A NEWLY DEVELOPED TRIAXIAL APPARATUS FOR INTERNAL EROSION TESTS

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1. INTRODUCTION

The seepage-induced internal erosion would lead to catastrophic consequences, especially in Dam Engineering. The previous work by authors (Ke and Takahashi, 2011) showed that the hydraulic conductivity of soil would increase with the progress of internal erosion. At higher average hydraulic gradient, more fines would be eroded, resulting in the soil strength reduction. The seepage tests were conducted by a fixed-wall permeameter with the measurement of water table by four standpipes at four different depths. A weakness of the fixed-wall permeameter is the sidewall leakage, which may lead to fatal errors in hydraulic conductivity measurement. Moreover, the saturation degree of the specimens would decrease with time. To overcome the above-mentioned shortcomings, a flexible-wall permeameters are developed. It could minimize the leakage and permit applying back pressure on soil specimens during seepage tests to ensure a relatively high saturation degree.

The purpose of this paper is to introduce the newly developed triaxial apparatus for seepage tests, capable of evaluating the influence of various parameters on internal erosion, such as effective confining pressure, and directly detecting the mechanical behavior of internal eroded soils. A brief summary of existing seepage tests procedures are also elaborated.

2. AVAILABLE INTERNAL EROSION TESTS

Internal erosion tests were inspired by the phenomenon that the base soil that satisfies the geometrical criteria may fail due to erosion of fine grains, discovered in the base soil and filter compatibility studies. An extensive laboratory seepage tests were conducted on those “poor graded” soils, such as gap-graded or coarse widely graded soils (Skempton and Brogan, 1994; Tomlinson and Vaid, 2000; Moffat and Fannin, 2006; among others). The main apparatus comprises a permeameter cell together with the measurement of pore water pressure spatial variations and effective stress distribution along the specimen. The permeameter cell is usually transparent in order to record the process of internal erosion by either microscope or visual observation. To prevent the formation of large seepage channels along the fixed-wall, an extra layer, such as a compressive rubber layer or a silicon grease layer against the inside wall is necessary. The tested soils are either above one filter layer or sandwiched between two filter layers. Controlled seepage flow is usually unidirectional, either upward or downward, which is generated by the hydraulic pressure difference between the top and bottom of a specimen. The inlet hydraulic pressure is maintained by a constant water head tank while the outlet is open to atmosphere or connected to another constant water head tank.

3. NEWLY DEVELOPED SEEPAGE APPARATUS

The newly developed triaxial internal erosion apparatus could directly investigate not only the hydraulic characteristics of soils during onset and progress of internal erosion but also the mechanical behaviors subjected to internal erosion. Details of the triaxial permeameter are shown in Fig.1 and the schematic illustration of the overall system is in Fig.2.

3.1 Automated triaxial system

The automated triaxial system used, capable of investigating the soil behavior at either small strain or large strain, could conduct measurement and controls by PC through 16-bit A/D and D/A converters. The vertical load could be automatically applied by a motor-gear system at any choosing velocity. The cell pressure is applied by air pressure which is maintained constant at 700kPa through an automatic air compressor. The cell pressure is known from a DPT, which joins the specimen base and cell. Pore pressure is estimated at the base of specimen with a pressure transducer mounted at the bottom. Small axial strain is measured locally over the central potion of the specimen by a pair of Linear Variable Deformation Transducers (LVDT) and the radial strain is by three pairs of Radial Displacement Transducers (RDT). All the measuring devices are connected to amplifiers and then to a PC through a 16-bit A/D converter.

3.2 Hydraulic control system

Hydraulic gradient and flow velocity are the vital parameters for hydraulics. The core of the hydraulic control system is to deliver water flow through a soil specimen by controlling either one of the two parameters while measuring the other. The flow velocity controlling type is applied in this apparatus. The system is composed of a flow pump for controlling flow rate through the specimen and a Differential Pressure Transducer (DPT) for measuring the pressure drop. In order to maintain the flow velocity constant, the size of all the flow channels is designed to be the same as 7mm and those tubes with high stiffness are used. To minimize the possible induced head loss in the top cap, instead of commonly used annular porous stone, a perorated plate is mounted in top cap, which directly attaches specimen. During the experiment,

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the range of assigned flow rate must ensure the resulting pressure drop is well below the confining pressure to prevent the separation of membrane from specimen

3.3 Eroded soil collection system

The main component of the collection system is the pressured sedimentation tank (Fig.3). The acrylic tube is mounted between a steel top and base plate, and is sealed by means of O-rings and five external tie rods. The pressure is set the same as the back pressure in soil specimen. The weight of eroded sands is measured by a high accuracy load cell, by use of which the continual monitoring of erosion rate is realized. The outlet valve will be opened at certain time interval to drain water in the tank, by means of solenoid valves with a timer.

4. SUMMARY AND CONCLUSIONS

A triaxial erosion apparatus is developed to investigate the initiation and development of internal erosion in the soil specimen. The apparatus allows independent control of flow rate and stress state. The flow rate is controlled through a water pump. The pressure drop at the top and the end of soil specimen is measured by a Difference Pressure Transducer. The vertical and lateral deformations could be obtained by LVDTs and RDTs, respectively. By those measurements the hydraulic conductivity change and mechanical behavior of soil specimens during internal erosion could be studied.

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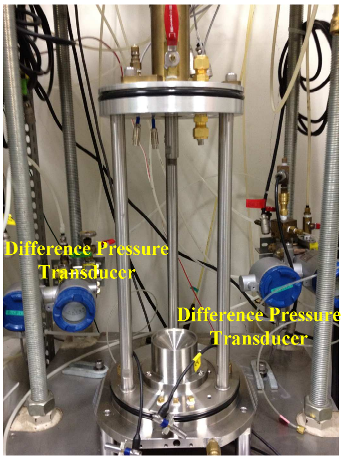

Fig.1: Triaxial erosion apparatus

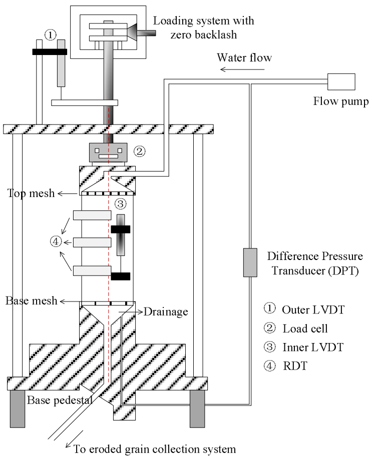

Fig.2: Schematic diagram of triaxial erosion apparatus

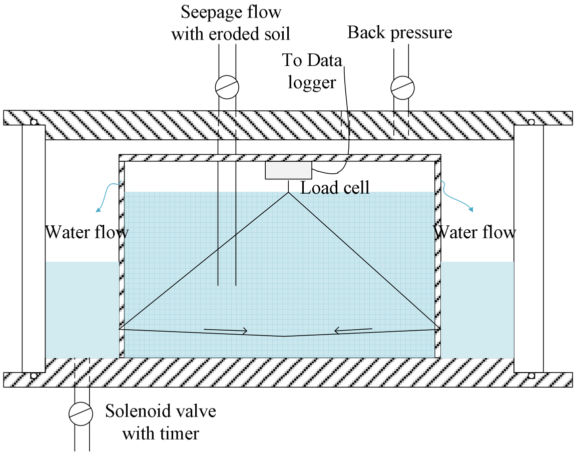

Fig.3: Schematic diagram of sedimentation tank

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