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A Review on Comparative Analysis of Raft Foundation, Raft with Drop & Pile Raft Foundation

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Abstract - *The study conducts a comprehensive comparative analysis of three distinct foundation systems: Raft Foundation, Raft with Drop, and Pile Raft Foundation. Employing advanced structural analysis and design software, the research aims to gain insights into the structural and geotechnical behavior of these foundation systems. Various loading scenarios and soil profiles are considered to assess their performance comprehensively. The analysis involves crucial factors such as load distribution, stress concentrations, and overall structural performance, utilizing the finite element analysis capabilities of CSI SAFE software. This sophisticated software is instrumental in modeling bearing capacity, settlement features, and the interaction between the foundation and soil, providing a holistic understanding of the geotechnical elements involved.*

Key Words: **Foundation Design, Raft Foundation, Pile Raft foundation, Raft with Drop, Structural Design, Seismic Load, CSI SAFE, Etabs.**

1. INTRODUCTION

The choice of a suitable foundation system for high-rise buildings is a crucial factor in determining their stability and resilience in the dynamic field of structural engineering. A deeper comprehension of foundation design is more and more important as urban landscapes, marked by an increasing demand for vertical development, continue to change. Using ETABS and CSI SAFE Software, this study aims to conduct a thorough investigation into the Comparative Analysis of Raft Foundation, Raft with Drop, and Pile Raft Foundation. The main objective is to carefully examine and make relevant comparisons between these three different foundation systems' geotechnical response and structural performance in the context of high-rise buildings. By utilizing cutting-edge engineering software, ETABS for structural analysis and design and CSI SAFE for thorough foundation modelling, this research aims to investigate the complex interactions between these foundations under the combined effects of different seismic zones and different soil types.

The main focus is on deciphering the intricate dynamics of how various foundation types respond to seismic forces and accommodate the various soil profiles typical of various geographic locations. It is anticipated that the results of this comparative analysis will offer practitioners and stakeholders priceless insights, enabling educated decision-making in the selection of foundation systems catered to the particular difficulties presented by various seismic zones and soil types. The ultimate goal of this research is to make a valuable contribution to the continuous improvement of foundation design techniques, which will protect high-rise buildings' structural integrity and long-term resilience in a variety of dynamic urban environments.

The use of ETABS for structural analysis and design suggests a commitment to utilizing cutting-edge computational power to examine and enhance the structural components of tall structures. This entails evaluating how the structure reacts to different loads, making sure it complies with safety regulations, and maximizing its overall effectiveness. In-depth foundation modelling is done concurrently with the use of CSI SAFE software, highlighting the crucial part that foundations play in the structural integrity of tall buildings.

Essentially, this study adds to the current discussion on high-rise building foundation systems and demonstrates the use of cutting-edge engineering instruments to carry out an exhaustive analysis. It is anticipated that the results will influence and direct structural engineering decisions in the future, assisting in the creation of high-rise buildings that are safer and more resilient in the face of changing urban environments and seismic hazards.

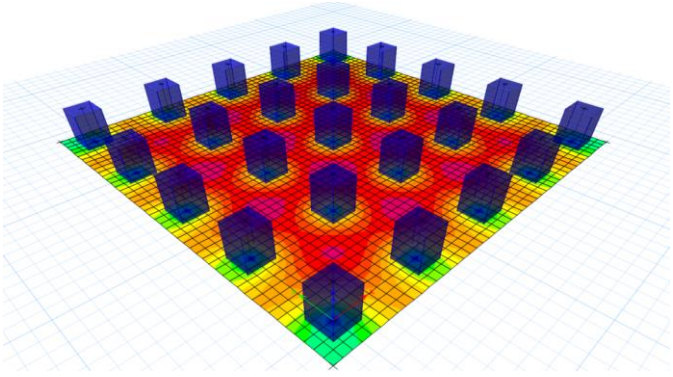

Figure 1: CSI SAFE Model of Raft Foundation

1.2 Objective

- To compare the Raft Foundation, Raft with Drop, and Pile Raft Foundation utilizing structural analysis and design software.
- To support ongoing advancements in high-rise building foundation design methodologies, guaranteeing long-term resilience and structural integrity in dynamic urban settings.
- To shed light on the relative merits and costs of various foundation designs, especially in regions with poor soil and big, heavy structures.
- To provide thorough understanding of different types of foundations, their advantages and disadvantages, suitable situations, and design construction.
- To research and evaluate the various kinds of foundations utilized in the building sector, as well as their designs and the application of alternative materials to improve their firmness, toughness, and environmental friendliness.
- To construct strong, affordable, and ecologically friendly foundation bases for bungalows and tall buildings alike.
- To examine elements like soil bearing capacity, settling, and seismic behaviour in relation to raft, pile, and piled raft foundations.

2. Literature Review

[1] Magar, J., Kudtarkar, A., Pachpohe, J., & Nagargoje, P. (2020). Study and analysis of types of foundation and design construction. IRJET, 7, 3301-3307.

The types of foundations used in the construction industry, their designs, and the use of substitute materials to improve their firmness, durability, and environmental friendliness are all covered in this paper. It highlights how crucial it is to build a solid foundation that will not collapse or deteriorate under any weather. For high-rise buildings and bungalows, different foundation types are utilized; each has a special configuration and design to improve stability and durability. The goal of the study is to create a foundation base that is resilient to natural disasters, economical, and environmentally friendly.

The study comes to the conclusion that various footing and foundation types have particular applications in particular regions and climates. It highlights how crucial it is to comprehend foundation work when performing construction-related tasks. The study emphasizes the necessity of building a solid foundation that is resistant to collapse and decay under all-weather circumstances. It talks about the different kinds of foundations used in the building sector, how they are designed, and how to use non-traditional materials to make them more sturdy, long-lasting, and environmentally friendly. In order to reduce the chance of a structure collapsing, the paper also stresses how crucial it is to use the right materials for the foundation. It offers details on the kinds of superstructures that require what kind of foundation, as well as appropriate materials and designs. The study's overall goal is to offer comprehensive and collective knowledge regarding the various kinds of foundations, their benefits and drawbacks, appropriate circumstances, and design construction.

[2] Srivastava, R. K. Structural Design of Raft Foundation For 30 story high rise building-A case study in Lucknow, Uttar Pradesh region, India.

The 30-story high-rise building's raft foundation's structural layout in Lucknow, Uttar Pradesh, India. The writers talk about the value of clever and affordable foundation systems for tall buildings in light of the limited availability of land in desirable areas, particularly in India's major cities. They stress the importance of the local soil and suggest a raft foundation on alluvial soil as a useful fix. To make sure the stresses are within the permitted bounds, the design considerations include examining the maximum axial load, soil pressure, and moments on the raft foundation. The application of geotechnical analysis and design principles for raft foundations in alluvial regions is also highlighted in the paper.

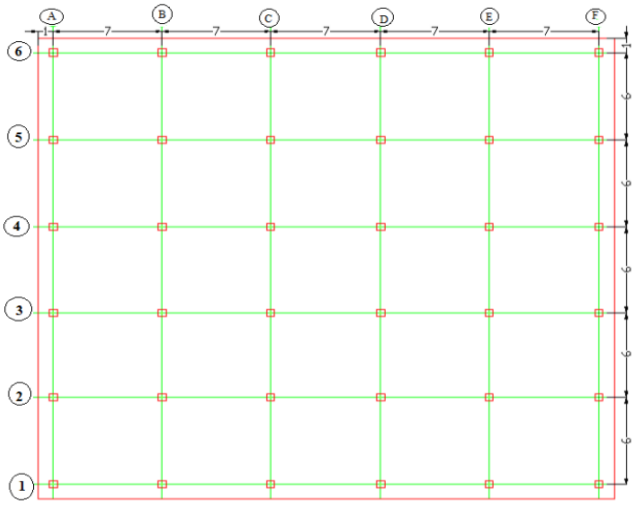

Figure 2: Raft Layout

Safety requirements were given when designing the Raft foundation in accordance with Indian Standards, taking into account the alluvial type of soil. This paper studies and applies the raft foundation design in relation to different geotechnical aspects that must be integrated into the final design. The entire raft is naturally sagging due to the bending moment caused by loose soil. But a tension zone forms as soil stiffness rises. The tension zone's extent and intensity increase as we move from the edge toward the center. But the effect is stronger in the X direction than the Y direction. The pressure distribution beneath the raft increases towards the center of loose soil, with the distribution being lower at the edge. It stays nearly constant in the central zone between

columns. The pressure distribution in medium soil is highest at the periphery and decreases very gradually towards the center. Pressure distribution in hard soil is high at the margins, decreases beneath the edge columns, and then rises in the center. There is less than 50 millimeters of settlement and punching shear factors are less than 1.

[3] Krishna, A. M., Teja, A. P., Bhattacharya, S., & Ghosh, B. Seismic Design of Pile Foundations for Different Ground Conditions. In 15 World Conferences on Earthquake Engineering, Lisboa 2012.

The importance of taking ground conditions into account during the design process is emphasized in this paper's discussion of the seismic design of pile foundations for various ground conditions. In addition to discussing design considerations based on various theories on pile foundation performance under seismic conditions, it presents the estimation of seismic loads for a multi-story building located in different seismic zones. The seismic design of pile foundations in accordance with Indian and European standards is demonstrated using two different ground conditions as examples.

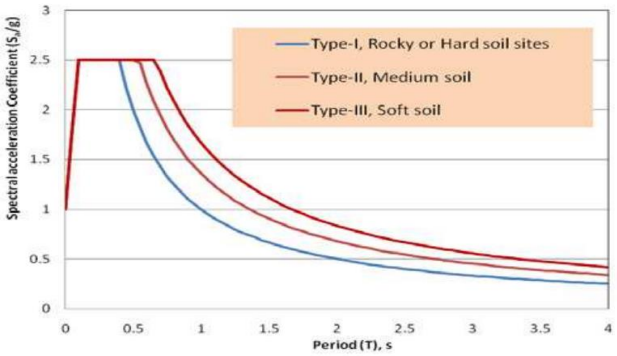

Figure 3: Response Spectra for Rock and Soil sites as per IS 1893 for five percent Damping

For different structures to function effectively under extreme seismic loading conditions, pile foundation seismic design is essential. The capacity of the foundation and the seismic loads transferred to it are largely dependent on the ground conditions, particularly the type of soil. The seismic design of pile foundations for various ground conditions is presented in the paper, taking European and Indian standards into consideration. It covers the estimation of seismic loads, theory-based design considerations, and offers examples of seismic design for various ground situations. The impact of liquefaction on pile design is also highlighted in the paper. It recommends ignoring the frictional resistance provided by the liquefiable layer's soil, building the pile as a column to prevent buckling, and taking liquefaction-related changes to the system's fixity point and natural period into account. The findings indicate that in order to achieve a factor of safety of 3.5 for a liquefiable soil layer, a driven cast in-situ, free-headed pile with a length of 18 m and a diameter of 0.95 m is advised.

[4] Azhar, S., Patidar, A., & Jaurker, S. (2020). Parametric Study of Piled Raft Foundation for High Rise Buildings. International Journal of Engineering Research & Technology, 9(12), 548-555.

By varying variables like raft thickness, pile diameter, pile length, and pile spacing, the study examines the behavior and performance of combined piled raft foundations. By altering these parameters, it seeks to comprehend changes in pile/raft load sharing ratios, differential settlement, maximum moment in the raft, and settlement. In order to prepare foundation models with various geometrical configurations in SAFE software, ETABS software is used to model and analyze a twenty-story building. The piled raft foundation's appropriate configuration and design are determined by a number of parameters, with the aid of the parametric study.

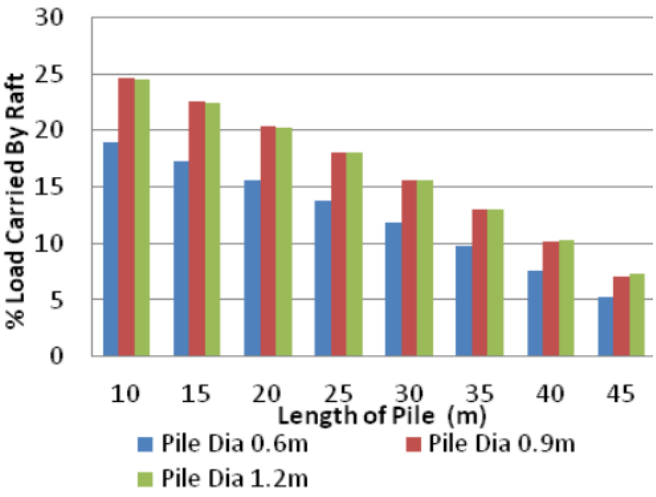

Figure 4: Effect of pile length on load carried by raft

Maximum pressure, settlement and differential settlement reduces only up to a limit with increasing raft thickness. Following that, there are no real benefits to thickening the raft. Instead, there is an increase in maximal moment. The need for steel may rise along with the thickness of the raft, creating parts that are not cost-effective. A clear decrease in the load supported by the raft occurs as the pile diameter increases. Greater diameter of the piles lowers differential, maximum pressure, and settling. As the pile diameter is increased past a certain point, there is virtually little decrease in these values. Therefore, the expense of a larger diameter will be more than the benefits. There is an increase in maximum pressure, differential settling, and settlement with increasing pile spacing. For every pile diameter taken into consideration, the resulting curves are quite similar. In order to cut costs, a smaller diameter must be chosen. As pile length increases, settlements and the maximum pressure beneath the raft diminish. Although the weight borne by the pile group increases as pile length grows, this increase is not as

important as the additional costs associated with longer piles. Although piled raft foundations are a superior way to manage settlements, for these foundation systems to perform at their best, the most cost-effective and ideal geometrical arrangement must be used.

[5] Dhage, A., & Solanke, S. S. (2023, June). Comparative Analysis of Raft, Pile & Piled Raft Foundation using Designing Software. In IOP Conference Series: Earth and Environmental Science (Vol. 1193, No. 1, p. 012006). IOP Publishing)

The paper compares the performance of raft, pile, and piled raft foundations using structural software, specifically for a G+20 residential structure. It analyzes factors such as seismic behavior, soil carrying load, and settling to determine the effectiveness of each foundation type. The study aims to provide insights into the effectiveness and cost-effectiveness of different foundation types, particularly in areas with weak soil and large, heavy structures.

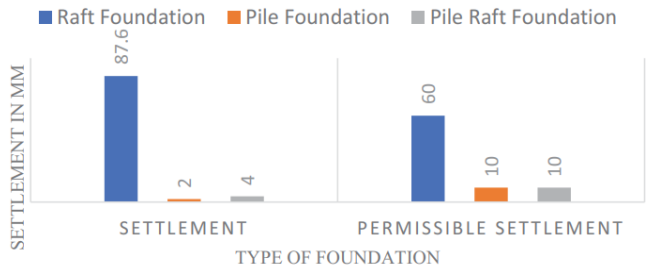

Figure 5: Settlement of Foundation

The piled raft foundation was found to have less upward soil carrying load and settling compared to the raft foundation, making it a more suitable option for areas with weak soil and large, heavy structures. The pile foundation was found to fail in punching shear, while the raft foundation failed in settlement conditions, exceeding the permissible limits. The settlement of the piled raft foundation was found to be below the permissible limits, indicating its stability. The soil upward pressure was reduced in foundations with piles, with the raft primarily governing the settlement of the structure in the soil. The piled raft foundation demonstrated lower soil pressure and punching shear values compared to the pile foundation, making it a safer option.

3. CONCLUSIONS

Through the use of software such as ETABS and CSI SAFE based research above, the study on different types of foundations such as raft foundation, pile foundation, pile raft foundation, and raft foundation with drop performance on different types of soil type and different types of Indian seismic zone, it is concluded that,

- The study's conclusion, which highlights the need of comprehending foundation work in building, states that different footing and foundation types have unique applications in distinct places and climates. It emphasizes how important it is to construct a sturdy foundation that will not collapse or deteriorate in any type of weather, and it provides information on different foundation types, designs, and the use of unconventional materials. The importance of choosing the proper materials for foundations is emphasized in the article, which also offers information on superstructures, suitable materials, and designs to lower the danger of structural collapse.

- The section on the Raft foundation in respect to Indian Standards emphasizes the need for safety and covers the design's geotechnical elements. It examines the tension zone that develops when soil stiffness rises as well as the raft's overall sagging caused by loose soil. Factors related to settlement and punching shear are described, as well as changes in pressure distribution in various soil types.

- The seismic design of pile foundations under extreme seismic loading circumstances is covered in the next section. It highlights how foundation capacity and seismic loads are dependent on ground conditions, especially soil kinds. The impact of liquefaction on pile design is one of the several ground conditions that are covered in the article on earthquake design. It offers precise instructions for obtaining a factor of safety in liquefiable soil layers and suggests countermeasures to liquefaction effects.

- The performance of raft, stacked and piled raft foundations is compared in the final section. It implies that stacked raft foundations offer higher stability, lower soil pressure, and reduced punching shear values compared to pile foundations. Large constructions and poor soil are thought to be more suited for the stacked raft foundation, which has a smaller settlement and soil-carrying load and is hence a safer and more cost-effective choice.

- In summary, the study provides comprehensive insights into different foundation types, their applications, design considerations, and safety measures. The comparison of raft, pile, and piled raft foundations suggests that the latter is a preferable option in terms of stability, soil pressure, and punching shear values.

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