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# Experimental simulation study on pore clogging mechanism of porous pavement

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## HIGHLIGHTS

- Visualized method is developed to study the mechanism of pervious pavement clogging.
- Clogging process especially the internal movement of sediments is studied.
- The effects of porosity, horizontal runoff, seepage and sediment size are studied.

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## ABSTRACT

Permeability reduction caused by clogging is a major issue with porous concrete pavements. Particulate matter infiltration owing to rainwater, movement, and accumulation/deposition in the pores is the main cause of clogging in porous pavements. In this study, in order to observe the internal movement of particles in pores and the clogging evolution directly, we focus on the accumulation of transparent sodium polyacrylate beads instead of pervious concrete aggregate. The clogging process caused by particles in surface runoff entering the internal pores of porous concrete was studied, and a visualization method was applied to analyze the clogging process in porous media. The effects of the porous concrete porosity, horizontal runoff velocity, seepage velocity, and particle size distribution on the clogging development with time, clogging development rate, and particle distribution in the clogging state were studied using the control variable method. The results demonstrate that the clogging process exhibits four stages, namely rapid clogging, partial recovery, slow clogging, and clogging stability. The effects of porosity and clogging particle size on the clogging development rate are significant. Porous concrete porosity, seepage velocity, and clogging particle size all have impacts on the distributions of clogging particle in the final clogging process, while the horizontal runoff effect can be neglected.



## 1. Introduction

Portland cement pervious concrete contains a large number of interconnected pores within the aggregate skeleton. Generally, the pervious concrete porosity is between 15% and 35%, and the initial permeability is between 2 and 6 mm/s, but can be as high as 10 mm/s [7,13]. The internal structure properties and hydraulics of concrete can be analyzed using X-ray CT images [14,15]. Zhang et al. [17] studied the pore characteristics and seepage flow in pervious concrete using computed tomography (CT) imaging and numerical simulation. The relationship between the seepage velocity and pressure gradient can be fitted by the nonlinear Forchheimer formula.

However, solid matter suspended in storm water runoff can enter the pervious surface, leading to a gradual reduction in permeability [16], which decreases the service life of pervious concrete pavements [12]. Porous concrete is susceptible to clogging within the first three years [11]. The permeability reduction of porous systems may be caused by two types of siltation processes: a slow siltation process with continuing or cyclic deposition of small sediment quantities, and a rapid siltation process triggered by a sudden slump or landslide [10]. Studies have been conducted on the slow siltation process; that is, clogging owing to long-term particle deposition or clogging phenomena based on cycle tests [9,5,8,4,6]. Kayhanian et al. [6] assessed the clogging of pervious concrete pavements in parking lots using the falling

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head method, with a National Center for Asphalt Technology (NCAT) device in the field. In order to evaluate the contribution of pores towards clogging susceptibility, Deo et al. [4] developed a falling head permeability cell to measure the clogging cycling simulation. Cui et al. [3] designed a continuous permeability measurement system to record the rapid clogging process of a pervious concrete pavement caused by storm water runoff. The tests indicated that the pore clogging process generally includes three phases: quick clogging, temporary clogging mitigation, and progressive clogging.

At present, although certain researches exist on clogging caused by the infiltration of particulate matter with rainwater, the mesoscopic mechanism of clogging inside porous concrete has not yet been intuitively established. In particular, there has been almost no direct observation of particle movements inside the pores and clogging evolution. Direct observation of the clogging process is crucial for explaining clogging causes and studying its prevention. Therefore, in this study, a comprehensive analysis of the mesomechanism of internal clogging is carried out through visualization of the porous concrete test method.

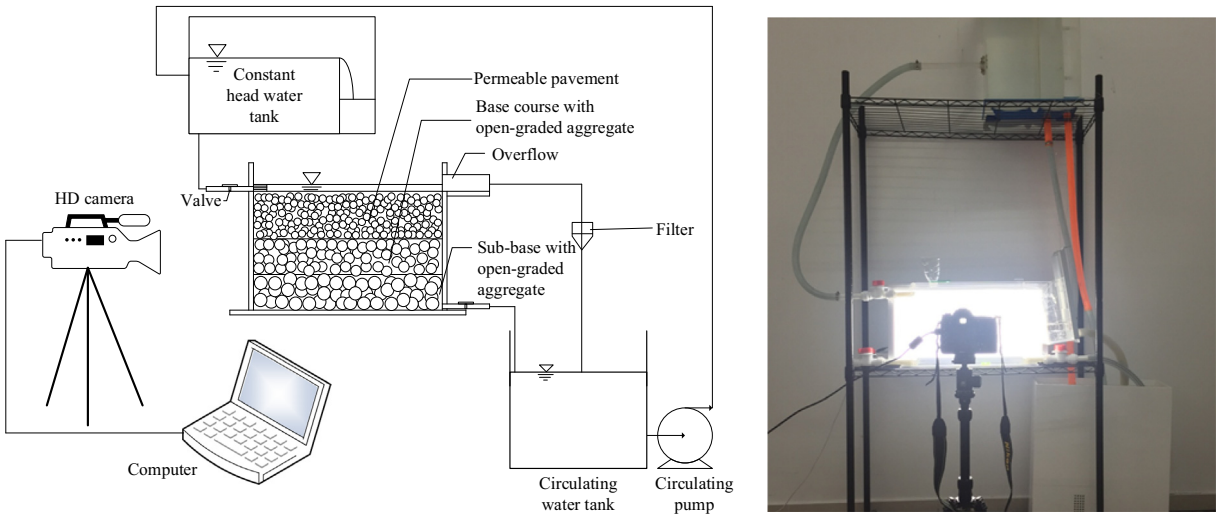
## 2. Experimental materials and processes

### 2.1. Test system design

The following experimental system was developed in order to observe the clogging process, which cannot be observed in the pores of the opaque permeable pavement structure layer. The main equipment includes a flume, circulating water tank, water pump, constant water supply tank, and HD camera, among others, as illustrated in Fig. 1.

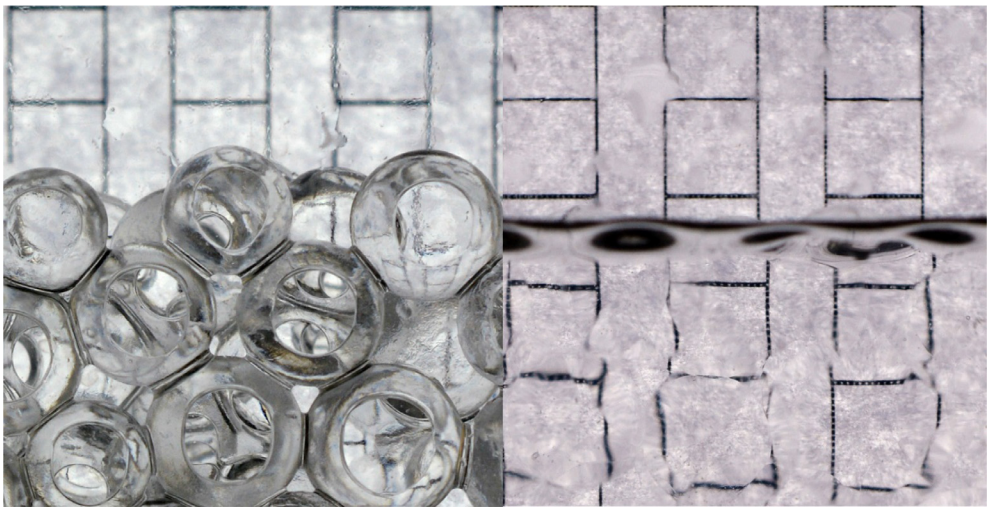
#### 2.1.1. Permeable pavement simulation device design

The main purpose of this study is to observe and record the clogging process of sediment particles in the permeable pavement structure layer pores directly, while the actual permeable pavement structure layer is not transparent. In order to study the internal pore clogging process, transparent sodium polyacrylate beads with a




(a) Schematic of test device (b) photo of test device

**Fig. 1.** Test device.



(a) Without water (b) Within water

**Fig. 2.** Porous concrete pavement experimental simulation with sodium polyacrylate beads.