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Evaluating Pile Bearing Capacity Through Integration of Laboratory Testing and Empirical Correlations

Shubham Gupta*, Vaibhav Singh**, Dr. Chinar Garg**
**(Department of Civil Engineering, SVVV Indore, Indore (M.P.)*
Email: shubham.geotech@gmail.com
*** (Department of Civil Engineering, SVVV Indore, Indore (M.P.)*
Email: vaibhav.singh740@gmail.com
*** (Department of Civil Engineering, SVVV Indore, Indore (M.P.)*
Email: chinaragrawal@gmail.com

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ABSTRACT
This study presents a comprehensive analysis of pile bearing capacity assessment using three distinct methodologies: laboratory testing, the N.V. Nayak method, and the Stroud correlation. The study aims to provide a detailed comparison of these approaches to determine their accuracy and reliability in predicting pile bearing capacity. Laboratory testing involves direct measurement of soil properties and pile behavior under controlled conditions, offering high precision in the evaluation process. The N.V. Nayak method, an empirical approach, provides practical and widely-used guidelines for assessing pile capacity based on soil parameters and pile dimensions. The Stroud correlation, another empirical method, utilizes standard penetration test (SPT) results to estimate pile bearing capacity. By applying these three methods to a series of test piles, the research evaluates the consistency and accuracy of each approach. Comparative analysis highlights the strengths and limitations of laboratory testing, the N.V. Nayak method, and the Stroud correlation, offering insights into their applicability in various geotechnical scenarios. The findings aim to guide engineers in selecting the most appropriate method for accurate pile bearing capacity assessment, ultimately contributing to safer and more efficient foundation design in construction projects.

***Keywords* -** Seismic Performance, Re-entrant Corners, RC Structures, Bracing Systems, Structural Irregularities

I. INTRODUCTION

The evaluation of pile bearing capacity through the integration of laboratory testing and empirical correlations is crucial in geotechnical projects. Calculating pile load carrying capacity using both laboratory methods and empirical methods is crucial for the success and safety of construction projects. Laboratory methods provide precise measurements of soil properties under controlled conditions, offering high accuracy in determining the pile capacity. This method allows for a detailed understanding of the soil's behavior, ensuring that the calculated pile capacity reflects the true interaction between the soil and the pile. Such precision is essential for designing foundations in complex or challenging ground conditions, where accurate data is vital for preventing structural failures. Empirical methods, on the other hand, are based on extensive historical data and field observations. These methods provide practical and quick estimates of pile capacity, validated by past performance and adapted to various soil conditions. Empirical correlations are especially useful during the preliminary design stages or when rapid assessments are needed, saving time and resources. They offer a broader context for understanding the pile's performance, which can be invaluable for regions with well-documented geotechnical data. Laboratory methods offer site-specific data, while empirical methods provide generalized solutions that can be tailored to local conditions. This balance between precision and practicality ensures that resources are used efficiently, resulting in a cost-effective and safe foundation design. In conclusion, using both laboratory and empirical methods to calculate pile load carrying capacity is essential for achieving accurate, reliable, and economical engineering solutions. Various methods, such as dynamic tests on precast concrete piles using optimization algorithms [1], empirical methods like IS code, Meyerhof, and Bazaraa and Kurkur methods, and graphical methods such as Hansen's and Chin-Kondner's methods [2], are employed to predict bearing capacity. Additionally, the analysis of pile bearing capacity involves assessing soil conditions, mechanical properties, and dynamic load tests [3]. Field tests like the Standard Penetration Test (SPT) are commonly used to estimate bearing capacity, with different empirical equations yielding varying results based on the design method used [4] [5]. Integrating laboratory testing with empirical correlations provides a comprehensive approach to accurately determine pile bearing capacity in geotechnical projects. Evaluating pile bearing capacity involves various methods such as laboratory testing, N.V. Nayak method, and Stroud correlation [6] [7] [8]. The laboratory method includes analyzing soil conditions and mechanical properties to determine the pile's structural strength and soil resistance, crucial for stability. N.V. Nayak method focuses on correcting field N-SPT data to estimate pile bearing capacity, with a graphical approach simplifying the process and accelerating predictions. Stroud correlation establishes a relationship between dynamic load tests and static load tests to assess pile bearing capacity accurately. By integrating these methodologies, this study aims to elucidate the strengths and limitations of each approach, offering a holistic understanding of pile bearing capacity evaluation. The comparison highlights the variations in results derived from laboratory testing versus empirical correlations, underscoring the importance of selecting appropriate methods for specific geotechnical conditions. Through this integrative approach, the paper seeks to enhance the accuracy and reliability of pile bearing capacity assessments, contributing valuable insights for geotechnical engineers and practitioners in the field.

II. METHODOLOGY

The proposed research involves identifying locations and collecting samples from one borehole with a depth of 35.00 meters. These borehole samples are then tested in the laboratory to determine the soil's engineering properties, which are essential for selecting a suitable foundation. A pile foundation is chosen due to the load capacity requirements of the structure. The pile capacity is estimated using both laboratory test results and empirical correlations. The load-carrying capacities obtained from these two methods are compared, and the differences are calculated. Empirical correlations that show significant deviations from the laboratory test results are adjusted accordingly to be used effectively in the design process. From the borehole data provided by the agency it has been observed that sub soil consists of silty sand/ silty clay/ clayey silt strata in alternate layers of variable thickness. Site Location and study are shown in figure 3.2 and 3.3 respectively.

Figure 3.2 Site Location

In all boreholes, disturbed soil samples were collected at specified intervals and whenever there was a significant change in the stratum (or as otherwise specified). Undisturbed sampling was conducted in accordance with IS: 2132 – 1986.

Undisturbed soil samples (UDS) were obtained every 3.0 meters following the approved methodology and sampling schedule. Tests on the disturbed soil samples are conducted for soil classification purposes, while shear parameters are determined using undisturbed samples. These shear parameters are used to evaluate pile capacity based on the static formula outlined in IS: 2911 (Part-1/Sec-2): 2010 and the formula in IRC: 78-2014. In estimating the pile capacity, both cohesion and the angle of internal friction are taken into account. In cases where undisturbed soil samples are unavailable due to hard strata or the lengthy process of performing laboratory tests on each sample, designers may use correlations based on SPT N values to determine the shear strength parameters. The corelations used are defined by Narayan V Nayak and Stroud. Pile capacity is evaluated by using field and laboratory test results and by using empirical correlations and the results are discussed in further sections.

III. SCOPE OF STUDY

In this study for N V Nayak and Stroude's Co-relation 100% mobilization of parameters has been considered.

IV. RESULTS AND DISCUSSION

Selected bore hole consists of filled up soil up to 0.50 m followed by brownish non plastic silty sand to clayey silt up to 12.00 m followed by blackish to grayish non plastic silty sand with gravels up to 13.00 m followed by blackish to grayish silty clay up to 14.00m followed by yellowish to grayish high plastic silty clay up to 16.00 m followed by yellowish high to medium plastic silty clay up to 17.00 m followed by yellowish non plastic silty sand up to 18.00 m followed by yellowish high to medium to low plastic silty clay with sand up to 33.00 m followed by yellowish non plastic silty sand up to 33.50m followed by brownish non plastic silty sand with gravels up to 36.50 m. The pile capacity based on BH-136 is evaluated considering the actual laboratory test results.

Laboratory Test Results

The Skin friction obtained for the pile length of 26.00m is 4198.39kN and the end bearing is 2289.11kN. The skin friction and end bearing were added to give the ultimate bearing capacity of 6487.51kN. This Ultimate bearing capacity on using factor of safety of 2.50 gives the safe load carrying capacity of pile as 246.88 T.

N V Nayak Empirical Approach

By considering the empirical parameters mentioned in NV Nayak approach considering 100% mobilization of the parameters, the Skin friction obtained for the pile length of 26.00m is 4926.70kN and the end bearing is 2894.88kN. The safe load carrying capacity of pile obtained is 301.28 T.

Stroud's Empirical Approach

By using Stroud's approach considering 100% mobilization of the parameters the Skin friction obtained for the pile is 4492.85 kN and the end bearing is 2479.77 kN. The safe load carrying capacity of pile obtained is 266.66 T.

V. CONCLUSIONS

1. The ultimate bearing capacity of the pile, determined from laboratory tests, is 6487.51 kN, resulting in a safe load carrying capacity of 246.88 T when using a factor of safety of 2.50.
2. Applying the N V Nayak Empirical Approach with 100% mobilization of parameters, the ultimate bearing capacity (sum of skin friction and end bearing) is higher, leading to a safe load carrying capacity of 301.28 T, which is significantly more than the laboratory test result.
3. Using Stroud's approach with 100% mobilization of parameters results in a safe load carrying capacity of 266.66 T, which is intermediate between the laboratory test result and the N V Nayak Empirical Approach result.

Table 1. Summary of Pile Capacity Results

Bore Hole No.	Method	Skin Friction (kN)	End Bearing(kN)	Safe Bearing Capacity (T)	% change with Laboratory Results
136	Laboratory	4198	2289	247	0
	N V Nayak	4927	2895	301	22.03
	Stroud	4493	2480	267	8.01

4. The percentage change between Laboratory test and N V Nayak approach is found to be 22 and for laboratory test and Stroude's it is 8.
5. The variations in the calculated skin friction and end bearing values across different methods suggest that the choice of method significantly affects the predicted ultimate and safe load carrying capacities, highlighting the importance of selecting an appropriate approach based on specific project requirements and conditions.

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