論 文 の 内 容 の 要 旨

論文題目　ACCELERATION MECHANISM OF VOID DEVELOPMENT IN CONCRETE SEAWALLS

（コンクリート被覆海岸堤防の空洞化の加速的進行機構）

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Among the failure modes of the seawalls, the collapse of the filled area due to leakage of backfill material causes destruction on the landward side of the seawall. Through holes or tears on geotextile, sheet walls or filter layers, backfill material can flow out towards the seaside or towards armor layer. Following the leakage of backfill material, the enlargement of voids continues until the soil cannot support the weight above it. Consequently, the collapse of the surface of the backfill takes place behind the seawalls.

In this study, the main objective is to confirm the acceleration of void development and to identify the void expansion mechanism after a void developed inside the backfill of the seawall due to the leakage of the backfill towards the seaside.

To confirm the acceleration of void development, laboratory experiments have been conducted in oscillatory flow tunnel to investigate the acceleration mechanism of the void development in the backfill of a seawall. Toy balloons have been used to simulate the voids that may present in a backfill. The leakage of sand through a small gap from an acrylic container under pressure oscillations have been examined. From the laboratory experiments, it is found that the rate of sand leakage is proportional to the air amount in the soil medium. The larger void appears to accelerate the further enlargement of the void. Following the leakage of soil, the voids increase which in turn increase the air amount in soil medium. Consequently, the void development accelerates until the subsidence of the surface of backfill.

Leakage of sand has been found to be closely related to the seepage flow due to the pressure gradient between the soil medium and the water. Therefore, propagation characteristics of the wave-induced pressure influence the leakage of sand. Compressibility and permeability of soil medium have been found to be two significant parameters for the rate of leakage. The introduction of air to the soil increases the compressibility of soil medium. As the compressibility increases, the pressure response is getting poor and high-pressure gradient can be produced. Therefore, the high-pressure gradient will cause more leakage.

As mentioned, another important parameter is the permeability of the soil medium. The pressure response becomes poorer as the permeability decrease. Therefore, similar to the compressibility, as the soil becomes less permeable, the produced pressure gradient increases. In turn, the high-pressure gradient results in high leakage of the soil grains.

Furthermore, in this dissertation, the wave-induced pressure response has been investigated from the theoretical point of view. A numerical model has been proposed based on the quasi-static assumption on Biot's consolidation equation using finite difference method in the one-dimensional domain. In the verification of the model, earlier researchers' data on wave-induced pressure obtained from laboratory experiments have been utilized. The vertical maximum pressure distributions and instantaneous pressure amplitudes computed from the developed model has been used for the validation.

Moreover, the numerical model has been tested with the parameters of present laboratory experiments. The results from the developed model using appropriate permeability and compressibility values have been compared with the leaked sand and displacements measured during the laboratory experiments. The amount of leaked sand has found to be strongly correlated with the maximum pressure gradients computed near the surface. Also, the displacements in the soil medium due to the pressure oscillations has been found to be related to both pressure gradients and compressibility of balloons.

According to the both laboratory experiments and the theoretical approach, the acceleration mechanism of void development has been confirmed. Two mechanisms that accelerate the void development are the pressure gradient between water and soil interface and displacements due to the compressibility of air content. The intensity of these two mechanisms increases as the voids enlarge which further accelerates the void development. Also, a good correlation between model and experiments have been obtained according to the reasoning of this study.