World Academy of Science, Engineering and Technology
International Journal of Energy and Power Engineering
Vol:18, No:07, 2024

Optimization of Metal Pile Foundations for Solar Power Stations Using Cone Penetration Test Data

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Abstract : Our research addresses a critical challenge in renewable energy: improving efficiency and reducing the costs associated with the installation of ground-mounted photovoltaic (PV) panels. The most commonly used foundation solution is metal piles - with various sections adapted to soil conditions and the structural model of the panels. However, direct foundation systems are also sometimes used, especially in brownfield sites. Although metal micropiles are generally the first design option, understanding and predicting their bearing capacity, particularly under varied soil conditions, remains an open research topic. CPT Method and Current Challenges: Metal piles are favored for PV panel foundations due to their adaptability, but existing design methods rely heavily on costly and time-consuming in situ tests. The Cone Penetration Test (CPT) offers a more efficient alternative by providing valuable data on soil strength, stratification, and other key characteristics with reduced resources. During the test, a cone-shaped probe is pushed into the ground at a constant rate. Sensors within the probe measure the resistance of the soil to penetration, divided into cone penetration resistance and shaft friction resistance. Despite some existing CPT-based design approaches for metal piles, these methods are often cumbersome and difficult to apply. They vary significantly due to soil type and foundation method, and traditional approaches like the LCPC method involve complex calculations and extensive empirical data. The method was developed by testing 197 piles on a wide range of ground conditions, but the tested piles were very different from the ones used for PV pile foundations, making the method less accurate and practical for steel micropiles. Project Objectives and Methodology: Our research aims to develop a calculation method for metal micropile foundations using CPT data, simplifying the complex relationships involved. The goal is to estimate the pullout bearing capacity of piles without additional laboratory tests, streamlining the design process. To achieve this, a case study was selected which will serve for the development of an 80ha solar power station. Four testing locations were chosen spread throughout the site. At each location, two types of steel profiles (H160 and C100) were embedded into the ground at various depths (1.5m and 2.0m). The piles were tested for pullout capacity under natural and inundated soil conditions. CPT tests conducted nearby served as calibration points. The results served for the development of a preliminary equation for estimating pullout capacity. Future Work: The next phase involves validating and refining the proposed equation on additional sites by comparing CPT-based forecasts with in situ pullout tests. This validation will enhance the accuracy and reliability of the method, potentially transforming the foundation design process for PV panels.

Keywords : cone penetration test, foundation optimization, solar power stations, steel pile foundations
Conference Title : ICPPTM 2024 : International Conference on Photovoltaic Power Technology and Modeling
Conference Location : Singapore, Singapore
Conference Dates : July 04-05, 2024