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Geotechnical Parametric Estimation and Susceptibility Analysis of Bicol University East Campus, Legazpi City, Albay, Philippines

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Abstract. Natural calamities and geotechnical hazards pose a major risk in maintaining an area's public safety and its ability to develop economically. Infrastructures must be built sustainably and robustly for sustainable, disaster-resilient structures. Engineering structures must be studied considering geotechnical aspects and risk assessments to comprehend the substrata. This study aims to assess the susceptibility of an area against liquefaction potential or settlement based on geotechnical characterization. Field and laboratory tests were conducted to obtain soil samples and analyzed the susceptibility to liquefaction potential and settlement. The soil was consistently silty sand (SM), with varying shear strength values in each borehole. Results revealed that, BH04, had the highest liquefaction potential and lowest Factor of Safety. Settlement analysis demonstrated that the settlement for BH04 was high compared to other boreholes, which gave the lowest N-Value. This study emphasizes the significance of thorough geotechnical studies for infrastructure sustainability and disaster resilience. The integration of laboratory analyses, field testing, and geotechnical analyses, will enable a thorough understanding of soil behavior and engineering design.

Keywords: *Geotechnical, borehole, soil properties, settlement, liquefaction*

1. Introduction

Philippine archipelago being vulnerable to natural hazards and climate change, pose significant concern in the context of physical and economic development (Lagmay et al., 2017). It is essential to prioritize disaster preparedness and it is crucial to address the aftermath effects of such hazards quickly. This can be addressed appropriately by conducting comprehensive process like geotechnical explorations. While hazard maps are in place in the province, further initiatives could be undertaken to safeguard existing infrastructures and maintain economic growth (Perez & Batisla-ong, 2022). State Universities and Colleges (SUCs) holds a significant role in the disaster risk management in LGUs which may help in enhancing community resilience and effective disaster response. SUCs can educate, conduct research, and disseminate research findings to LGUs (Abedin & Shaw, 2015). This is useful for university's land development and for every structure to be built, considering structural aspects and geotechnical characteristics which will assist designers in pinpointing critical areas prone to significant geotechnical hazards. Historically, there have been occurrence of liquefaction in the Province of Albay (Buhay et al., 2024). Specifically, this research aims to parameterized geotechnical data as reference to structural design, assess the liquefaction potential and settlement evaluation for the study area.

2. Materials and Methods

2.1. Study Area and Geotechnical Process

Research was initially conducted at the vicinity of the College of Engineering, East Campus in Bicol University, Legazpi City, Albay, Philippines. Geotechnical in-situ and ex-situ tests were performed to parameterized the geotechnical properties and assess the susceptibility of the area against geotechnical hazards. Five (5) boreholes were drilled to a depth of six (6.0) meters using Standard Penetration Test (ASTM D-1586). Samples were extracted at every 2.0m depth and brought in the laboratory determining geotechnical properties following the standardized test process of American Society of Testing Materials (ASTM).

2.2. Geotechnical Analyses

Data from the in-situ and ex-situ tests were used to evaluate the vulnerability and to ascertain geotechnical abnormalities. Settlement was calculated using the principle from elastic settlement (Das & Sobhan, 2014):

$$S_e = \Delta\sigma(\alpha B')\frac{1-\mu_s^2}{E_s} I_s I_f \qquad (1)$$

Where, $\Delta\sigma$ - the net applied pressure on foundation, μ_s – Poisson's ratio of soil, E_s – modulus of elasticity of soil, B' – width of the foundation, and I_s, I_f is the shape factor

and depth factor, respectively. Susceptibility against liquefaction, the Factor of Safety (FoS) was calculated from Idriss & Boulanger:

$$FS_{liq} = \frac{CRR}{CSR} \qquad (2)$$

Where, CRR is the cyclic resistance ratio and CSR is the cyclic stress ratio.

3. Results and Discussion

Figure 1 presents the parameterized geotechnical data obtained from five boreholes in the conducted in-situ and ex-situ tests for BU East Campus giving insights into the subsurface conditions. SPT gave N-values ranges from 3-50bpf, which increases with depth. The soil was consistently classified as Silty Sand (SM), based on the Unified Soil Classification System (USCS). Moisture content, (ω) shows a decreasing trend with depth generally high moisture at the surface. Void ratio, (e) values decreases with depth and unit weight, (γ) ranges from 14 kN/m^3 to 21 kN/m^3 increases with depth. The shear strength parameter, considering a cohesionless soil, friction angle, gave higher value at greater depth.

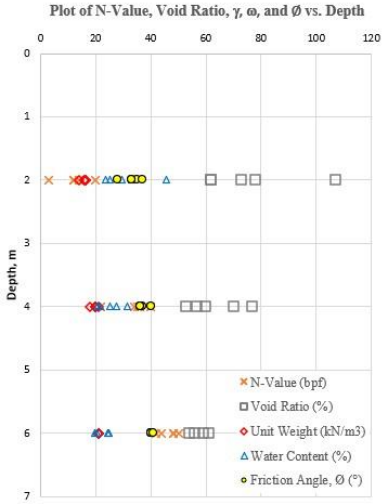

Figure 1. Parameterized geotechnical value for all the five (5) boreholes.

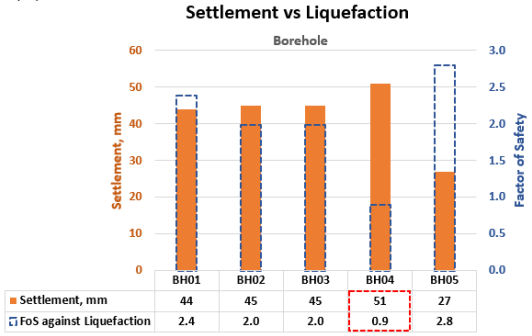

Figure 2. Magnitude of settlement and FoS against liquefaction for all the five (5) boreholes.

From settlement analyses, for all the boreholes, gave values that ranges from 27mm – 51mm with BH04 exhibiting the maximum (Figure 2). The FoS against liquefaction, where FoS values less than 1.0 indicate high susceptibility to liquefaction. Since BH04 gave a lower FoS = 0.90, shows a critical concern to liquefaction and with highest settlement magnitude, S_{ult} = 51mm. BH04 has the highest settlement with lowest FoS, suggesting a strong correlation between high settlement values and increased liquefaction susceptibility which may further exacerbate foundation instability.

4. Conclusion

It is concluded that the upper strata are relatively loose and susceptible to ground deformation giving lower N-value and deeper soil layer provides better bearing capacity. Lower value for void ratios at deeper depths implicates denser soil and less soil compressibility. Soil's shear strength, friction angle increases with depth, which indicates stronger resistance between solid particles. Structures that may be built with proximity to BH04 must consider the presence of loose layer, which also gave higher value of settlement magnitude and lower value of FoS against liquefaction. Hence, ground improvement must be done before the erection of any structures in the area. It is noteworthy that SPT test indicates that soil with low N-values imply susceptibility to settlement and liquefaction while higher N-values suggests better soil properties and stable against liquefaction and lower value of settlement magnitude. The variability of soil parameters necessitates site-specific analysis and careful consideration during foundation design and construction

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