EVALUATION OF HORIZONTAL RESISTANCE ON PRE-BORED PILE FOUNDATION SYSTEM DUE TO CYCLIC LATERAL LOADING

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論文題名　：EVALUATION OF HORIZONTAL RESISTANCE ON PRE-BORED PILE FOUNDATION SYSTEM DUE TO CYCLIC LATERAL LOADING
（繰返し水平荷重を受けたプレボード杭基礎の水平抵抗とその評価）

区　　分　：甲

論　文　内　容　の　要　旨

Conventional bridges are designed with elastomeric bearing and other structural releases that allow the girder to expand or shrink freely due to environmental thermal forces. These bearings have a limited ductility and durability that need to be maintained every year. In order to maintain the performance of this bearing, it requires high cost for construction and maintenance works. Integral abutment bridges are becoming popular because the elastomeric bearings are eliminated, which can reduce construction and maintenance costs. However, because of the bearing elimination, the girder displacement due to environmental thermal forces is directly supported by the pile foundation, which can increase the pile stresses and pile bending moment. Pile foundation need to become more flexible because there is no expansion joint like in conventional bridges. Pre-bored pile foundation system can be used to reduce the pile stresses on integral abutment bridge foundation using a pre-bored hole covered with steel ring and filled with elastic materials. However, the behavior of soil and soil response due to the attachment of pre-bored pile foundation system is still rarely explained. The proposed design refers to the previous researcher to conduct a new system foundation that can maintain the flexibility of the pile. The characteristic of filler material and standard design of this system also developed in this research.

The specific objectives are mentioned as follows. The first is to investigate the influence of pre-bored ring and filler material on the pre-bored pile foundation system under cyclic lateral loading. The appropriate filler properties and the dimension of this system are expected to reduce the bending moment along the pile body due to lateral displacement loading, which can solve the problem on the integral abutment bridge foundation. The second is to evaluate the failure pattern of soil on the pre-bored pile foundation system under cyclic lateral loading. This failure pattern can affect on determining the effective dimension of pre-bored ring system based on the failure zone during the cyclic lateral loading. The third is to introduce the simplified model for predicting the lateral pile capacities on the pre-bored pile foundation system which consider the soil-pile interaction during the lateral loading. Thus, in order to achieve these goals, this research consists of 7 chapters, as follows.

Chapter 1 describes the background of this research. The necessity of this research is to investigate the soil-pile behavior of pre-bored pile foundation system, which is explained in this chapter. The objectives of this research are briefly outlined, and the original contributions of this research are presented.

Chapter 2 provides a summary of the previous research on integral abutment bridge foundation system subjected to lateral loading. It reviews the following aspects: integral abutment bridge structure, loading mechanism, failure mechanism of the laterally loaded pile, and methods for predicting the lateral resistance of pile under lateral loading. Furthermore, a summary of the previous experiments performed by previous

researchers on a single pile under static and cyclic lateral loading is shown in this chapter.

Chapter 3 shows a comprehensive description of the experimental works that carried out in the laboratory (1g model). Five types of sand were used with different geotechnical properties (e.g., particle size distribution, relative density, internal friction angle) to evaluate the appropriate filler material properties on pre-bored pile foundation system under cyclic lateral loading. The effective depth of pre-bored ring system also evaluated using single pile embedded in two-layered ground soil under cyclic lateral loading. A clear description of the experimental setup, instrumentations, scale factors, ground soil material preparation, loading mechanism, and pile model used in this research are explained.

In Chapter 4, a parametric study was carried out using 1g laboratory model test to evaluate the filler material properties and pre-bored ring dimension under static and cyclic lateral loading. The effectiveness of filler material properties such as soil uniformity and density were evaluated to reduce the pile bending moment. The effective dimension of the pre-bored hole that can maintain the bending moment of the pile foundation also evaluated in this chapter. Filler material with low uniformity coefficient and medium or high density provide a stable pile performance during the cyclic loading. The effective diameter of the ring is recommended more than the plastic deformation area of the soil for a shallow depth of the ring.

Chapter 5 evaluates the stress and strain distribution on pre-bored pile foundation system under cyclic lateral loading. Image analysis using Particle Image Velocimetry method was used to evaluate the strain distribution on the system under cyclic lateral loading. Three different diameters of the pre-bored ring were used to evaluate the effect of ring dimension on this system. Placement of pre-bored ring system can reduce the potential increase of pile stress during the cyclic loading. The optimum diameter of the ring is between 3 to 5 time of pile diameter that can provide more stable results of pile stress and soil behavior. The smaller diameter of the ring provides a higher pressure on the ring structure that causes ring movement during cyclic loading. Influence of pre-bored ring with ring diameter ratio more than 5 is not significant.

Chapter 6 introduces the simplified model for the design of pre-bored pile foundation to estimate static lateral pile capacity developed in the previous chapters. An analytic closed-form solution is proposed for estimating the ultimate lateral resistance of piles in sandy soils considering the soil-pile interaction. Furthermore, to evaluate the accuracy and to verify the proposed model, a statistical analysis was conducted using three statistical criteria; (a) best fit line criterion, (b) cumulative probability, and (c) statistical parameter criterion and were compared with the previous methods. The proposed closed-form solution can reduce average error percentages compared to values resulted from other methods, and the estimation of lateral pile resistance for both rigid and flexible pile can be represented using the proposed method.

Chapter 7 shows the conclusions, the main outcomes of the study, and the recommendations for future research target.