九州大学学術情報リポジトリ
Kyushu University Institutional Repository

ELASTIC SETTLEMENT PREDICTION OF CEMENT-TREATED CLAYEY GROUND IN SMALL STRAIN MECHANICAL BEHAVIOR

ムハンマド, アクマル, プテラ

https://hdl.handle.net/2324/5068202

出版情報：Kyushu University, 2022, 博士（工学）, 課程博士
バージョン：
権利関係：

KYUSHU UNIVERSITY

（様式２）

氏　　名　：MUHAMMAD AKMAL PUTERA

論 文 名　：ELASTIC SETTLEMENT PREDICTION OF CEMENT-TREATED CLAYEY GROUND IN SMALL STRAIN MECHANICAL BEHAVIOR
(微小変形領域におけるセメント安定処理地盤の弾性沈下予測に関する研究)

区　　分　：甲

論 文 内 容 の 要 旨

Among other developing countries, Indonesia is developing its infrastructure, including a High-Speed Railway (HSR) project (maximum speed of 300 km/h) that is expected to connect the Jakarta and Surabaya cities, extending for 700 km. Along the railway, the lowland area is comprised mainly of clayey soil extending for a depth of 10-15 m on average. The clayey soil is characterized by high compressibility index and liquid limit, which exhibits settlement behavior. The engineering properties, mainly the compressibility index and liquid limit, are similar to the natural Ariake clayey distributed around the Ariake sea. Therefore, it was adopted for testing in this research. The maximum allowable settlement can be divided into two categories based on the Japanese railway standard for HSR, ranging from 10 mm to 30 mm. Proper railway structures such as ballastless tracks are usually considered to reduce the settlement potential. Despite the track structure, the subsoil mechanical properties often require improvement to limit the railway's settlement. Using Cement-Treated Soil (CTS) is a low cost-technique with high stiffness improvement in a short time. Thus, it is considered a reliable cheap technique, especially for developing countries. Through this study, settlement behavior mainly within elastic conditions was investigated considering the actual low vertical stress near-zero displacement on the ground surface. However, in reality, the accumulation of stress with time might cause elastoplastic settlement of the ground. Furthermore, anticipating and observing the mechanical behavior of CTS is associated with remarkable uncertainties, especially for the small-strain ranges within the elastic and elastoplastic conditions. In addition, optimizing laboratory mechanical behavior (Shear strength) testing using small-strain tools can improve the accuracy under small-strain ranges. The results are expected to be a simple tool for estimating the optimum mixing ratio for cement-treated soils in small-strain ranges.

To achieve the aims of this thesis, several objectives were formulated, including optimizing laboratory testing using triaxial testing equipped with axial and radial local displacement transducer and bender element. The optimization process of this apparatus differs in its features and testing procedure, which were then compared to the conventional strain measurement in triaxial testing. The reliability and applicability of the proposed configuration and test procedure for the small strain range were confirmed experimentally. Furthermore, the optimum mixing ratio of the CTS under small strain ranges was studied. The investigation considered various parameters such as the cement content, curing period, and confining pressure. Finally,

a prediction model of the elastic settlement under dynamic loading considering the curing period based on the mechanical properties of CTS was proposed. Several influence factors were considered in many ways to enhance the accuracy of this empirical method, such as CTS stiffness, curing period, depth of embedment, and vertical loading of the structure.

Chapter 1 introduces the new development project of Indonesia HSR on Java Islan. It is planned to be constructed in the Lowland area, making it susceptible to settlement-related problems, where a ground improvement to ensure the reliability of the railway structure is necessary. The proposed aim and its vital role in reducing the settlement behavior, original contributions, and the framework of the thesis are represented.

Chapter 2 provides a brief literature review illustrating the research carried out in relation to the scopes considered in this thesis. The chapter is divided into three main sections where the first section discusses the recent experimental and field investigation methods for determining the mechanical behavior in clayey soil ground. Furthermore, the second and third sections deal with the mechanical behavior and state of the art of elastic settlement prediction.

Chapter 3 presents the optimization of experimental testing of CTS in triaxial testing using the small-strain tools. The small-strain axial LDT, radial LDT and BE device were utilized for testing. This chapter also explains the testing procedure, including testing setup and configuration of the devices to ensure high accuracy measurements within the elastic zone. Finally, the elastic to elastoplastic characteristics can be determined using the proposed testing methodology.

Chapter 4 presents the mechanical behavior of CTS in large to small-strain ranges subjected to the confining pressures, curing period, and cement content using triaxial testing. Considering the degradation stiffness modulus during the static shearing process with low shearing speed, it is necessary to use LDTs with the triaxial testing to ensure accurate results. Furthermore, a formula for estimating the mechanical properties of CTS in small strain ranges has been proposed using a power function that considers the confining pressures and cement content.

Chapter 5 focuses on the elastic settlement prediction of CTS as a shallow ground improvement. This chapter mainly discusses the influence of dynamic train loading on the behavior of the CTS layer. Also, to enhance the prediction method considering the strict allowable settlement for high-speed railways, the influence of displacement factor and rigidity index factor of CTS is proposed and included in the prediction model. Finally, the elastic settlement can be predicted by simply extrapolating the settlement with time using a power function, focusing mainly on the operation phase. In addition, the prediction model can be used to determine the optimum mixing ratio needed at a specific curing period to satisfy the allowable settlement.

Chapter 6 summarizes the main findings of this thesis and delineates the remaining problem to be solved related to the practical and academic points of view. Furthermore, it defines goals for future research and scopes that need to be investigated subjected to the dynamic loading behaviors in laboratory testing.