（ 続紙 1 ）

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論文題目	Reinforcement approach based on arch action in liquefaction-susceptible embankments studied by dynamic centrifugal model tests（動的遠心模型実験による液状化の影響を受けやすい盛土におけるアーチ作用に基づく補強アプローチ）		

Embankment structures are widely used in civil engineering, playing critical roles in transportation and water control. However, under seismic loading, these essential earthworks are often susceptible to deformation and failure, including a novel failure mode known as the arch collapse mechanism. In this mechanism, soil arching occurs within the embankment due to basal settlement. If saturation occurs, dynamic loading can cause the collapse of the soil arch, leading to the upper part caving into the liquefied zone and damaging the embankment. Recognizing that embankment damage is primarily caused by the collapse of the soil arch due to liquefaction has prompted a crucial exploration of strategies to minimize such damage.

In this study, a series of preliminary studies were conducted to modify the experimental procedure and measurement instruments to reproduce the arch collapse failure mode in centrifuge tests. Subsequently, centrifuge experiments were carried out under various conditions to investigate the influence of liquefaction and soil arch collapse on embankment damage modes. The results indicate that soil arching in embankments with basal settlement can mitigate large deformations caused by dynamic loads, as long as the arch action endures, regardless of whether internal liquefaction occurs or not. Embankment damage occurred in cases lacking a soil arch or where the arch collapsed under dynamic load. In summary, reinforcing the soil arch can effectively improve the deformation resistance of embankments. However, due to the complex stress conditions within the embankment during dynamic loading, the reliability of liquefaction evaluation methods has been discussed. Using the results of triaxial tests, an algorithm for data analysis was developed, and the energy-based method (EBM) was used to determine the liquefaction-triggering energy to predict liquefaction occurrence in centrifuge tests.

Chapter 1 introduces the study, outlining the background, challenges, and clearly state the objectives of this study: (1) study static and dynamic load transmissions in embankments with a saturated zone subjected to basal settlement using geotechnical centrifuge model tests; (2) explore the interaction between soil arching and liquefaction, and their combined impact on embankment failure modes and the onset of collapse mechanisms; (3) propose an innovative concept for reinforcement to inhibit the damage in embankments prone to internal liquefaction and seismic instability; (4) investigate the application of energy-based method (EBM) in evaluating liquefaction susceptibility of embankments under various conditions.

Chapter 2 delves into the fundamental principles of centrifuge model testing and the basic properties of materials. The basic test conditions are introduced, laying the groundwork for the subsequent experimental chapters.

Chapter 3 details a preliminary study involving a series of centrifuge experiments designed to trigger soil arching effects and liquefaction, and to reproduce arch collapse failure modes in laboratory tests. It also examines the dynamic response of embankments at different depths and introduces the methodology for data analysis.

Chapter 4 focuses on the improvement of the experimental procedure and the assembly of a two-dimensional earth pressure sensor using a 3D printer. The reliability of its measurement for the two-dimensional state of stress is evaluated through experiments under centrifuge acceleration, contributing to the accuracy of data collection and interpretation.

Chapter 5 explores the soil arching effect and its formation development under different height conditions by conducting a series of centrifuge experiments under varying embankment heights. The Fixed Principal Axes (FPA) is used to obtain the earth pressure distribution of embankment, and the solution shows the soil-arching will be influenced by embankment height. Soil-arch action limited deformation to the region below the arch, while the embankments lacking sufficient height, experienced widespread deformation. Embankment height changes were assessed by combining basal and top settlement data, revealing trends consistent with soil-arch action and deformation.

Chapter 6 introduces the use of soil nail reinforcement in embankment model construction. A series of centrifuge experiments is conducted under various reinforcement methods to investigate arching effects, liquefaction resistance, and deformation behavior. Through dynamic centrifuge tests, comprehensive insights into the behavior of shear-reinforced embankments under various conditions are provided. The direction of the soil nail and a sufficient number of soil nails is important for optimal performance.

Chapter 7 proposes the algorithm for data analysis focusing on energy analysis and its use in future research. The results of triaxial tests were used to obtain energy-based method parameters and predict the occurrence of internal liquefaction of an embankment model in centrifuge tests using the energy method.

The final chapter provides the conclusion of this dissertation and outlines future work.

This dissertation contributes valuable knowledge to the field by offering insights into soil arch interactions, liquefaction dynamics, and the influence of soil arch reinforcement on embankment behavior under seismic loading.