It discovered that seismic forces are less effective than wind forces for tall buildings because tall buildings are more flexible, but seismic forces are more effective for short buildings. Storey displacement is considerable at upper levels during seismic events, but negligible at top floor with wind forces.

Amir Hassan et al (2018), They studied the influence of soil condition beneath the isolated base of (G+12) storey building is investigated using ETAB software. The seismic performance of multi storey buildings is compared and examined using a systematic approach. The result shows that the values of base shear is proportional to the flexibility of the soil and the stiffness of the superstructure.

Gourav Sachdeva et al (2017), They studied the effect of different soil and seismic zones on varying height of framed structure. There are three varieties of soil: soft, medium, and hard with heights of 15m, 18m, 21m, and 24m, respectively, are evaluated and studied for maximum bending moment in hard soil strata are decreasing in comparison to soft soil strata in seismic zone II, III, and V, and the least for the same.

Md Mahmud azzad et.al (2015), Their study reveals that, the effect of building shape on wind and earthquake response. In the current study, three distinct building forms were studied, and a comparison of different building shapes against the influence of lateral loads due to wind and earthquake was presented. The investigation took into account the Bangladesh National Building Code (BNBC) of 2006. The results show that the design of the structure has a substantial effect on minimizing building drift.

OBJECTIVES OF THE PRESENT WORK

1. Analysis of High rise Building (G+40) by equivalent static method and response spectrum method for different soil types under various earthquake zones using ETAB software.
2. To model and compare the results obtained by both the methods.

III. METHODOLOGY

In the present work structural elements must be collected or assumed based on Indian standard codes (National building code) Building type, dimension, soil type, nature, and loads existing on the structure, such as dead, live, wind and other dynamic load data. The (G+40) storey high-rise structure is taken as the subject of this investigation.

A. BUILDING CONFIGURATION DETAILS

By assuming various values as per Indian standards codes (IS: 456 2000 and IS: 875 Part-1 and Part-2 1987), the construction details required for analysis are presented in Table 1.

Table 1: Details of the structural elements and live loads.

Type of Structural elements	R.C.C. framed
Nature of the building	Residential
Building dimension	30m * 30m
Base area	900 m^2
Total floors	41 (G+40)
Height of the building	132.0 m
Bottom floor height (GF)	4m
Similar floor height	3.2m
Grade of concrete	M_{30}
Grade of steel	HYSD 500
Column dimension	750mm * 750mm
Beam dimension	300mm * 600mm
Slab thickness	150mm
Live load on slab	3 kN/m^2
Floor finish load on slab	0.75 kN/m^2

B. PLAN AND ELEVATION OF THE BUILDING CONSIDERED FOR ANALYSIS

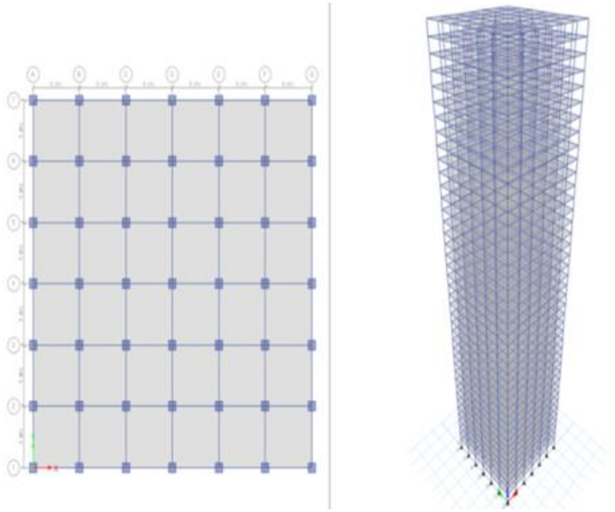

Fig. 1: *Plan and Elevation of building (G+40)*

IV. RESULTS AND DISCUSSION

In this chapter the analysis results of (G+40) storey high rise building by adopting both equivalent static and response spectrum method of analysis are reported and discussed.

1. EQUIVALENT STATIC METHOD OF ANALYSIS

a. Lateral forces

The analysis results of lateral forces for various soil types corresponding to different loads is shown in Fig. 2.

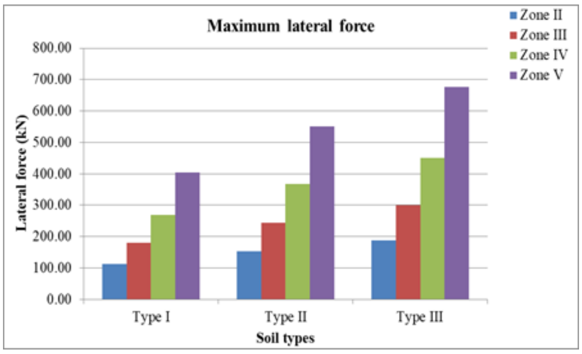

Fig. 2: *Graph of Soil types verses Lateral forces results for seismic zone II, III, IV, and V.*

Observations: From the Fig. 2, the maximum lateral forces increasing from soil type I to soil type III. The obtained value shows that maximum lateral force is at soil type III under different seismic zones.

b. Storey shear

The analysis results of storey shear for various soil types corresponding to different loads is shown in Fig. 3.

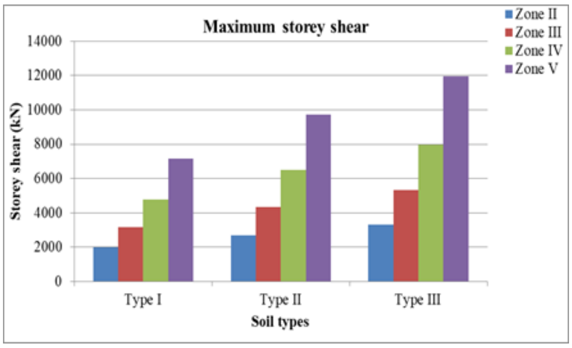

Fig. 3: *Graph of Soil types verses Storey shear results for seismic zone II, III, IV, and V.*

Observations: From above Fig. 3 shows that maximum storey shear is different seismic zones in soil type III and decreasing from different seismic zones in soil type I.

c. Storey drift

The analysis results of storey drift for various soil types corresponding to different loads is shown in Fig. 4.

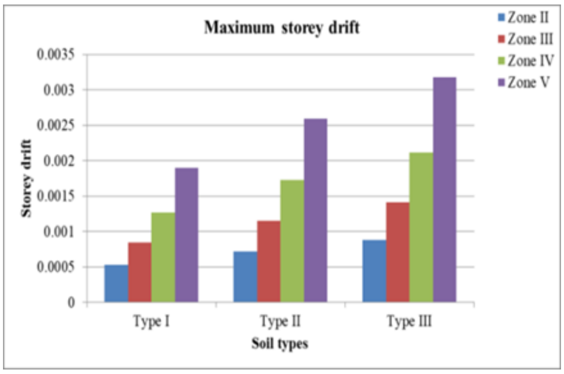

Fig. 4: *Graph of Soil types verses storey drift results for seismic zone II, III, IV, and V.*

Observations: From the Fig. 4, the maximum storey drift increasing from soil type I to soil type III. The storey drift results are well within the limitations as per Indian standard code IS 1893 (Part 1):2016.

d. Storey displacement

The analysis results of storey displacement for various soil types corresponding to different loads is shown in Fig. 5.

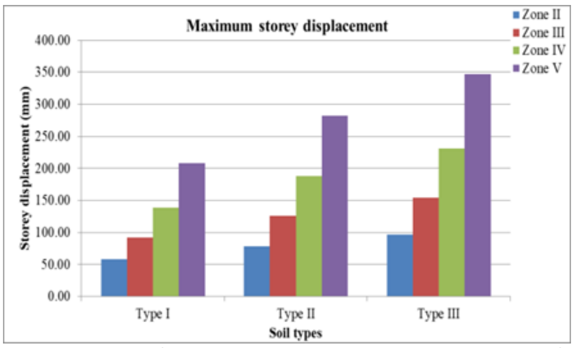

Fig. 5: *Graph of Soil types verses Storey displacement results for seismic zone II, III, IV, and V.*

Observations: From the Fig. 5, the maximum storey displacement increasing from soil type I to soil type III. The storey displacement value is within the limit of total height of

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the building by 500 (H/500).

e. Overturning moment

The analysis results of overturning moment for various soil types corresponding to different loads is shown in Fig. 6.\

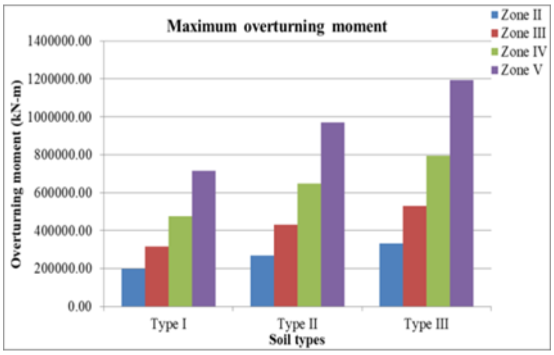

Fig. 6: *Graph of Soil types verses Overturning moment results for seismic zone II, III, IV, and V.*

Observations: From the Fig. 6, the maximum overturning moment increasing from soil type I to soil type III. The obtained value shows that maximum overturning moment is at soil type III under different seismic zones.

2. RESPON SESPECTRUM METHOD

The analysis results for the (G+40) storey high rise building for different soil type subjected to various earthquake zones are reported as follows.

a. Storey shear

The analysis results of storey shear for various soil types corresponding to different loads is shown in Fig. 7.

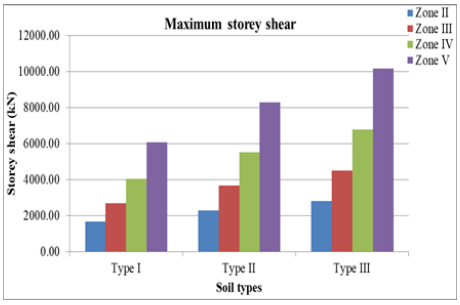

Fig. 7: *Graph of Soil type verses Storey shear results for seismic zone II, III, IV, and V.*

Observations: : From the Fig. 7, the maximum storey shear increasing from soil type I to soil type III. The obtained value shows that maximum storey shear is at soil type III under different seismic zones.

b. Storey drift

The analysis results of storey drift for various soil types corresponding to different loads is shown in Fig. 8.

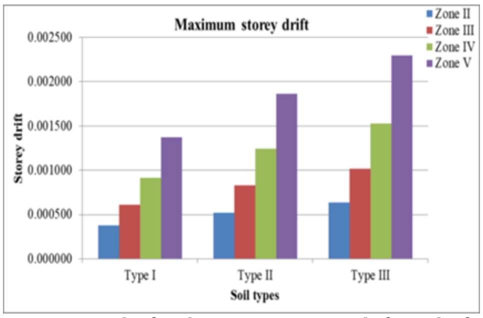

Fig. 8: *Graph of Soil type verses Storey drift results for seismic zone II, III, IV, and V.*

Observations: From the Fig. 8, the maximum storey drift increasing from soil type I to soil type III. The storey drift results are well within the limitations stated in Indian standard code IS 1893 (Part 1):2016.

c. Storey displacement

The analysis results of storey displacement for various soil types corresponding to different loads is shown in Fig. 9.

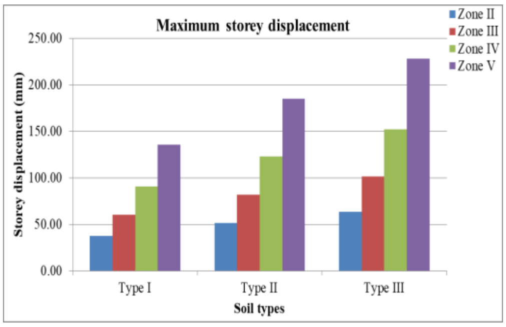

Fig. 9: *Graph of Soil type verses Storey displacement results for seismic zone II, III, IV, and V.*

Observations: From the Fig. 9, the maximum storey displacement increasing from soil type I to soil type III. The plotted value shows that maximum storey displacement is at soil type III under different seismic zones.

d. Overturning moment

The analysis results of overturning moment for various soil types corresponding to different loads is shown in Fig. 10.

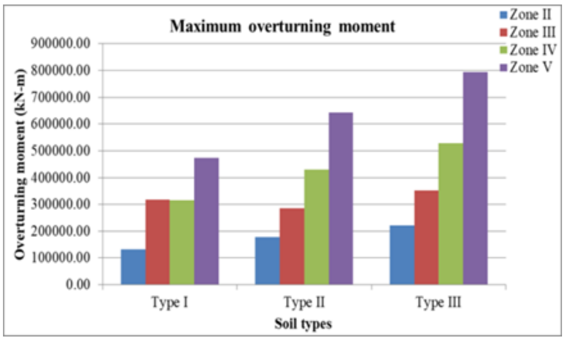

Fig. 10: *Graph of Soil type verses Overturning moment results for seismic zone II, III, IV, and V.*

Observations: From the Fig. 10, the maximum overturning moment increasing from soil type I to soil type III. The obtained value shows that maximum overturning moment is at soil type III under different seismic zones.

V. CONCLUSIONS

The important conclusions are drawn on the bases of present investigation

1) The response of structures subjected to various seismic zones in soil type I and III, the optimum responses of all the five parameters are seen to be higher by around 40-45%.

2) The storey shear of seismic zone V is higher than 72.2%, 55.55%, and 33.33% as compared to zones II, III, and IV respectively.

3) The storey drift of seismic zone V is higher than 3.6, 2.25, and 1.5 times higher than the zones II, III and IV respectively.

4) The storey displacement of seismic zone V is higher than 3.6, 2.25, and 1.5 times higher than the zones II, III, and IV respectively.

5) The overturning moment of seismic zone V is higher than 72.22%, 55.55%, and 33.33 % as compare to zones II, III, and V respectively.

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