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SOIL CHARACTERIZATION: INTEGRATING IN-SITU TEST, LABORATORY ANALYSIS, AND TERRAIN PARAMETERS

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This research introduces an innovative methodology for characterizing geotechnical parameters of soils, crucial for designing foundations for various structures. Rather than relying on general correlations from geotechnical books, the primary goal is to obtain specific characteristic values tailored to the study area. The methodology establishes correlations between in-situ tests and laboratory tests to determine soil parameters in the Valley of the Chillos. The Valley of the Chillos is a geographical region in the southeastern part of Quito, Ecuador. It falls within the administrative zone of Los Chillos in the Metropolitan District of Quito. The valley is surrounded by the inactive Ilaló volcano to the north and the Pasochoa, Antisana, and Lomas de Puengasí mountains to the south, east, and west, respectively. To achieve the research objective, soil samples were collected using the Standard Penetration Test (SPT) at depths ranging from 1 to 15 meters, following the ASTM D-1586 standard. Additionally, undisturbed soil samples from the thin-walled Shelby tube were obtained in the field and subsequently tested in the laboratory. These tests covered aspects such as natural moisture content, granulometric analysis, Unified Soil Classification System, classification, liquid limit, plasticity index, specific gravity, void ratio, and degree of saturation. The results from both field and laboratory tests will be used to calculate the load capacity of foundations specifically for characteristic soils in the Los Chillos Valley, considering their classifications.

Keywords: Geotechnical parameters, Foundations, SPT, USCS.

1 INTRODUCTION

In civil engineering, O'Neill *et al.* (2023) state that in the field of civil engineering, geotechnics plays a crucial role in the design of foundations for a wide range of structures, such as buildings, bridges, and roads, facilitating the efficient transmission of loads generated by internal and external forces to the ground, which in turn helps to ensure the stability and safety of structures. In particular, in-situ tests have proven to be a comprehensive and efficient source of information in geotechnical engineering studies. The Standard Penetration Test (SPT), as one of the oldest in-situ tests globally, the Standard Penetration Test (SPT), as described by Laouedj and Bouafia (2017), involves penetrating the soil at various depths using a sampling tool and repeated blows. Arafianto *et al.* (2021) argues that the Standard Penetration Test (SPT) has evolved as a complementary tool to laboratory tests, balancing practical application with the need to minimize unreliable information often present in investigations relying solely on controlled laboratory environments. Worldwide, SPT is a common and basic test due to its low cost and the lack of availability of more advanced tests. In-situ tests allow soil analysis in its natural environment without alterations, representing a more realistic version of soil behavior. Regardless of the analysis model, invasive techniques remain the most effective tool for obtaining geomechanical soil parameters with less uncertainty, as long as they are adapted to the site's geology, correlations of geotechnical parameters, and laboratory tests performed.

2 METHODOLOGY

In this research, a methodology based on correlations between in-situ tests and characteristic geotechnical parameters of soil in the Los Chillos Valley, Ecuador, is presented. This is achieved by obtaining soil samples using the Standard Penetration Test (SPT) in the field. The aim is to obtain values for moisture content, particle size analysis, classification according to the Unified Soil Classification System (USCS), and specific gravity, which are useful for calculating the bearing capacity of foundations. The developed methodology is presented as a significant contribution to obtaining reproducible and reliable soil mechanics parameters, aligned with the dynamic behavior of soil morphology.

3 OBJECTIVE

Through the implementation of the SPT field test and laboratory tests, including USCS classification, moisture determination, and specific weight, correlations are sought to establish reliable parameters for the soils of the Los Chillos Valley.

4 THEORY REVIEW

Geotechnical characterization of soils is an essential component in the design of foundations and structures, with its importance lying in the need to understand soil behavior under applied loads. In the context of the Los Chillos Valley, Ecuador, obtaining accurate geotechnical parameters is crucial to ensure the safety and efficiency of structures in this seismically active region. This review focuses on the key elements constituting the proposed methodology for obtaining geotechnical parameters through Standard Penetration Test (SPT) field tests, laboratory tests, and the consideration of characteristic terrain geotechnical parameters.

4.1 Standard Penetration Test (SPT)

Lunne *et al.* (1997) demonstrated the effectiveness of the SPT, a widely used procedure for assessing soil resistance and obtaining critical geotechnical data. This test involves measuring the number of blows required for a rod to penetrate the soil to a specified depth. Previous studies have utilized the SPT to obtain geotechnical parameters, such as undrained shear strength and internal friction angle. Additionally, research conducted in geotechnically similar areas supports the utility of this test in soil characterization (Eslami and Taiebat 2013).

4.2 Undisturbed Sampling with Shelby Tubes

Diniz *et al.* (2017) emphasize the importance of obtaining undisturbed soil samples for accurately determining properties such as moisture content, density, and soil structure. Disturbed samples with thin-walled Shelby tubes are acquired by extracting intact soil cylinders at specific depths. These samples offer detailed insights into the soil's structure and physical properties. Previous studies have successfully utilized this type of sample for soil classification and determining geotechnical parameters.

4.3 Unified Soil Classification System (SUCS) Tests

Mitchell and Soga (2005) highlight the common practice in geotechnical engineering of classifying soils according to the Unified Soil Classification System (SUCS). This system categorizes soils based on their particle size distribution and plasticity characteristics. The SUCS classification offers valuable insights into understanding soil characteristics and behavior under applied loads.

4.4 Natural Moisture Content and Fundamental Relationships Test

Das (2008) stresses the importance of determining the natural moisture content of the soil for comprehending its behavior and properties. Fundamental relationships, including the correlation between soil moisture and density, play a crucial role in foundation design and soil compaction assessment. Furthermore, correlations between geotechnical parameters, such as internal friction angle and cohesion, are employed to predict soil behavior under various conditions.

4.5 Research Model

In the research context, approximately 1000 meters of drilling were conducted in the field, with the execution of SPT tests at each drilled meter. Drilling depths varied between 6 and 15 meters. Additionally, representative samples were extracted at various depths using thin-walled Shelby tubes, ensuring the integrity of the samples.

A total of 117 characteristic points from the SPT tests were carefully selected, recorded, and converted to N60 values, following the specified calculation parameter in the corresponding theory.

In the laboratory setting, 117 tests were uniformly conducted to determine the natural moisture content. This process was carried out using an oven at a controlled temperature of 100±5°C. Additionally, Atterberg limit tests were performed, covering liquid limit, plastic limit, and plasticity index, using the Casa Grande method. Particle size characterization was performed using sieves with mesh sizes of 4, 10, 40, and 200 mm. Likewise, a fundamental relationships test was carried out, mainly obtaining the specific weight of each sample, and then establishing correlations with the results obtained in the SPT test.

During the SPT tests in the field, drillings were conducted at various depths, ranging from 1 to 15 meters, with one-meter intervals, meticulously recording the number of blows. The Pearson coefficient was employed to analyze the dynamic relationship between different points, providing information on how the movement of one point can affect the movement of others, thus generating a correlation coefficient.

Additionally, correlations were obtained using logarithmic and quadratic equations as part of a strategy aimed at ensuring the reliability of this research and validating the results obtained.

5 DATA ANALYSIS

5.1 Correlations

Three correlations were performed, namely: N60 vs. specific weight, N60 vs. void ratio, and degree of saturation vs. void ratio, yielding the following results. Refer to Figure 1-2-3 below.

5.2 Discussion

Regarding the reliability values of 0.59 and the Pearson coefficient of 0.549 obtained in the N60 vs. specific weight correlation, it is acknowledged that these do not reach acceptable levels nor are considered highly acceptable. It is crucial to extensively and in detail discuss these results, explaining the possible underlying reasons that led to a correlation that is not deemed adequate.

In the analysis of the N60 vs. void ratio correlation, where a reliability value of 0.47 and a Pearson coefficient of 0.38 were obtained, a degree of correlation is evidenced that, although considered acceptable, raises questions about the factors that could be affecting the relationship between the variables.

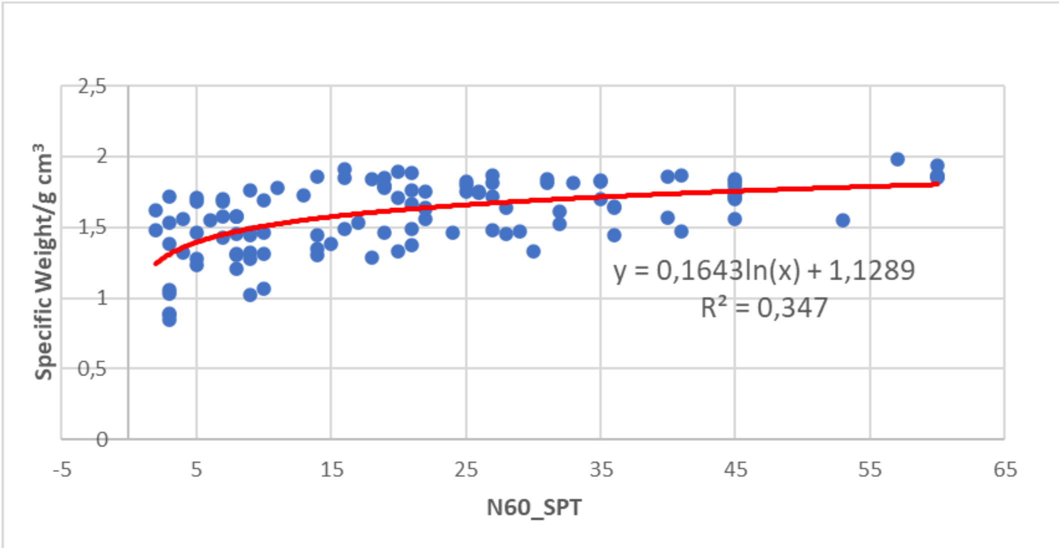

Figure 1. N60 vs. specific weight.

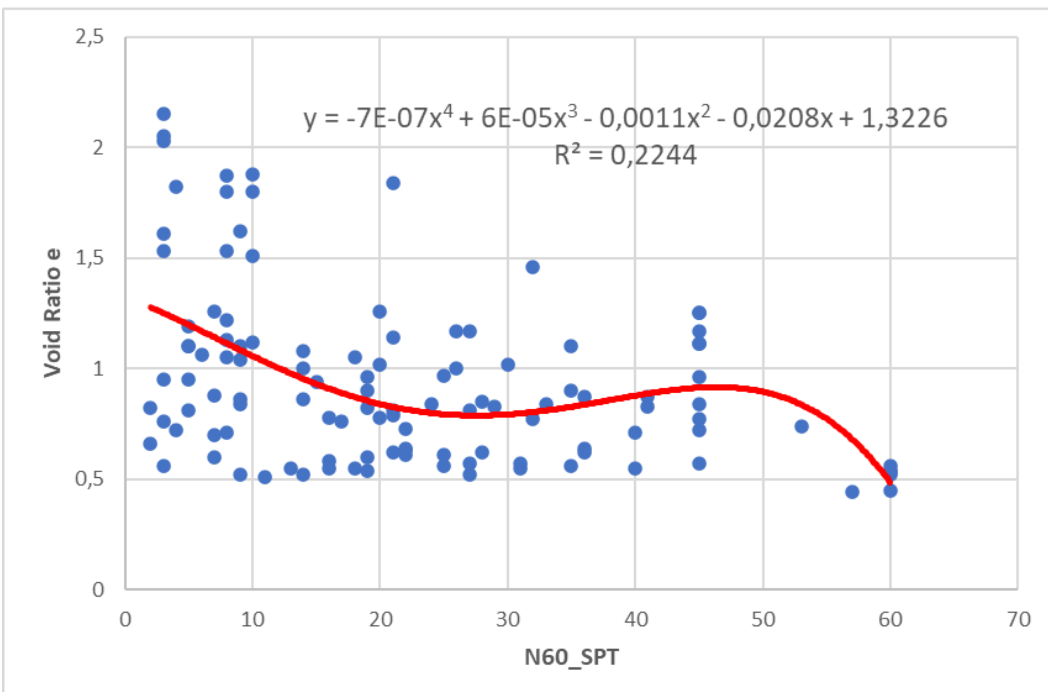

Figure 2. N60 vs. void ratio.

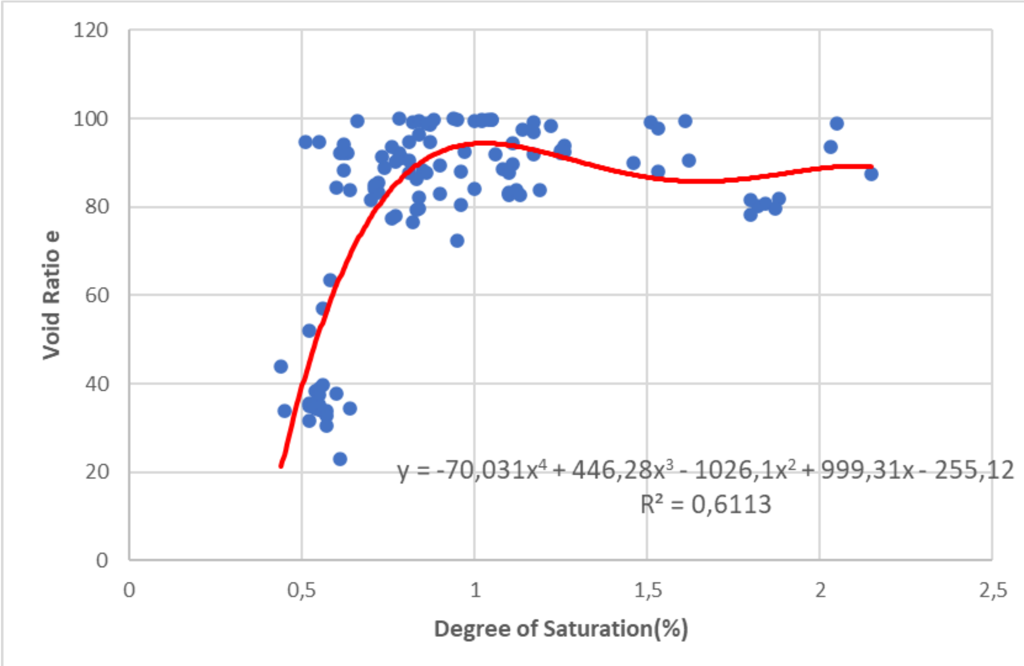

Figure 3. Saturation degree vs. void ratio.

On the other hand, the correlation between degree of saturation and void ratio yielded a reliability value of 0.78 and a Pearson coefficient of 0.47, indicating a highly acceptable degree of correlation. This positive finding suggests that, in certain cases, a more consistent and reliable correlation is achieved.

In the detailed discussion of these results, possible sources of variability, methodological limitations, or external factors that could explain the lack of correlation in some correlations will be explored, contributing to a more comprehensive and well-founded understanding of the results obtained in the research.

6 CONCLUSION

The correlations established between N60 and specific weight revealed an acceptable level of correlation, supported by a reliability value of 0.59 and a Pearson coefficient of 0.549. This finding validates the reliability of N60 as a reliable indicator of specific weight in geotechnical contexts.

In the case of the correlation between N60 and void ratio, although a reasonable level of correlation was observed with a reliability value of 0.47 and a Pearson coefficient of 0.38, the strength of this relationship is lower than the N60 vs. specific weight correlation. Nevertheless, the valuable contribution of this correlation to understanding the relationship between N60 and void ratio is highlighted.

In contrast, the correlation between degree of saturation and void ratio demonstrated a highly acceptable relationship, supported by a reliability value of 0.78 and a Pearson coefficient of 0.47. This strong connection suggests that changes in one variable can reliably predict changes in the other, providing valuable information for geotechnical analyses involving these parameters.

These conclusions highlight the different strengths of correlation among the evaluated parameters, offering a more specific perspective on the utility of each correlation in geotechnical assessments and design. Despite variations in the strength of correlations, each provides valuable information that can be effectively applied in soil analysis in the study area.

In the context of future research, there is a suggestion to expand the sampling range to improve correlation values. Consideration is proposed for the inclusion of other geotechnical parameters, such as those related to soil shear strength, to obtain a more comprehensive view of geotechnical properties in the Los Chillos Valley. It should be noted that one of the most important parameters in foundation calculations is to consider the specific weight. It is crucial to have soil parameters from the research area to enhance the designs.

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