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A column system for modeling bentonite slurry infiltration in sands

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Background

- A highly permeable filter cake leads to long penetration distance and less effective support force, which may cause a failure of the tunnel face.





Problems

- the change of the hydraulic conductivity of the filter cake during filter cake forming has not been studied through tests and experiments.

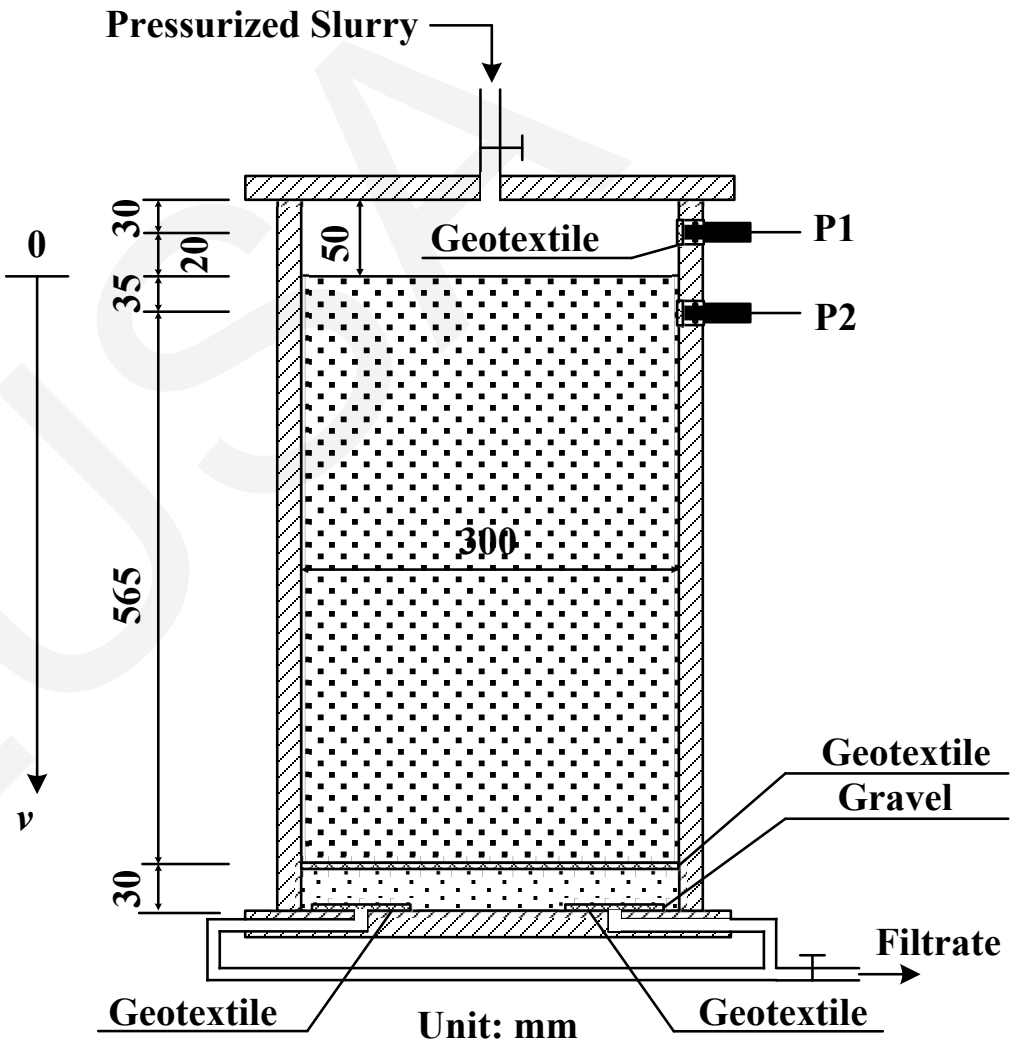
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Experimental Setup

- **Research objects:**

1. Hydraulic conductivity of the filter cake

2. Influence of the slurry infiltration



Schematic view of the infiltration column (unit: mm).

Experimental Materials

Materials:

Yangtze river sand: k_s = 2E-4 m/s, n = 0.39, d_{10} = 0.137 mm

Bentonite slurry: bentonite content 5%, $\tau_f \approx$ 2 Pa

funnel viscosity 35 s

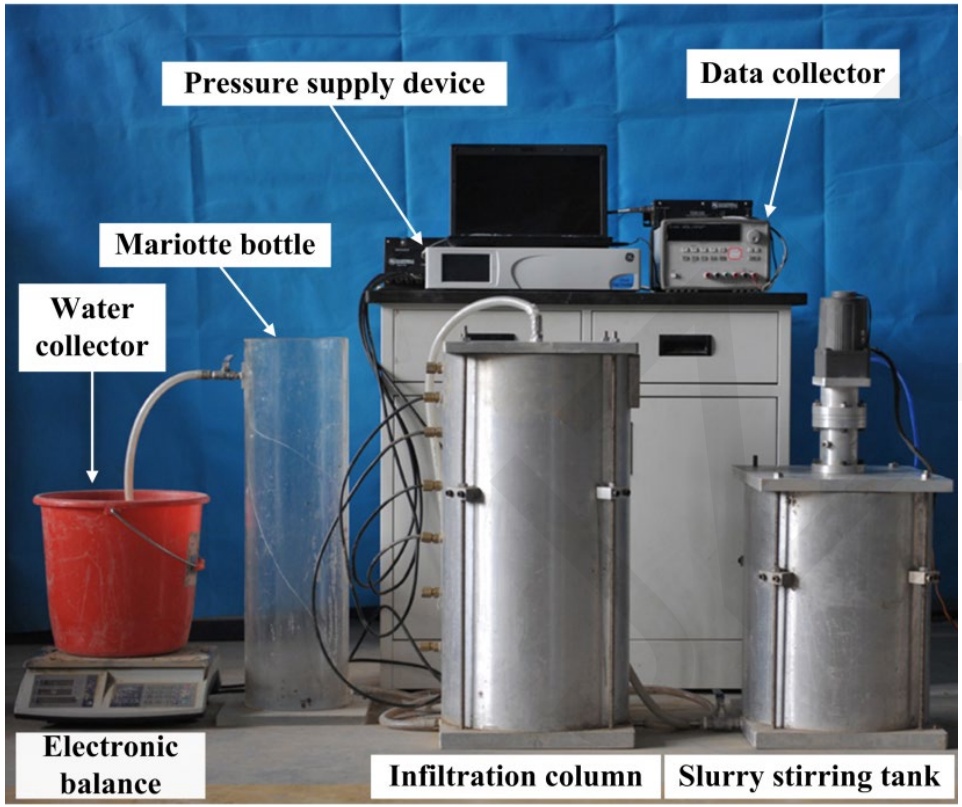
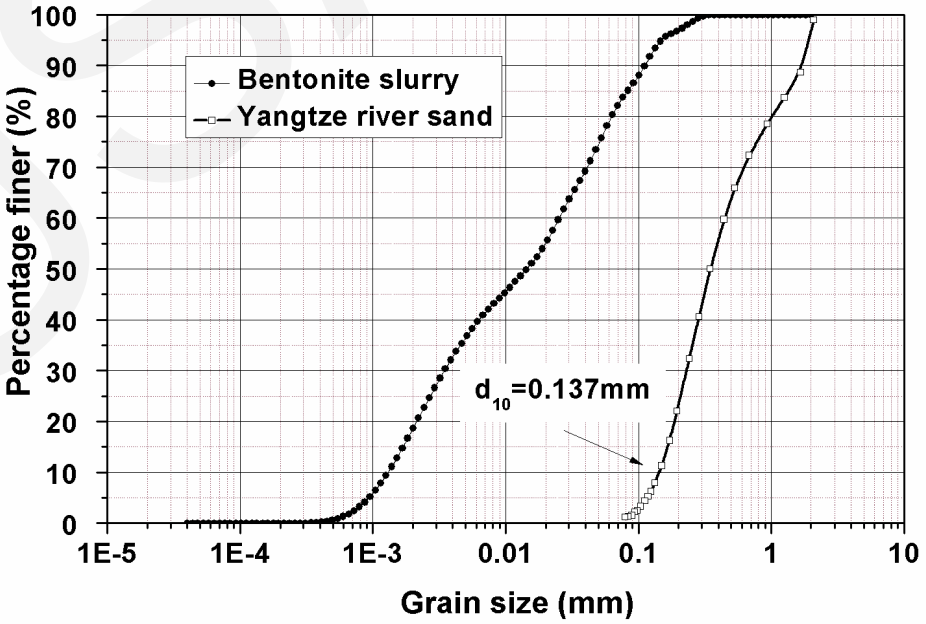
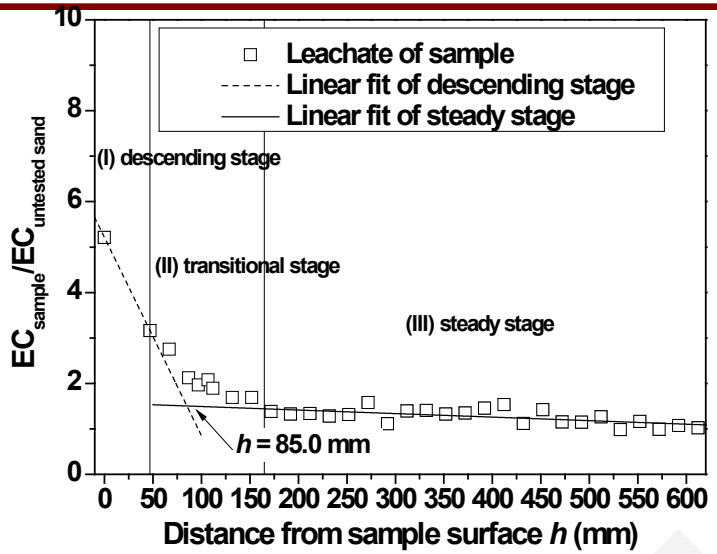


Photo of the test apparatus system

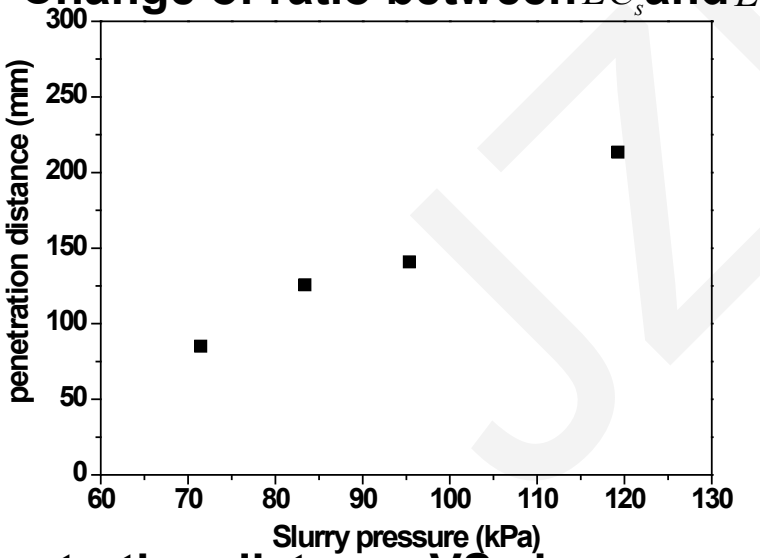


Grain size distributions of bentonite slurry and Yangtze River sands

Results

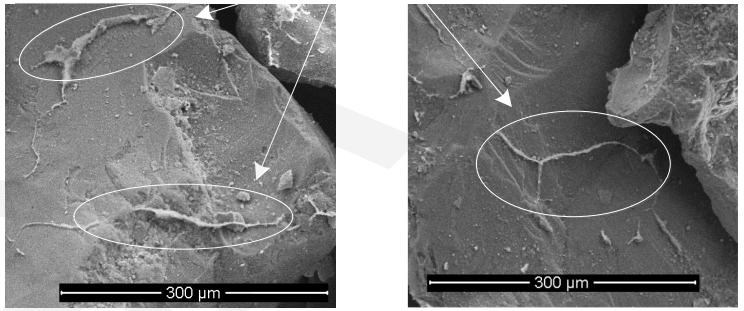


Change of ratio between EC_s and EC_u .

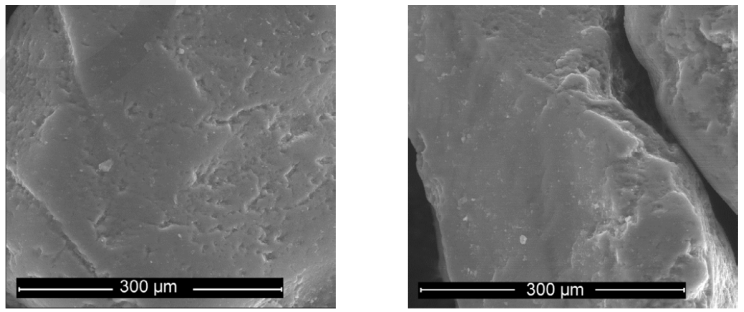


Penetration distance VS slurry pressure.

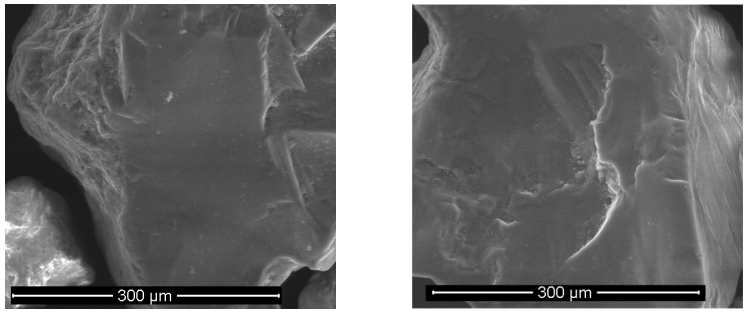
Dried aggregated solid matter of slurry



(a) h = 0 mm (on the sand specimen surface)



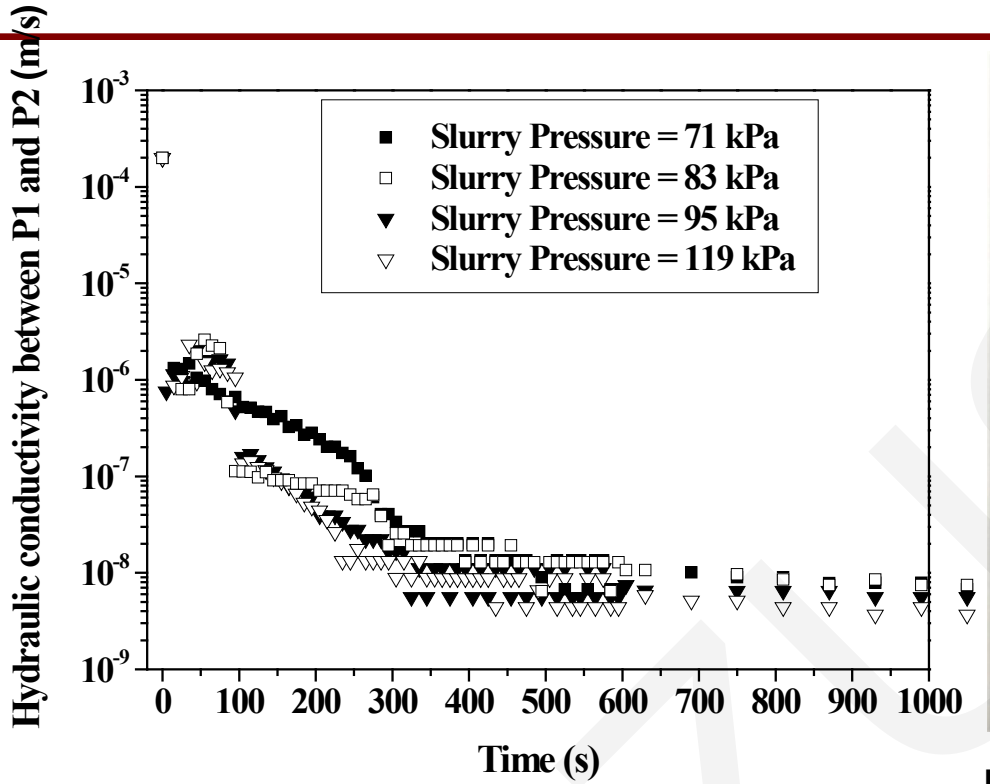
(b) h = 47mm



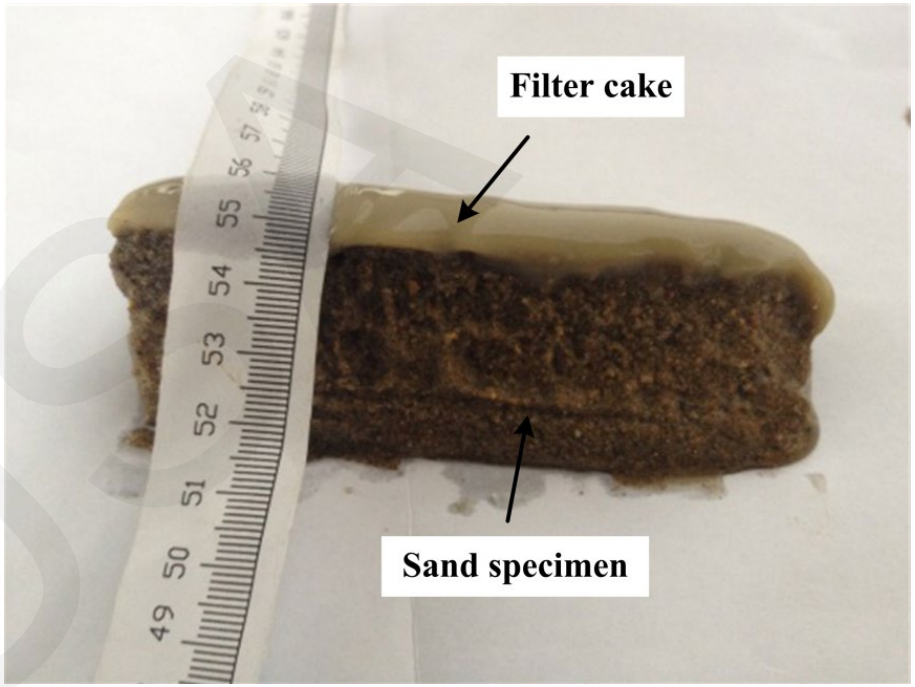
(c) h = 512mm

Microscopical sand grains

Results



Hydraulic conductivity of the filter cake VS time



Final filter cake(slurry pressure = 71 kPa)

No.	Slurry pressure (kPa)	Final thickness of filter cake (mm)	Final permeability of filter cake (m/s)
Test 1	71.48	5	5.7×10^{-10}
Test 2	83.4	4.5	5.4×10^{-10}
Test 3	95.37	4	3.2×10^{-10}
Test 4	119.26	3.5	2.2×10^{-10}

Hydraulic conductivity of the filter cake VS slurry pressure

Conclusions

A column system was developed to model slurry infiltration in sandy soil at varied excess pressures. The results show that the electrical conductivity of soil is a good indicator for estimating the slurry penetration distance. In the sand specimen, the content of slurry decreases quickly along the infiltration direction. The majority of the fine particles are within the range 100 - 300 mm in the sand specimen. This range is dependent on slurry pressure. The time for forming an impermeable filter cake is at least 300 s, which indicates the impermeable filter cake is hard to form during excavation. Greater attention should be paid to the slurry pressure on the tunnel face after the entire removal of the filter cake by cutters in advance of the slurry shield.