C10

# Use Constant-head Injection Test for In-Situ Estimation of Hydraulic Conductivity in Gravel Bed Rivers

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Abstract

In order to get more comprehensive understanding of the in-situ data of hydraulic conductivity in rivers that has low accessibility, we use modified Constant Head Injection Test method and developed a set of portable equipment to conduct field survey of hydraulic conductivity in gravel bed rivers. Equipment includes a micro water pump powered by portable electricity generator, a manually driven permeameter made by steel pipe, measuring cylinder, and several accessories. Problems were detected during the trial in Tenryu River and improvements were made afterwards.

**Introduction**

River bed hydraulic conductivity plays an important role in the surface water and ground water exchange process which has been showed in many former studies. （Butler et al. 2001; Kollet and Zlotnik 2003）

Yet, it is difficult to directly measure the streambed hydraulic conductivity, due to it is usually beneath the riverbed and submerged by stream water, especially for the in-situ estimation or in relative larger spatial scale and intensity survey. The traditional ways to investigate the river bed hydraulic conductivity such as standard slug test, grain-size analysis and observation wells are both time- and resource-consuming procedure.

In order to quicker and use less resources to get intensive information of riverbed hydraulic conductivity in the field, we use modified Constant Head Injection Test (CHIT) method and beforehand-made spread sheet to estimate the in-situ river bed hydraulic conductivity, and capable to get the result almost immediately. This method fits better for large scale and intensively survey of the gravel bed river especially with low accessibility.

**CHIT method**

For sub-meter scale we assume Kh=Kv=K

$K = Q/2\pi LPy$ (Cardenas, 2003) and (Cho, 2000)

Where:

Kh is horizontal hydraulic conductivity

Kv is vertical hydraulic conductivity

K is the general hydraulic conductivity

Q is the stabilized injection rate

L: screened length

P: shape factor (dimensionless coefficient)

y: distance between stream stage and the desired water level in the permeameter

$$\boldsymbol{P} = \frac{1.1}{\ln((l+L)/r_w)} + \frac{\mathrm{A} + \mathrm{B}\ln[b-(l+L)/r_w]}{L/r_w}$$

Where: A and B are dimensionless coefficients that were originally in graphic form. These coefficients were approximated by Van Rooy (1988) (details in Butler, 1998)

The constant head injection test is standard tool used by many soil and civil engineers. While the original idea is for measuring the low K value media, e.g. silt and clay. We use the modified CHIT method developed by Cardenas and Zlotnik to measure the higher K value rivers such as gravel bed rivers. The purposes of this report is to show the instrumentation, field process, and data analysis for using the CHIT method to study the gravel bed rivers in Japan, for the development of the theory please refer the following papers. (Bouwer and Rice, 1976; Dagan, 1978; Cardenas and Zlotnik, 2003).

Using the modified CHIT theory, we only need to measure the Q and y in the field, other values are given. By using a spreadsheet, the K value can be calculated in the field.

**Instrumentation and field process**

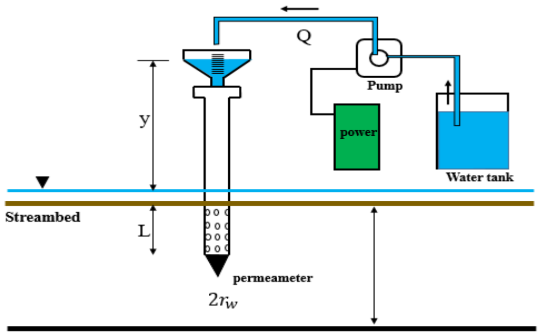

Figure 1The instrumentation of CHIIT method

The permeameter was specially designed for the higher K value riverbed materials such as gravel and sandy rivers. The total length of the pipe is 1220mm (1200+20mm inside the cap), the inner diameter of the pipe is 45 mm; the outer diameter is 50mm, the thickness of the pipe wall is 2.5mm. The tip of the instrument is a solid cone which the height is 75mm and the circumference is 50mm. The cone is made of solid steel. The bottom part of the pipe is the hole area, the length is 200mm. Diameter of all the holes is 5mm, the distance between the center of the hole to the edge of the hole area is 10mm, both the top edge and the bottom. （assume the permeameter is stand） the vertical distance between two holes is 40mm, and the lateral distance is 15mm. There are 110 holes in total, 10(vertical row) ×11(lateral row).

Stream water was collected in a bucket (without much suspended load, which could clog the hole area and streambed sediment), then pumped into the permeameter by the micro water pump which can adjust the discharge manually in order to keep a constant water level in the top of the permeameter. As the water level attained the designed height y and was steady (e.g. for 10s to several minutes), pull out the pipe into a volume cylinder, as the same time start the timer, thus the injection rate Q can be measured.

Known test geometry, injection rate Q and operational head y, K can be easily calculated.

**Field trial**


Figure 2 first trial in Tenryu river

The first trial was conducted in the upstream of Tenryu river on Oct 29$^{th}$, 2018. The riverbed is characterized by coarse materials and newly deposited sediment. K value was expected to be very high. At first we tried to measure the hydraulic conductivity of the top 20-30cm layer of the riverbed. While when stream water was pumped into the pipe it just went down into the very loose sediment instantly, which means the K was too high for this instrument to measure. As we hammered the pipe into the 80cm depth, the water table inside the pipe was steadily kept by adjusting the micro water pump, Q was measured by a volume cylinder. As calculated, K= 0.01429 cm/s= 12.35m/day.

**References:**


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