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Article

Effect of Soil Classification on the Seismic Response of a 20-Story Building Using ETABS

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Abstract: Soils have varying properties in different locations, thus requiring them to be considered in structural engineering. The present study evaluates the effects of soil conditions on the structural behavior of a 20-story building with a frame structure design, categorized into various types of soils based on the American Code. Soil effect on shear forces, lateral displacement, and column forces was assessed. The findings show that soil conditions affect the structural response, since there are huge differences of up to 100% in shear forces in stiff and soft soils. Additionally, shear forces showed increasing trends as soil conditions went from stiff to soft.

Keywords: Soil , Base Shear; High-Rise Buildings; ETABS Software.

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1. Introduction

A reliable foundation is an indispensable condition to ensure stability and structural safety of any structure, especially when building heights increase. The growing demand for land resources efficient use encourages the development of high-rise constructions, for which it is vital to analyze the interrelation of the structural systems with foundation and soil conditions [1]. Different properties of soils affect the response of buildings subjected to loading, as changes in stiffness of soil layers and their supporting conditions can cause alterations in internal forces values in structural components depending on the particular type of structural system used – moment frames, shear walls, hybrid systems [2]. Axial force, shear force, and bending moment values may be increased or decreased depending on soil properties; the type of internal forces can change from compression to tension and vice versa. Thus, it is necessary to examine the effect of different soil types on the structural behavior of high-rise structures. This study focuses on the analysis of structural system responses to different soil types and the evaluation of the difference in internal forces values [3-7].

Aim of the research:

The aim of the current research is to study the effect of varying soil types beneath a structure on the forces generated within the building.

2. Methodology of the research

This paper aims at studying the effect of soil classification on the structural behavior of a conceptual 20-storey building in Iraq. Dead alivnd e load effects on the building are considered, and the seismic effects on it are analyzed through response spectrum approach. The building is designed with frame structure system, and numerical modeling and analysis is conducted using ETABS 2016 software. The major concern in this study lies in the effect of different soil types on the forces generated in the structural system. Five

numerical models are created considering the soil classifications provided in the Uniform Building Code (UBC 1997), which are soil type SA, SB, SC, SD and SE [8].



Building model:

The building under analysis is a hypothetical structure that has a square layout with the size of 25 m × 25 m. The structural system includes six rows of columns in both directions, having six columns in each row. The size of the supporting columns is 60 cm × 80 cm, whereas the slab with ribs has the thickness of 33 cm. Concrete with the characteristic compressive strength of 300 kg/cm² (about 29.4 MPa) is used in the structural components. This set of geometrical and physical characteristics is taken as a basis for modeling and analyzing the structure [9,10]. As n fig 1

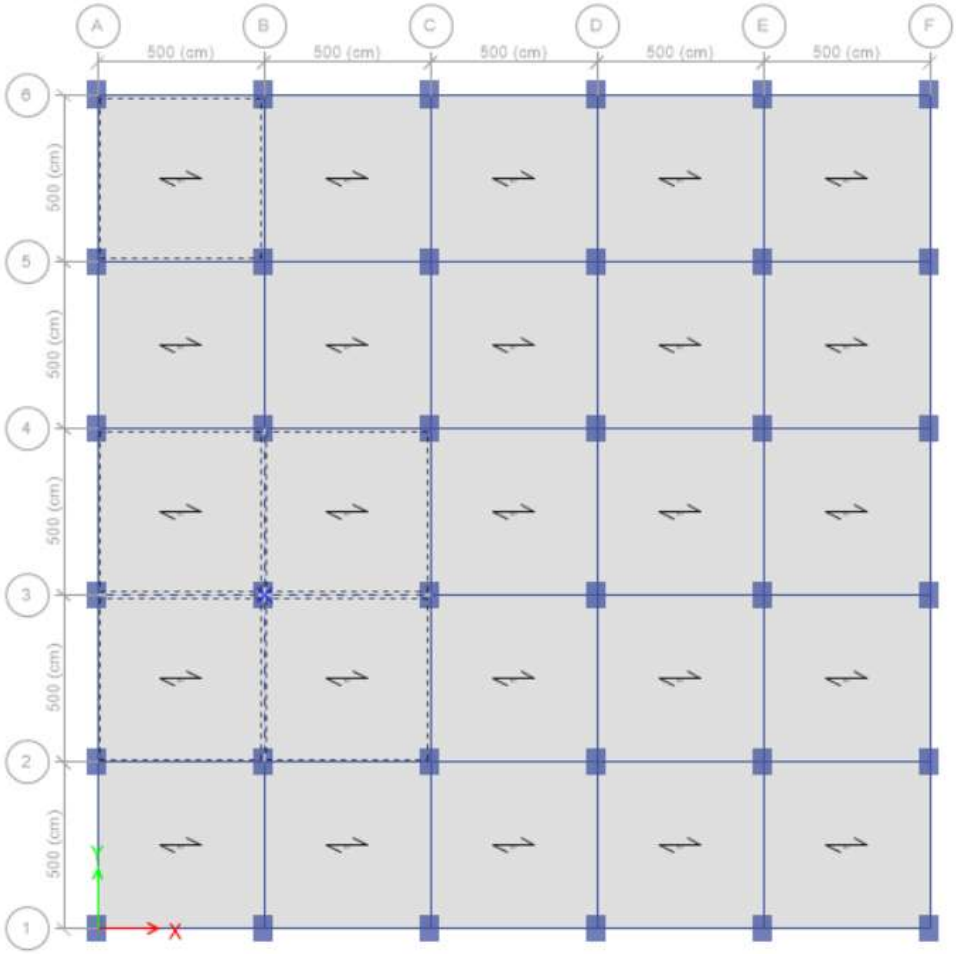


Figure 1. Model Plane

The structure has been tested against two kinds of applied loads: one dead load of 300 kg/m² and one live load of 200 kg/m², apart from the weight of the structural members that is automatically included while analyzing the structure through ETABS software. The model has been created via ETABS software and prepared for structural analysis based on the inclusion of dead, live, and response spectrum loads. This method of modeling has been chosen to test the behavior of the structure based on different soil conditions, mainly

considering the variation in the internal forces and displacements due to the type of soil chosen for the study [10]. As in fig

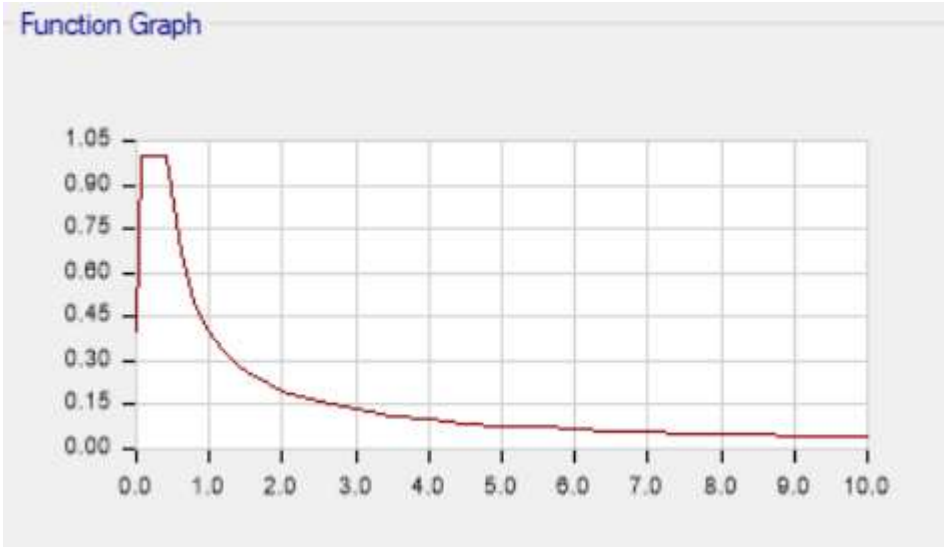


Figure 2. Response Spectrum

3. Results and Discussions

The findings from the structural analysis are utilized for the purpose of comparing the five numerical models in graphical form along with numerical values. Comparison will be made in terms of the obtained base shear value, lateral displacement at the top story level, and the maximum tensile and compressive forces in the columns. The aim of this comparison is to see how the soil classification influences the structural behavior and internal forces. The structural model obtained through the use of ETABS 2016 is presented in the figure below [11,12]. As in fig 4

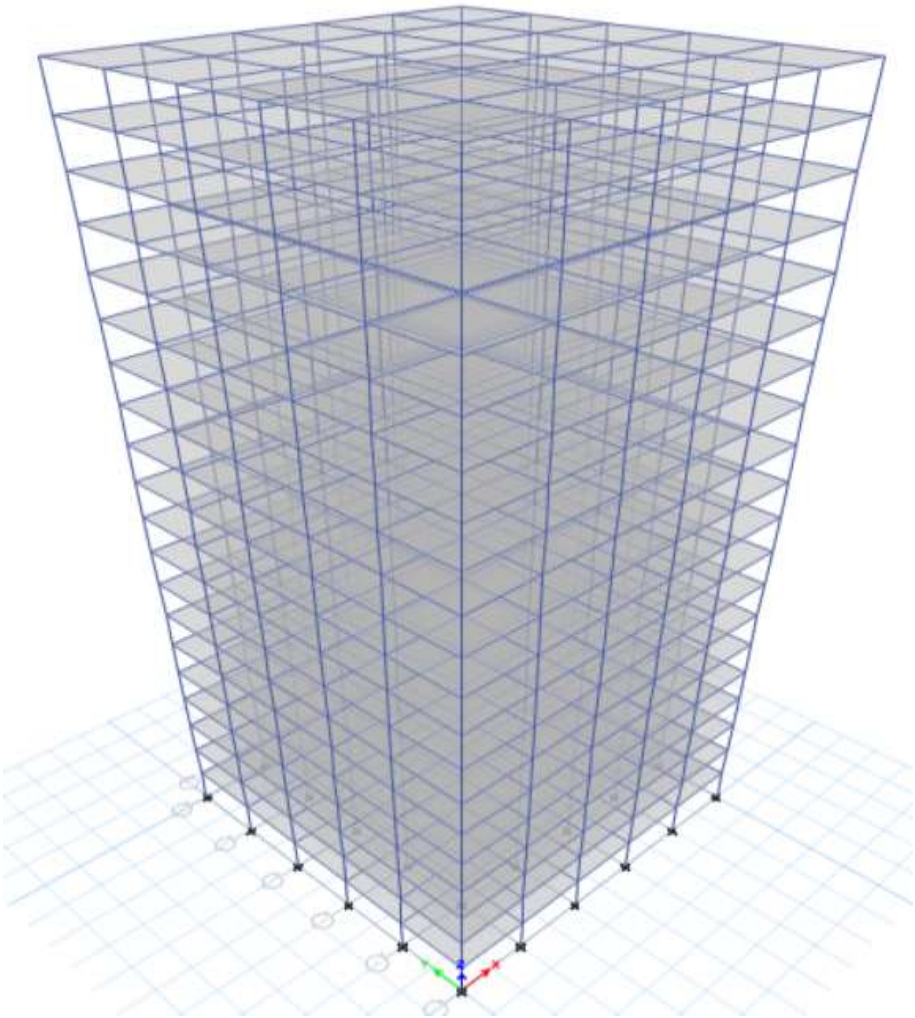


Figure 3. Model

Shear Force:

The following figure demonstrates the difference in shear force under static loading with respect to the change in soil classification from Class I, through Class II, to Class III. The findings show an incremental rise in shear force with the upgrading of soil class, since it correlates with a decrease in soil strength and rigidity. It rises significantly, up to about 100%, when moving from soil class I to soil class III. Nonetheless, the values of shear force measured for soil class II and soil class III are almost equal, meaning no differences in structural behavior with regard to these two soil conditions [13]. As in fig 5

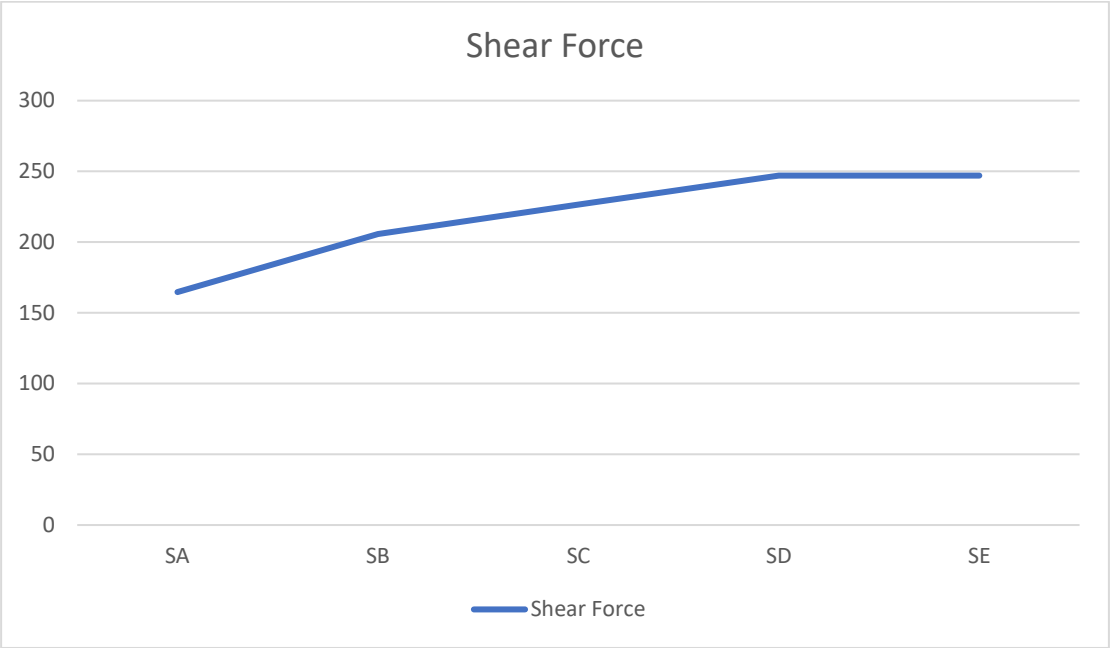


Figure 5. Effect of Soil Classification on Shear Force under Static Loading

MAX Moment in Column

The diagram below depicts the changes in the bending moment acting on the footings of the first floor columns under static loads depending on the change in soil classifications from Class I to Class II and finally to Class III. From the results obtained above, it can be observed that there is an increase in the bending moment as soil class increases, which is associated with a decrease in the bearing capacity and stiffness of the soil. The increase in bending moment is quite large, going up to almost 50% when going from Class I to Class III soil . as in fig 6

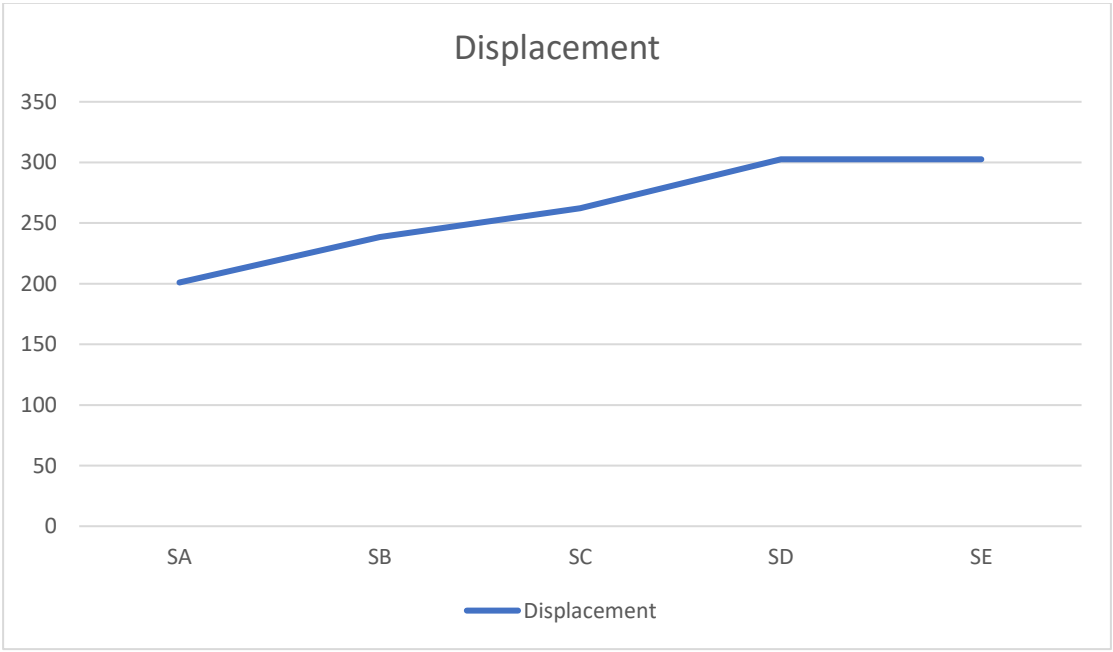


Figure 6. Variation in Bending Moment with Soil Classification under Static Loading.

Max Displacement

The following diagram represents the change in lateral displacement with respect to static loading as the soil type changes from Class I to Class II and then to Class III. The findings show that the lateral displacement on top of the building structure increases with an increase in the soil type, which signifies a decrease in soil bearing capacity and stiffness. This is notable, with an increase of about 25% between the first and third soil types. It should be noted, however, that the lateral displacement values for the second and third soil types are the same, indicating that there is no increase in displacement between the two soil types [15].

In addition, it was found that there was a consistent relationship among the models with regard to the weight of the structure and loads produced by it. As in fig 7

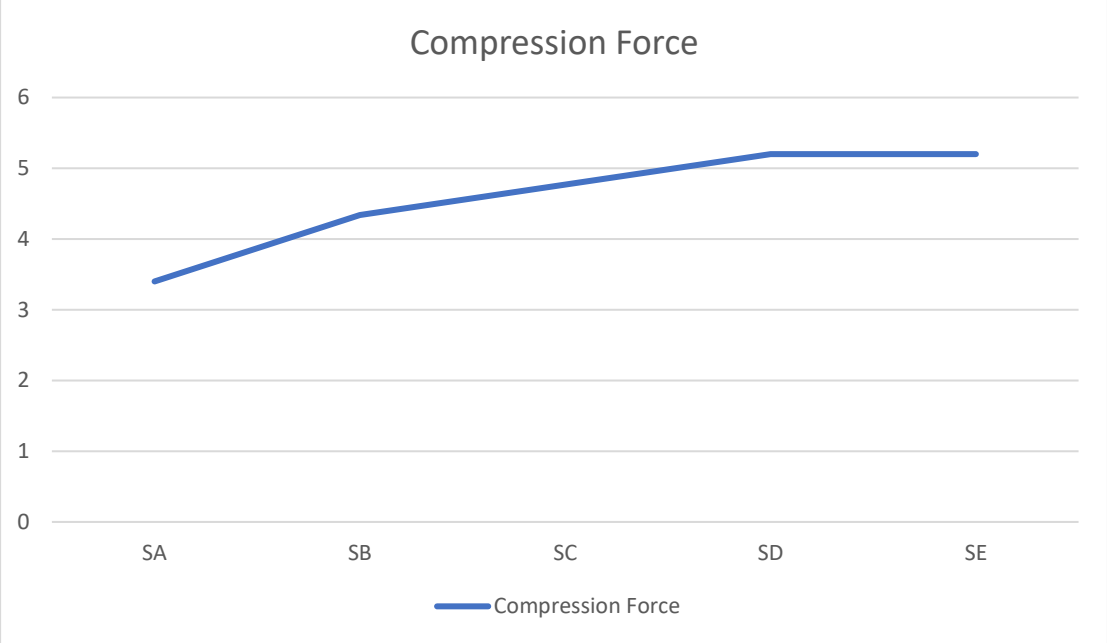


Figure 7. Effect of Soil Classification on the Lateral Displacement of the Building under Static Loading.

4. Conclusion

The current research explored the effects of soil conditions on the response of a regular 20-story structure subjected to seismic loadings through ETABS software. The five models corresponding to the various soil classes were evaluated. It was found out that the soil properties had a noticeable impact on the structure's response. The base shear force nearly doubled in the case of transitioning the soil from the stiff class to the soft one. It means that the demand for seismic force would greatly increase for the structure. Also, the bending moments in column bases and the lateral displacement of the top of the building increased by about 50% and 25%, respectively, due to the decrease of soil stiffness. Nevertheless, the soil classes SD and SE did not have any significant differences in their responses to the applied loads.

Considering the results, the additional analysis of the structure is suggested. It is necessary to perform some other methods of investigation, such as nonlinear and dynamic analysis, including nonlinear time history analysis and pushover analysis.

REFERENCES

[1] ASCE/SEI 7-22, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*. Reston, VA, USA: American Society of Civil Engineers, 2022.

[2] C. Bolisetti, A. S. Whittaker, and H. B. Mason, "Soil-structure interaction effects in nuclear and conventional structures considering non-linear site response," *Earthquake Engineering & Structural Dynamics*, vol. 47, no. 4, pp. 980–998, 2018.

[3] A. D. Keçeli, "Allowable bearing pressure in soils and rocks through seismic wave velocities," *Earth Sciences Research Journal*, vol. 16, no. 1, pp. 127–134, 2012.

[4] X. Lu et al., "Effects of soil–structure interaction on the seismic response of high-rise structures under long-period ground motions," *Buildings*, vol. 14, no. 12, Art. no. 3796, 2024.

[5] G. Mylonakis and G. Gazetas, "Seismic soil-structure interaction: Beneficial or detrimental?" *Journal of Earthquake Engineering*, vol. 4, no. 3, pp. 277–301, 2000.

[6] S. H. Tabatabaiefar, B. Fatahi, and B. Samali, "Seismic behavior of building frames considering soil-structure interaction," *International Journal of Geomechanics*, vol. 13, no. 4, pp. 409–419, 2013.

[7] National Institute of Standards and Technology (NIST), *Soil-Structure Interaction for Building Structures*, NIST GCR 12-917-21, Gaithersburg, MD, USA, 2012.

[8] Federal Emergency Management Agency (FEMA), *NEHRP Recommended Seismic Provisions for New Buildings and Other Structures*, FEMA P-750, Washington, DC, USA, 2009.

[9] A. Kukwas et al., "A review on seismic analysis of tall building (G+10)," *Advances in Sustainable Construction Materials*, vol. 2759, no. 1, Art. no. 050010, 2023.

[10] M. Harati and J. W. van de Lindt, "Impact of long-duration earthquakes on successive earthquake-tsunami fragilities for reinforced concrete frame archetypes," *Journal of Structural Engineering*, vol. 150, no. 7, 2024.

[11] C. Zhai, W. Wen, Z. Chen, S. Li, and L. Xie, "Damage spectra of structures subjected to mainshock-aftershock sequences," *Earthquake Engineering & Structural Dynamics*, vol. 45, no. 4, pp. 631–650, 2016.

[12] S. L. Kramer, *Geotechnical Earthquake Engineering*. Upper Saddle River, NJ, USA: Prentice Hall, 1996.

[13] L. A. Qureshi, N. Nasiruddin, N. S. Janjua, and U. Rasool, "Seismic analysis and design of high rise buildings in different base profiles," in *New Developments in Structural Engineering and Construction*, pp. 1–7, 2013.

[14] A. C. Suryawanshi and V. M. Bogar, "Seismic analysis of building resting on sloping ground with soil structure interaction," *International Journal for Research in Applied Science and Engineering Technology*, vol. 6, no. 7, pp. 2135–2149, 2019.

[15] W. Azzam, B. Eltaly, A. Elsobky, and T. El-shenrawy, "Geotechnical impact of outrigger-induced lateral response in tall buildings: A numerical study," *Water Science*, vol. 40, no. 1, p. 36, 2026.