International Association of Chinese Infrastructure Professionals

IACIP

The 11th Annual Workshop:
Low Carbon Technologies and Resilience for Long-Lasting Infrastructure

A novel method to improve the soil erosion resistance with fungi for sustainable bridge

Xijin Zhang, Ph.D. Candidate, Case Western Reserve University, xxz677@case.edu
Xudong Fan, Ph.D. Candidate, Case Western Reserve University, xxf121@case.edu
Chen Wang, Assistant Professor, Tongji University, cwang33@tongji.edu.cn
Xiong (Bill) Yu, Professor, Case Western Reserve University, xxy21@case.edu

Background

Soil erosion leads to extensive environmental problems and compromises the serviceability of infrastructure such as bridges.

- ❖From 1960s to 1990s, over 600 bridges collapsed due to the scour erosion of bridge in United States.
- ❖The average annual cost bridge repairs related to scour erosion is estimated at $30 ~$50 million.

Fig. 1. Scour revealed as cause of bridge collapse

Objectives

In this study, a filamentous fungus, *Pleurotus ostreatus*, was used to improve soil erosion resistance.

1. The scour resistance test was carried out.
2. The mechanism of enhancing soil erosion resistance was discussed, which includes reinforcing soil and hydrophobicity of fungal mycelium fibers.
3. The anti-scouring behaviors by fungal hyphae were simulated by Finite Element Method.

Experimental Design

Fungi Growth Behaviors

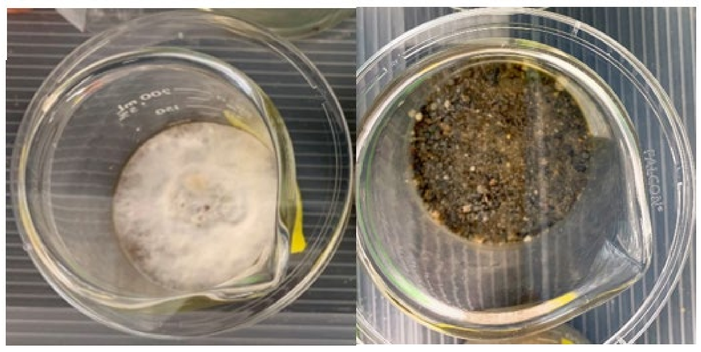


Fig. 2. (a) Fungi-mediated soil (b) Control sample

Anti-scouring test and behaviors

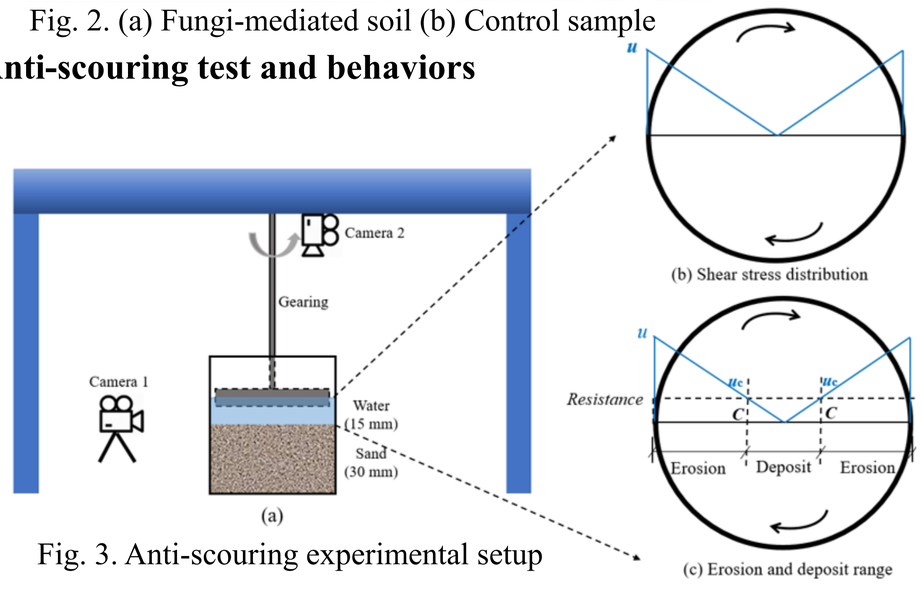
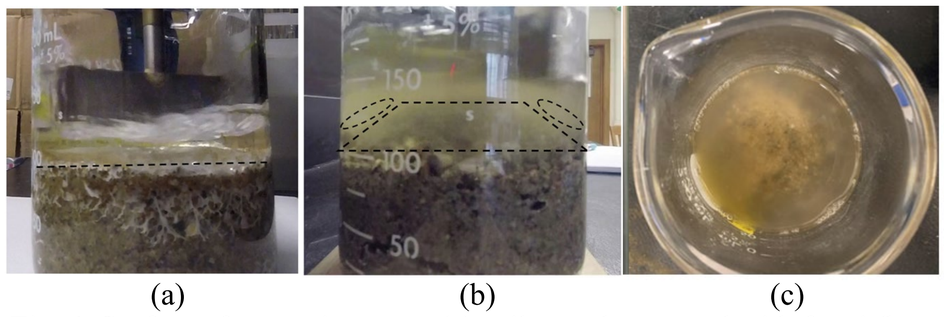


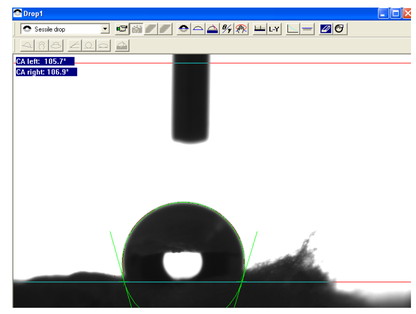
Fig. 3. Anti-scouring experimental setup



(a) (b) (c)

Fig. 4. Surface after erosion tests (a) soil sample covered with fungi (b and c) regular sand

Surface properties of fungal mycelium



Contact angle (CA) measurement result

No.	CA left (°)	CA right (°)
1	105.7	106.9
2	110.7	110.1
3	120.3	120.2
4	118.4	118.3
5	127.3	126.3
Mean ± SD	**116.48 ± 10.82**	**116.36 ± 11.00**

Fig. 5. Contact angle of mycelium

The mechanism of anti-scouring by fungal mycelium

1. Reinforcing soil particles and improving critical shear stress of soil
2. Hydrophobic surface reduces the shear stress applied on soil surface

Finite Element Model simulation

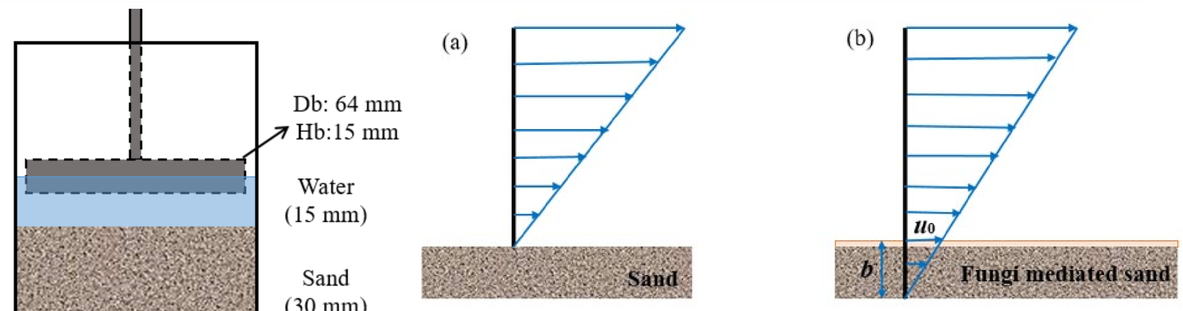
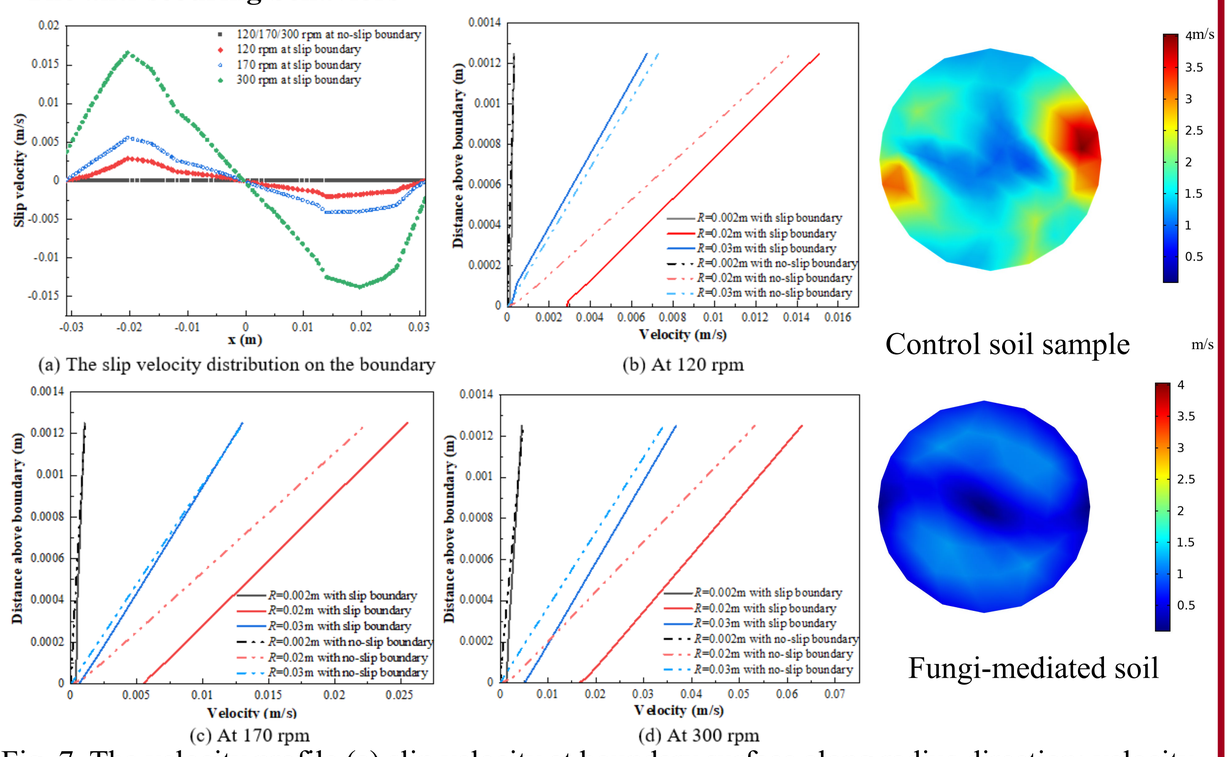


Fig. 6. Streamline slip velocity at a water-solid interface (a) no-slip boundary; (b) slip boundary

The anti-scouring behaviors

- Velocity at 120 rpm



(a) The slip velocity distribution on the boundary (b) At 120 rpm (c) At 170 rpm (d) At 300 rpm

Fig. 7. The velocity profile (a) slip velocity at boundary surface along radius direction; velocity profile near boundary along vertical direction (b) at 120 rpm; (c) at 170 rpm; (d) at 300 rpm.

Conclusion

This study presents a preliminary study of the effect of fungal mycelium on improving soil erosion resistance. Fungal mycelium was found grown successfully through the particle pores and produces the reinforcing effect on surrounding soil. After 21 days of growth, fungal mycelium covered the soil surface with a diameter of 64.20 mm. Scour resistance tests were conducted on soil sample mediated by fungal mycelium and compared with the controller group of plain soil sample. The results showed that Fungal mycelium significantly improved the scouring resistance of soil sample. The mechanism is attributed to their reinforcing effect of hyphae as well as the hydrophobic property of fungal mycelium surface. Noteworthy, the hydrophobicity of mycelium causes a slipping effect at the water and soil interface and the FEM simulation results showed the existence of mycelium reduces the shear stresses at the boundary.