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論文題目	Seismic response of embankment dams with different upstream conditions （ため池堤体の異なる貯水状態を考慮した地震時応答）		

（論文内容の要旨）

This study sets out with the aims of evaluating the effect of seepage and different upstream conditions of embankment on its response to earthquake and deformation when subjected to earthquake. Centrifuge model tests and numerical simulations were performed. There are six chapters in total in the thesis.

Chapter 1 presents the introduction of this study. In this chapter, different methods and analysis which are present at the moment to analyze the response of embankment to seepage and shaking have been presented. Different types of failure modes of the earthen embankment dam are also explained briefly. This chapter gives a brief view of introduction to the readers before going into details.

Chapter 2 presents the review of current literature related to the response of embankments to shaking and seepage. A few cases of dam incidents and failures were presented along with studies related to seepage analysis and seismic analysis of embankments individually. There was an intense research studies by different researches in the field of response of embankment to seepage in the body of embankment. There were different methods proposed by different experts to formulate and design the embankment structure. For these methods, seepage, different parts in the embankment structure and earthquake were considered. However, the influence of different upstream slope seepage conditions is needed to study under seismic loading. Therefore, the objective of this study is to understand the effect of different upstream seepage conditions and densities of the soil on the response of embankment to earthquake.

Chapter 3 presents the basic parameters of the soil used in this work. It presents the various laboratory experiments conducted in this work along with the data obtained from these experiments. Different laboratory tests performed in this test are grain size distribution, proctor compaction test, hydraulic permeability test, monotonic tri-axial tests and cyclic tri-axial test were conducted on two different densities of the soil and presented in this chapter. For analyzing the unsaturated condition of the soil, an experiment to obtain the suction pressures with different volumetric contents (SWCC tests) were also performed on two different densities of the soil.

Chapter 4 presents the centrifuge experiments on the embankment model. It describes the various cases conducted with different densities and upstream water levels. Embankment model tests performed in geotechnical centrifuge with different upstream conditions were presented. A custom made centrifugal box was used to create realistic conditions while performing centrifugal tests. Centrifuge experiments on embankment by inducing seepage and

shaking were repeated and the results between each of these tests were in good agreement with each other. In the case of an embankment with a higher dry unit weight, neither piping nor erosion is observed in the embankment irrespective of the level of water on the upstream side. Whereas the embankment with lower dry unit weight, failed at toe of downstream side in seepage, only in the cases with water level of 95% of the height of embankment on the upstream side. Due to the variability of stiffness of embankment between the embankments of different densities, the embankment with lower dry unit weight has deformed while the embankment with higher dry unit weight did not deform due to shaking. The height of water level on the upstream side of the embankment affects the deformation of embankment due to shaking because of the difference in external water pressure on the embankment. In the cases of higher dry unit weight, embankment had a local failure only due to the increase in PWP value at the location of failure. This suggests that the embankment of higher dry unit weight is highly vulnerable to shaking after it is subjected to rapid drawdown.

Chapter 5 presents the numerical study done in this study. The finite elements modeling was done with three different materials. Different stages were used to simulate the embankment model. For each stage different boundary conditions need to be given to simulate the embankment model. Simulation of embankment model subjected to centrifugal acceleration, rise in water level and drawdown on the upstream slope and horizontal acceleration. From the numerical simulations of the embankment model subjecting it to seepage and shaking. Aerial elements are important for achieving convergent form of solution of the FEM in the stage of seepage in an embankment model. Simulation of embankment model using FEM was successful in all the cases by varying the upstream conditions of the embankment. The settlement value of the top of embankment is a little higher than the experiments when the water level is higher on the upstream side of embankment. Except degree of saturation, all other parameters are similar to each other in the analysis varying the SWCC parameters as wetting and drying curves. The response of embankment to shaking is sensitive to SWCC parameters in the elements near to the water level on upstream slope and at the downstream toe. The analysis using drying curve of SWCC overestimates the response of embankment to the shaking irrespective of the water level on the upstream slope.

Chapter 6 summarizes and concludes the present study and suggests scope for future works.