

# Experimental Study on Mechanism and Hydraulic Conditions of Soil Piping

## 土壤管湧破壞機制與臨界水力條件研究

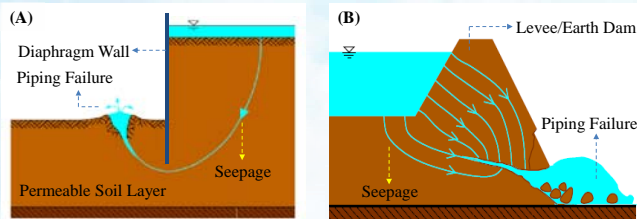
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### 1. Background

Soil piping is a hydraulic and geotechnical phenomenon that soil fails induced by seepage force, which may happen in geotechnical engineering structures and ecosystem. (Figure 1)

#### ■ Geotechnical Engineering Structures



#### ■ Ecosystems

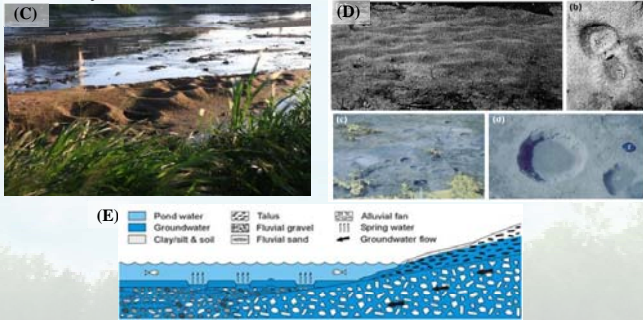


Figure 1. Photographs of soil piping: (A) & (B) soil piping causes geotechnical structure failure; (C), (D) & (E) Soil piping forms spring pits in riverbank and potential impact on urban river ecosystem.

### 3. Methodologies

This research is going to conduct a series of seepage experimental tests. Figure 3 shows the illustration of test setup: (1) permeameters; (2) Adjustable constant head device; (3) data acquisition system and water pressure gauge.

Test variables include: (1) soil type; (2) thickness of soil layer ( $H$ ); (3) soil grain size distribution; (4) relative density ( $D_r$ ).

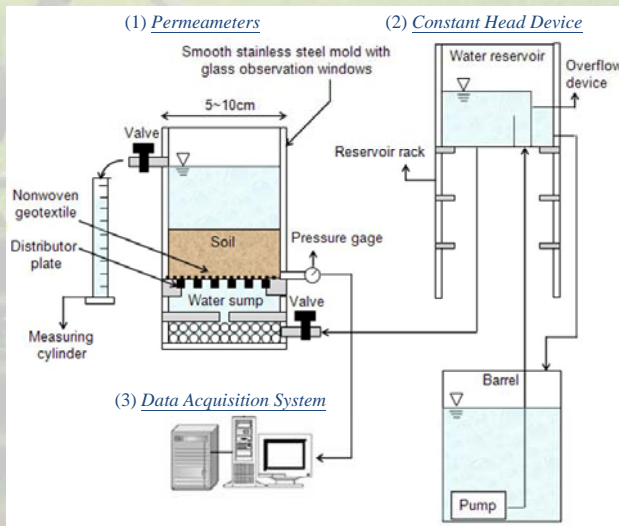


Figure 3. Illustration of upward vertical seepage test apparatus.

### 2. Motivation & Purpose

Critical hydraulic gradient  $i_{cr}$  of soil is commonly used in geotechnical engineering to predict the onset of soil piping failure, which can be evaluated using the following equation proposed by Terzaghi (1936) based on effective stress equal to zero:

$$i_{cr} = (G_s - 1)(1 - n) \quad (1)$$

where  $G_s$  = specific gravity of soil solids;  $n$  = porosity of soil. The typical value of  $i_{cr}$  predicted by Eq. (1) varies from 0.9 to 1.1, with an average of 1.0. However, in some soils, the value of  $i_{cr}$  can be much less than 1.0 (Figure 2). Thus it likely leads to a unsafe design.

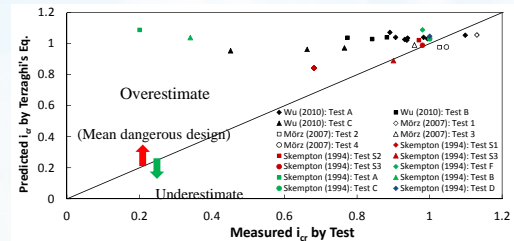


Figure 2. Comparison of measured  $i_{cr}$  and predicted  $i_{cr}$

Therefore, the objective of this research is to investigate the mechanism and hydraulic condition of soil piping by conducting a series of experiment tests. Finally, the results of this research is expected to provide useful insights into soil piping.

### 4. Preliminary Study Results

Figure 4 shows a preliminary test result. The soil piping failure is determined at a sudden increase of seepage velocity when  $i > i_{cr}$ . Figure 5 shows the process of seepage with increasing hydraulic gradient until soil piping occurs.

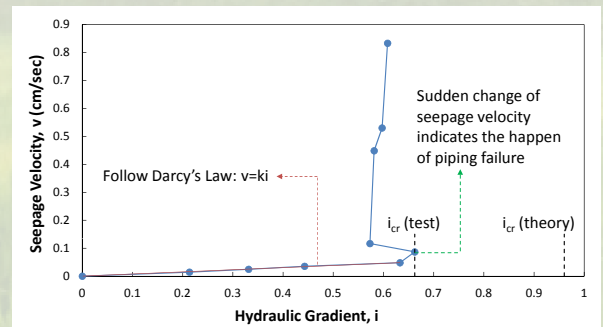


Figure 4. Relationships between seepage velocity and hydraulic gradient from Wu (2010): Test C3-1.

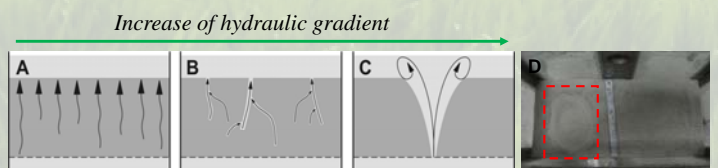


Figure 5 Seepage process with the increase of hydraulic gradient. (A) homogenous Darcy flow; (B) formation of micro-channels and conduits due to the increasing seepage velocity. The sample is still stable and seepage velocity follows Darcy's Law; (C) pipe formation leads to a hydraulic failure of the sample. Darcy's Law is no longer valid. (Mörz, 2007); (D) photograph of soil piping.