An Experiment of Rainfall Infiltration under Different Boundary Conditions

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Introduction

Rainfall infiltration is a two-phase flow of water and gas, which should be simulated through solving the nonlinear governing equations of gas and water flow. In order to avoid the three main problems, such as convergence, numerical stability and computational efficiency in the solution of the nonlinear governing equations, Richard equation was usually used to simulate rainfall infiltration when the effect of gas phase could be ignored. **The purpose of this work is to study the effect of boundary condition on rainfall infiltration, and to know in which cases Richard equation is available for the simulation of rainfall infiltration.**

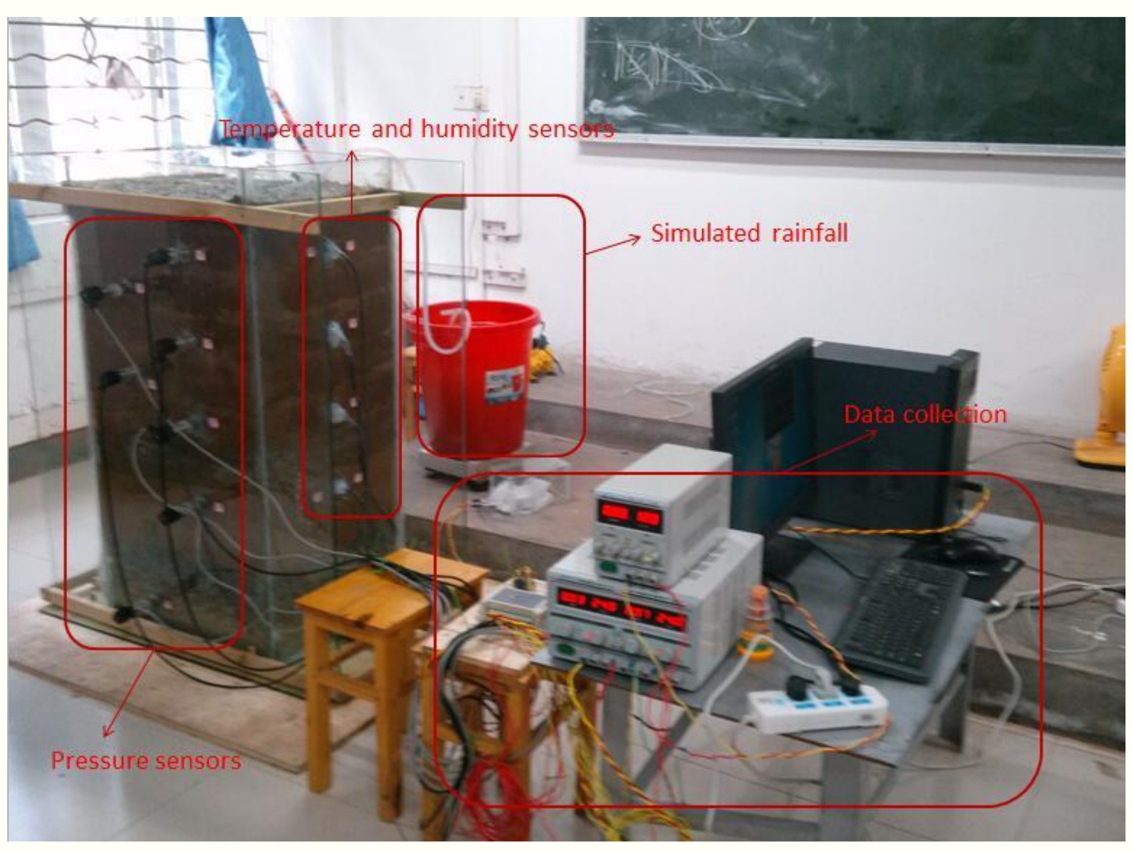

Fig. 1 Layout of experimental system

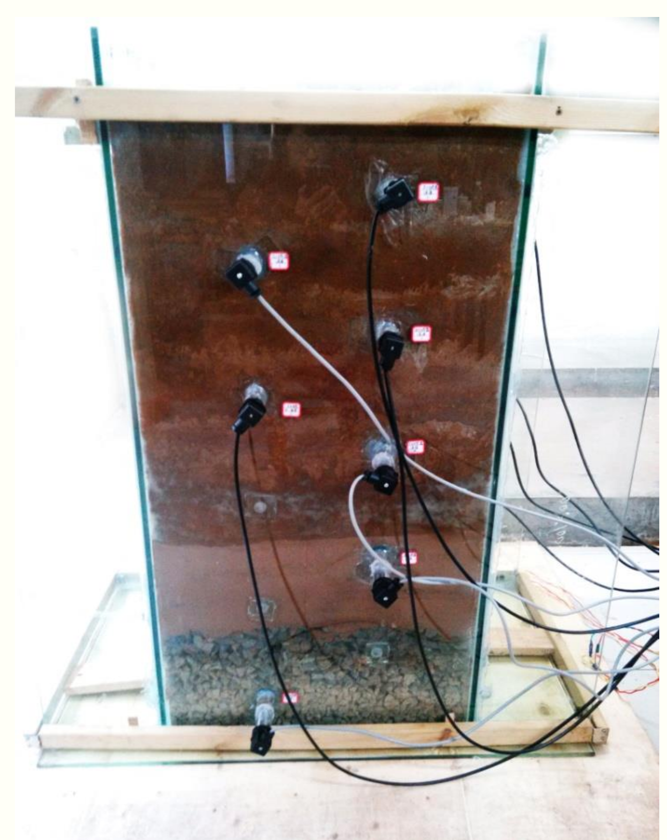

Fig. 2 Soil sample and sensors

The experimental systems include glass sleeve, sample soil, rainfall simulated system. The instruments consist of temperature and humidity sensors, pressure sensors, data acquisition card, powers and computer programs(Fig. 1).

The sample of soil has a height of 1200 mm. It is tightly enclosed in a toughened glass sleeve(Fig. 2). The gas tight of its bottom can be controlled by a tap to simulate two different gas boundary conditions, permeable boundary and impermeable boundary.

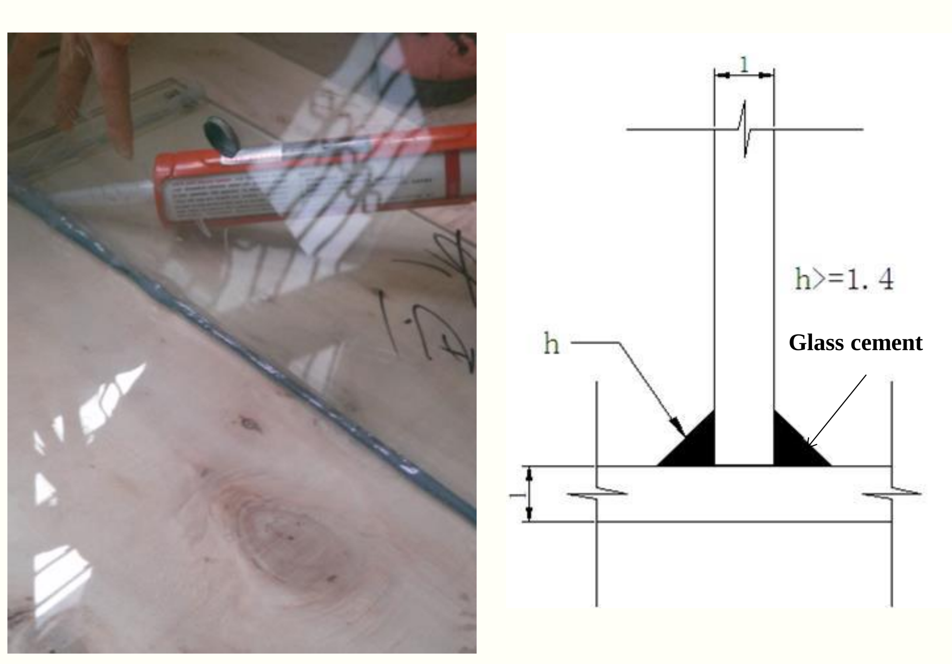

Fig. 3 Measurements of keeping impermeable

The significant measurement technique which dominants the success of experiment is that the container's impermeability.

Glass cement would be use to insure the gas cannot permeate through the boundary region of the device(Fig. 3) .

The method of avoiding the contact leakage is using glass cement on the side wall to increase the contact area(Fig. 4).

The soil sample are expected to keep layer and vibrate.

Fig. 4 Installation of the sample soil

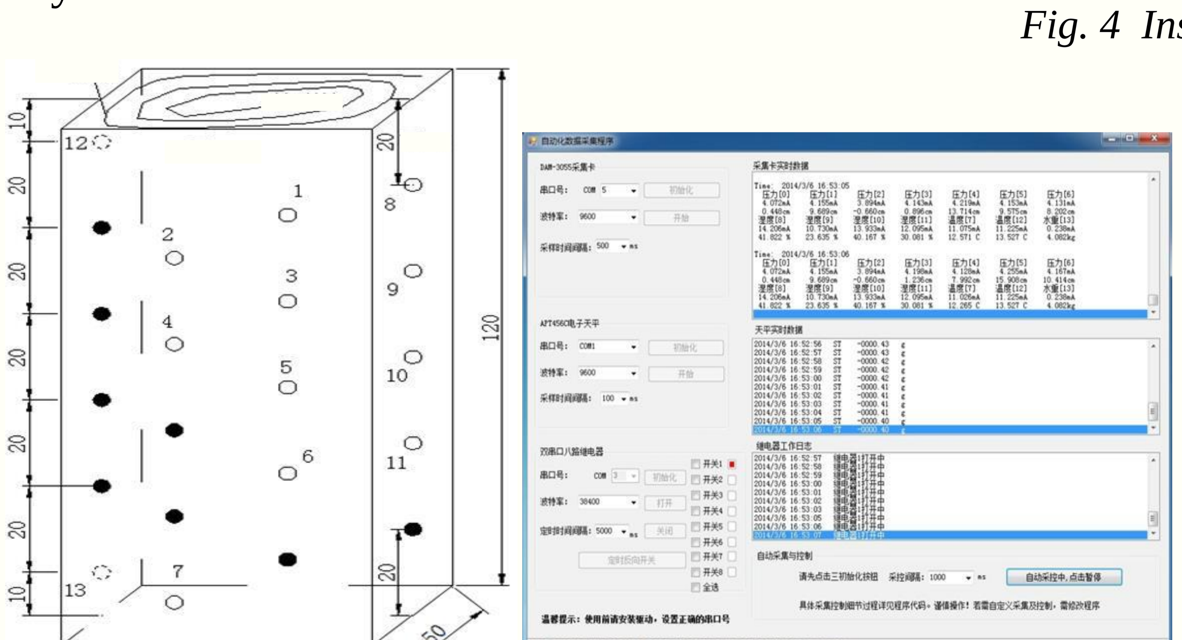

Fig. 5 Diagram of sensors and data acquisition interface

Humidity sensors and pressure sensors distribute on different heights around the outside of wall(Fig. 5).

All the sensors are controlled by computer programs and detected by data acquisition card(Fig. 5).

Protocol

Protocol for different permeable condition

Start-up Date	Initial Rainfall(kg)	Ending Date	Final Rainfall(kg)	Boundary Condition	Initial Humidity
18/12/14 17:48:14	14.39	18/12/14 20:04:28	14.25	Permeable	27.65
19/12/14 11:10:26	24.53	19/12/14 17:49:41	24.40	Permeable	31.68
12/03/15 16:02:35	35.37	15/3/15 17:15:19	26.50	Impermeable	33.44
14/06/15 12:57:50	32.33	16/06/15 08:29:25	30.54	Impermeable	28.35

Results

The measured and calculated results of pore gas pressure and infiltration rate as functions of time are mainly presented by following figures.

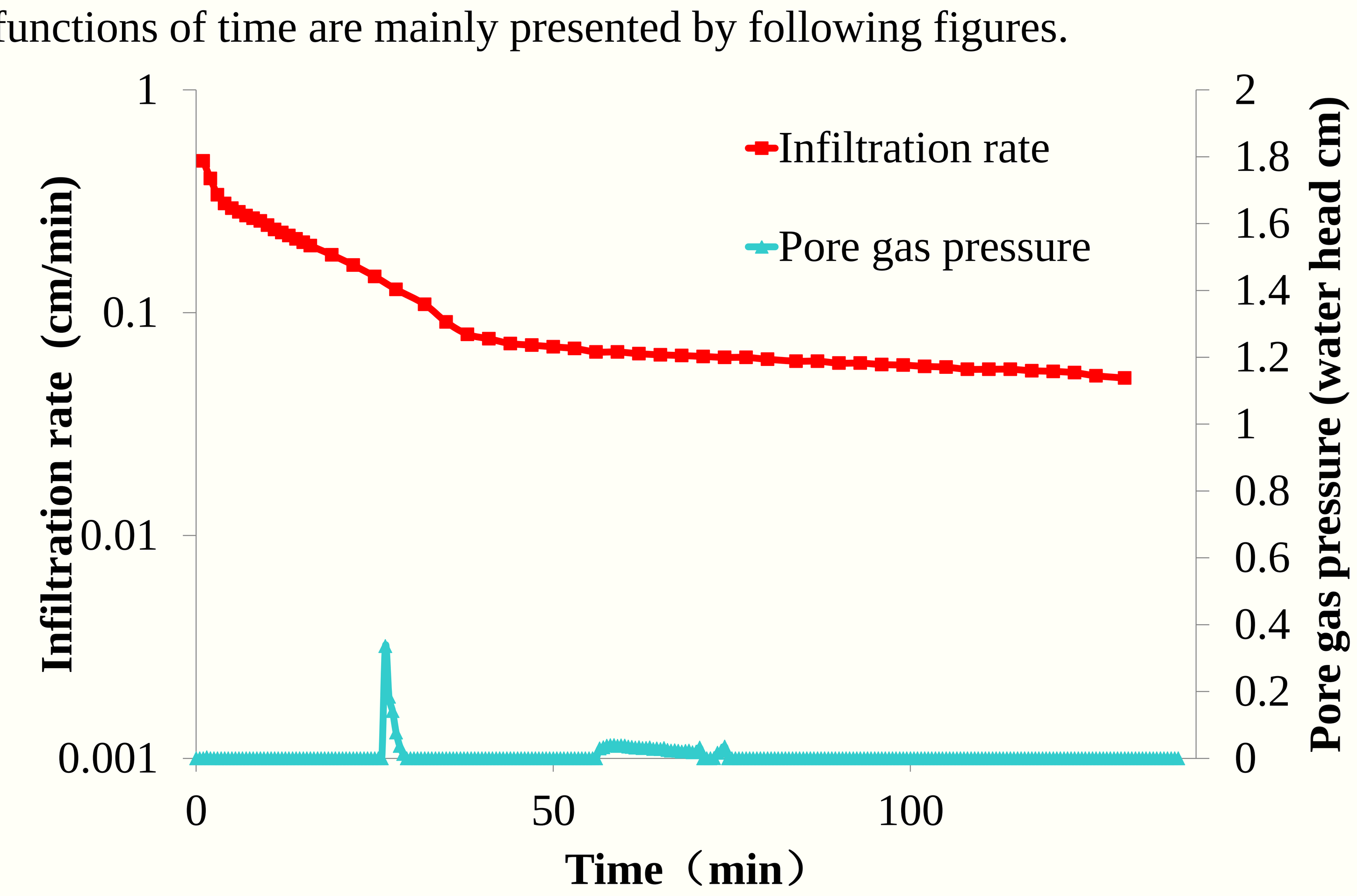

Fig. 6 Evolution of infiltration rate and pore gas pressure ***under permeable boundary condition***

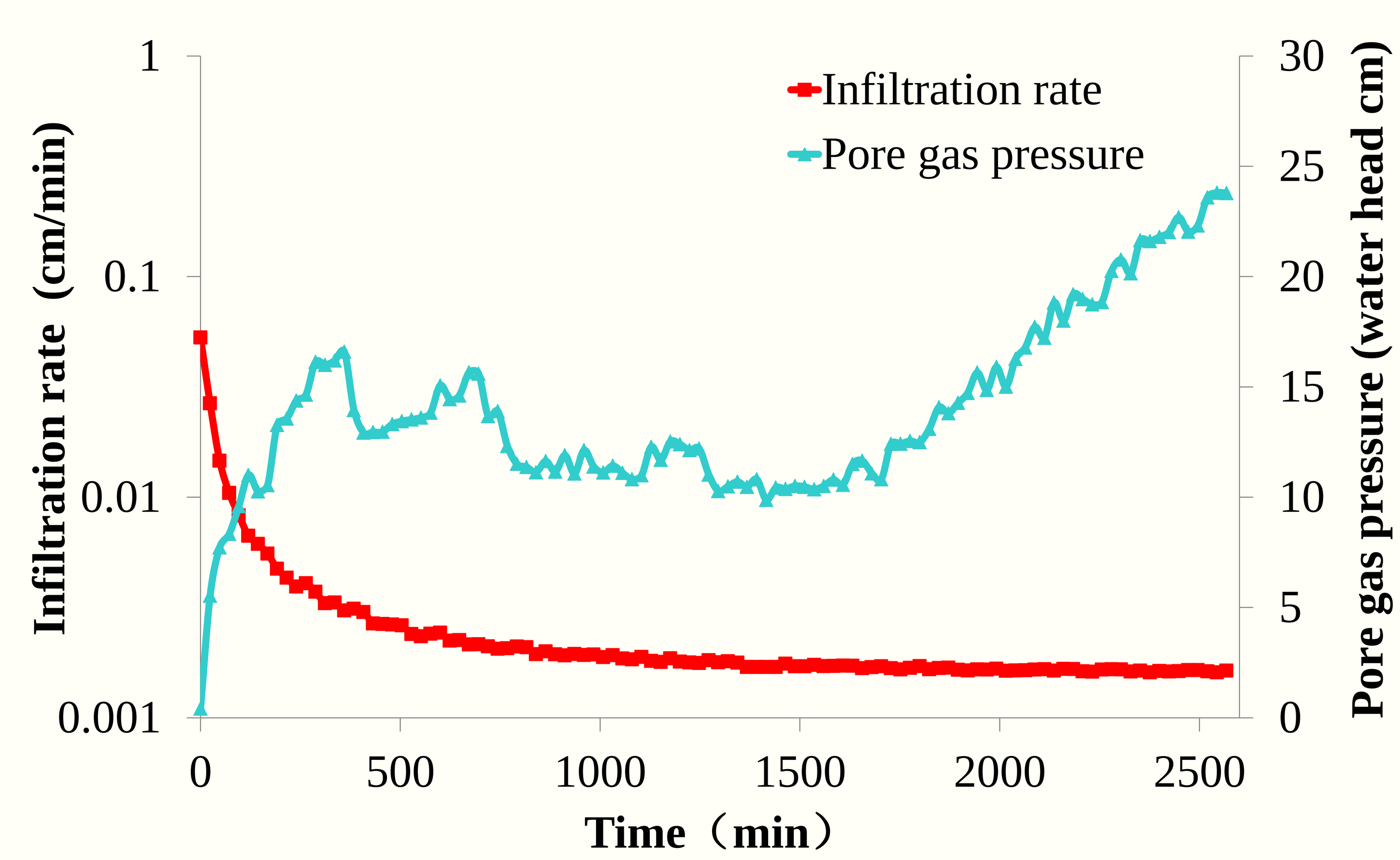

Fig. 7 Evolution of infiltration rate and pore gas pressure ***under impermeable boundary condition***

The line charts obviously show that the pore gas pressure is dramatically higher at impermeable boundary condition than permeable boundary. At the same time, the infiltration rate is strongly correlative with the pore gas pressure. At permeable boundary the gas pressure nearly equal to atmospheric pressure, and the infiltration rate is almost fifteen times higher than it at impermeable boundary. By contrast at the impermeable condition with the rapid increase of pore gas pressure the infiltration rate drop sharply. Surprisingly, after the infiltration rate is stable the pore gas pressure is still upward over the constantly rainfall process (Fig. 6&Fig. 7).

Conclusions

In summary, people basically negate the correlation between gas pressure and rainfall infiltration rate, but the evidence points out that the effect of gas pressure is in a significant position and Richard equations are not accurate under gas impermeable condition.