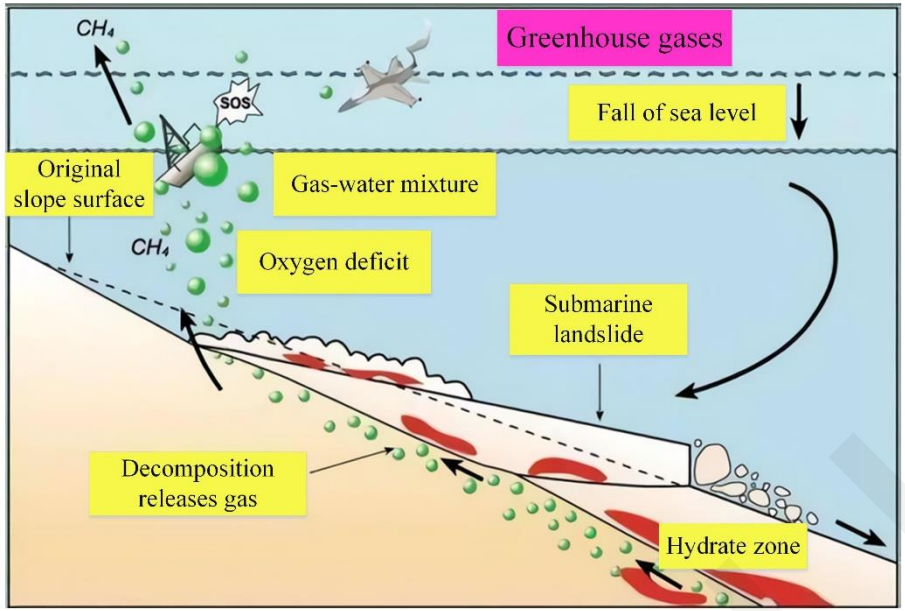
Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)

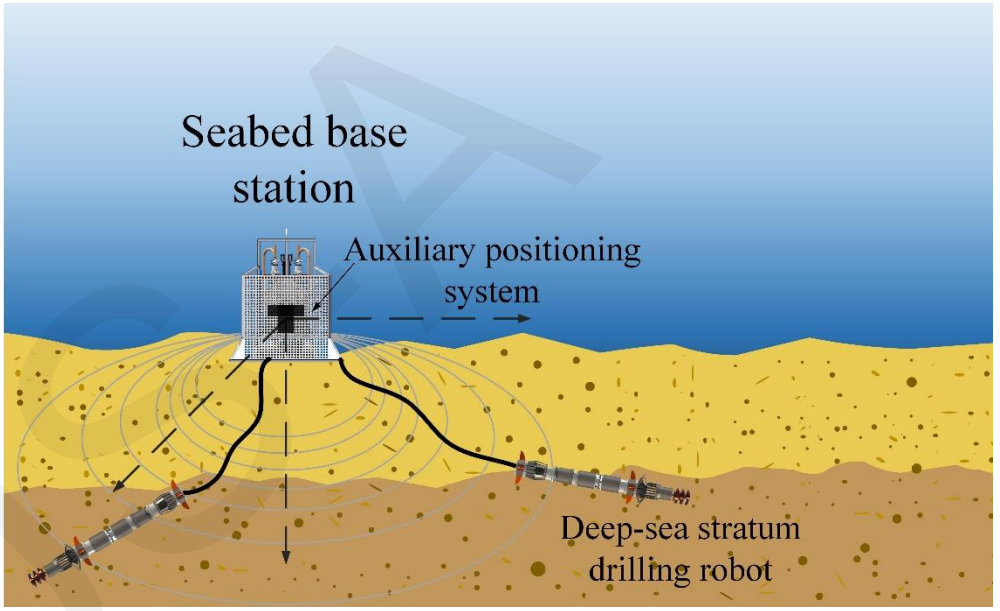
Design and comparative analysis of self-propelling drill bit applied to deep-sea stratum drilling robot

Peihao ZHANG

Cite this as: Peihao ZHANG, Xingshuang LIN, Hao WANG, Jiawang CHEN, Zhenwei TIAN, Zixin WENG, Ziqiang REN, Peng ZHOU, 2023. Design and comparative analysis of self-propelling drill bit applied to deep-sea stratum drilling robot. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 24(10):925-936. https://doi.org/10.1631/jzus.A2200351

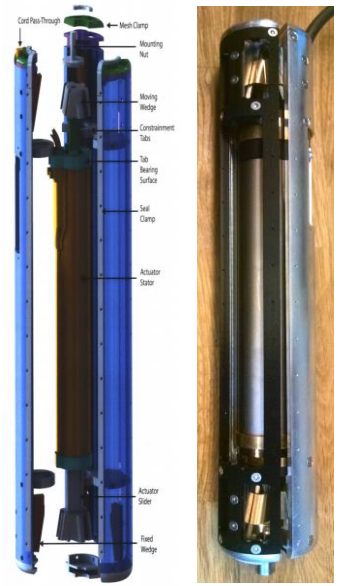
Background —Hydrate decomposition and subsea strata exploration



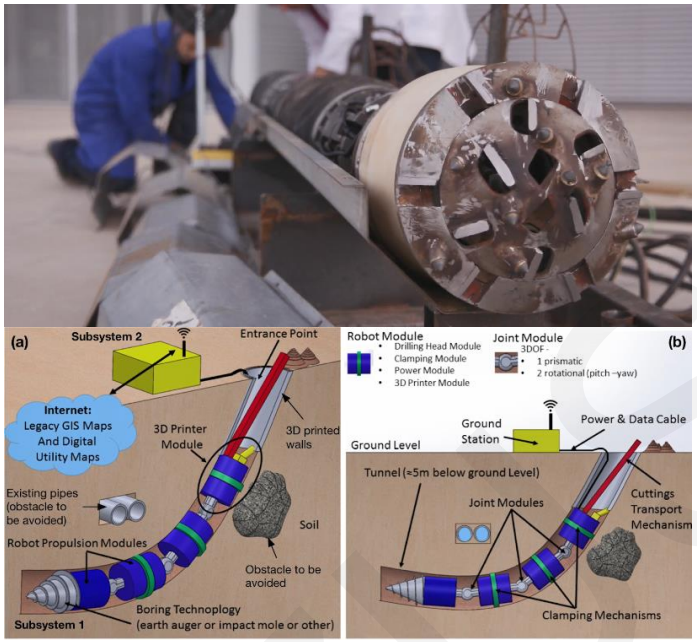


- In recent years, subsea gas hydrates attracted attention due to broad energy prospects.
- Exploitation changes the reservoir condition, and it may cause marine geological disasters.
- A new tool to explore and monitor the subsea sediment strata has been designed — deep-sea stratum drilling robot.

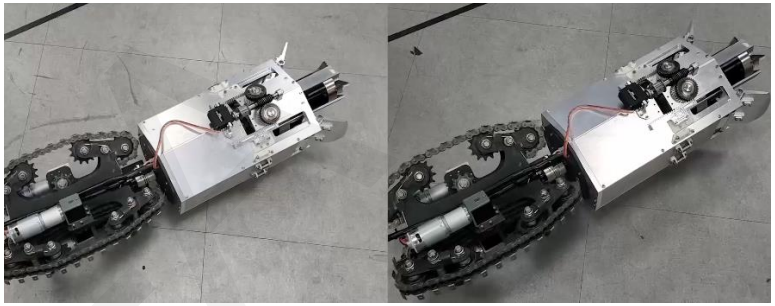
Introduction—Exploration drilling robot



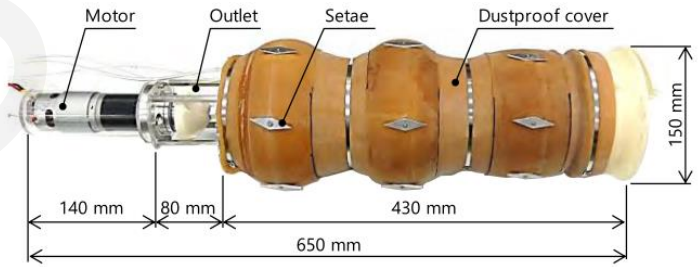
RoboClam (MIT)



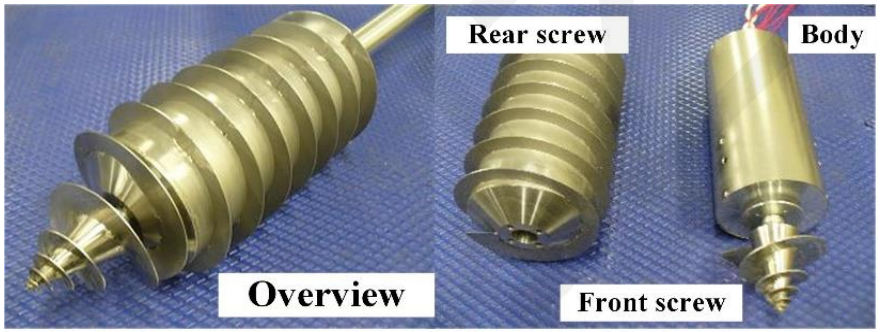
Badger Explorer



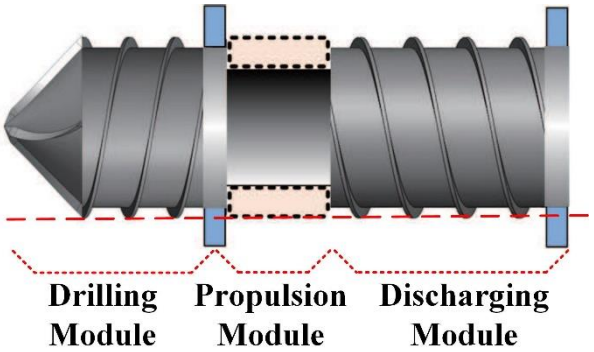
MoleBot (KAIST)



SEAVO series (Chuo University)



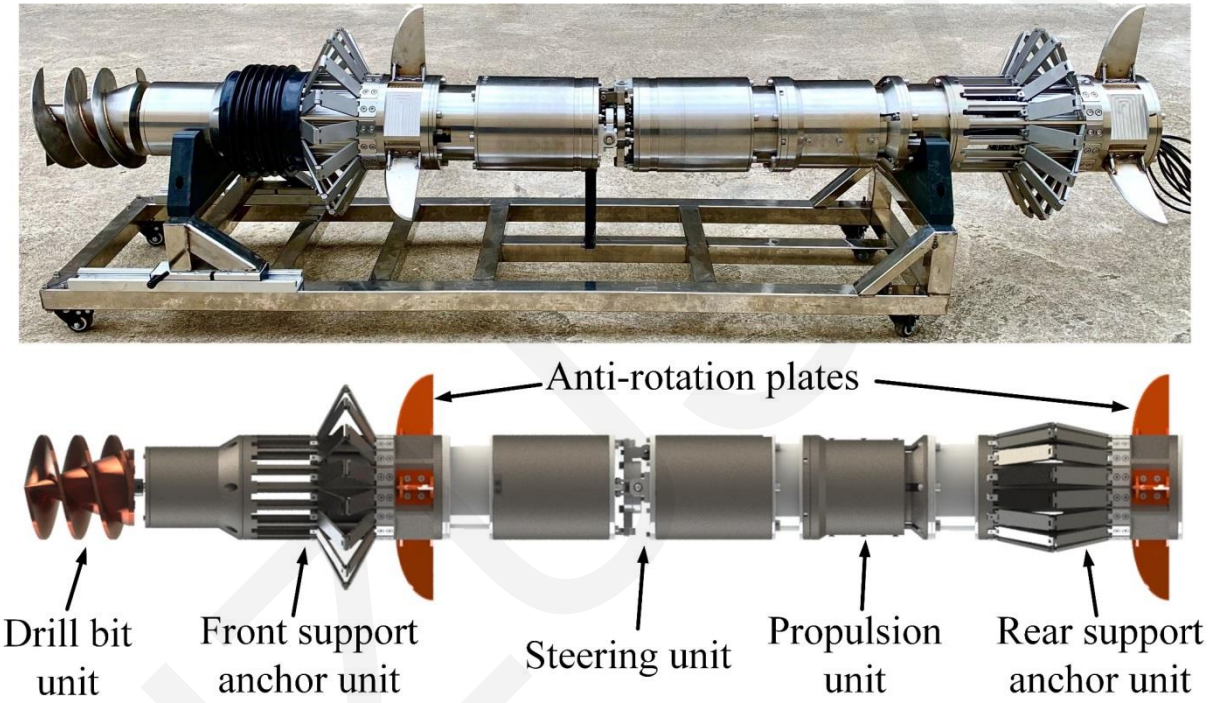
Autonomous Burrowing Screw Robot (JAXA)



Inchworm Boring Robot (HIT)

Mechanical structure design

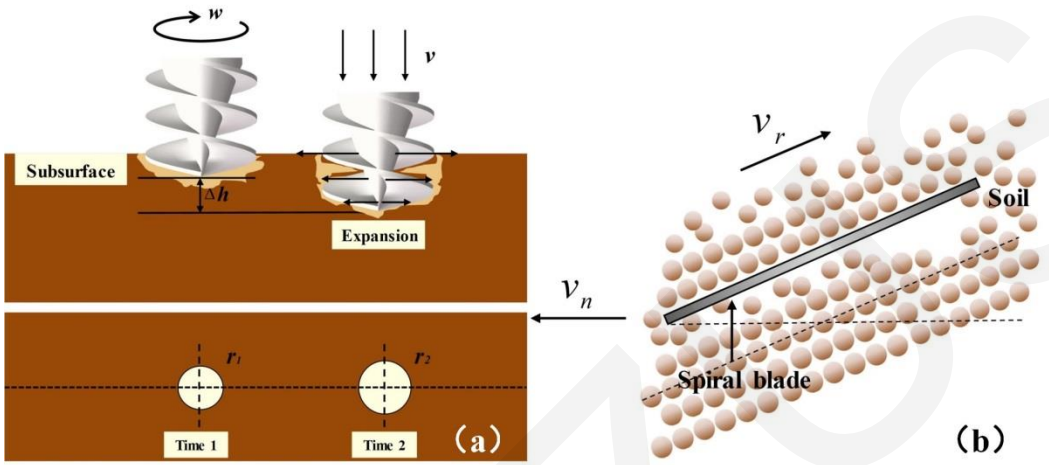
- **The deep-sea stratum drilling robot**



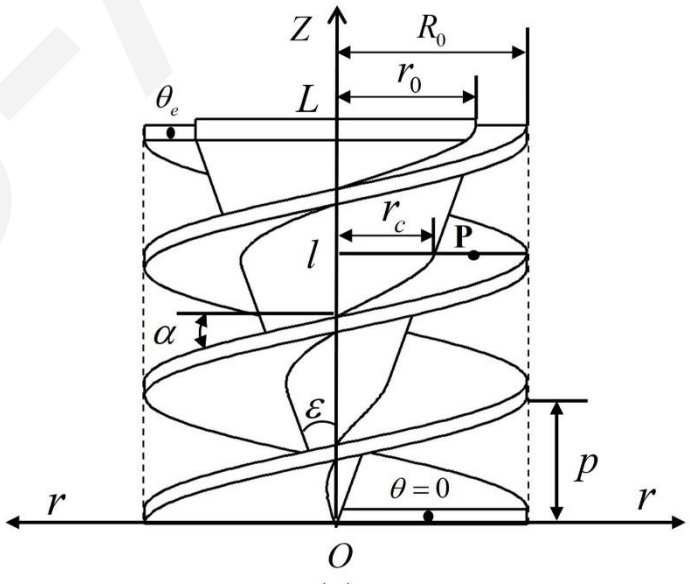
Prototype and 3D structure of the deep-sea drilling robot

It comprises five units: a drill bit, front support-anchor unit, steering unit, propulsion unit, and a rear supporting-anchor unit.

Analysis of the drill bit motion process



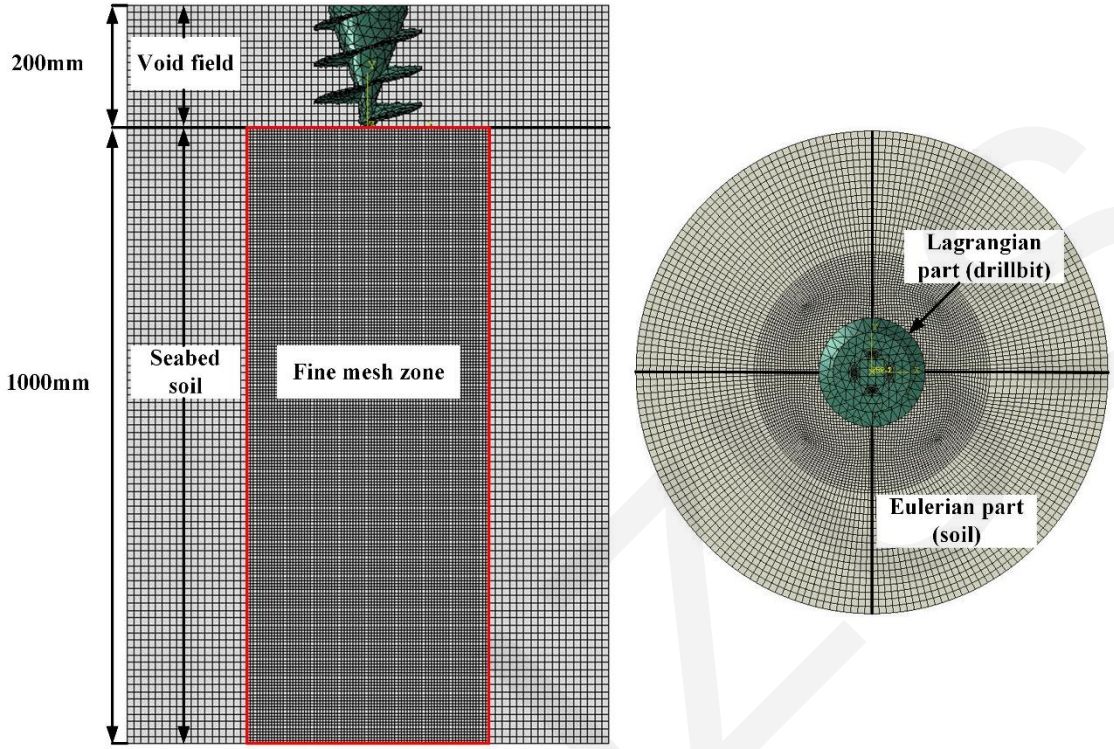
A schematic diagram of the drilling process and drill bit (a) Drilling process (b) Soil debris transportation



Geometric model of the self-propelling screw drill bit

JZUS-A

Comparison of bits by FEM simulation

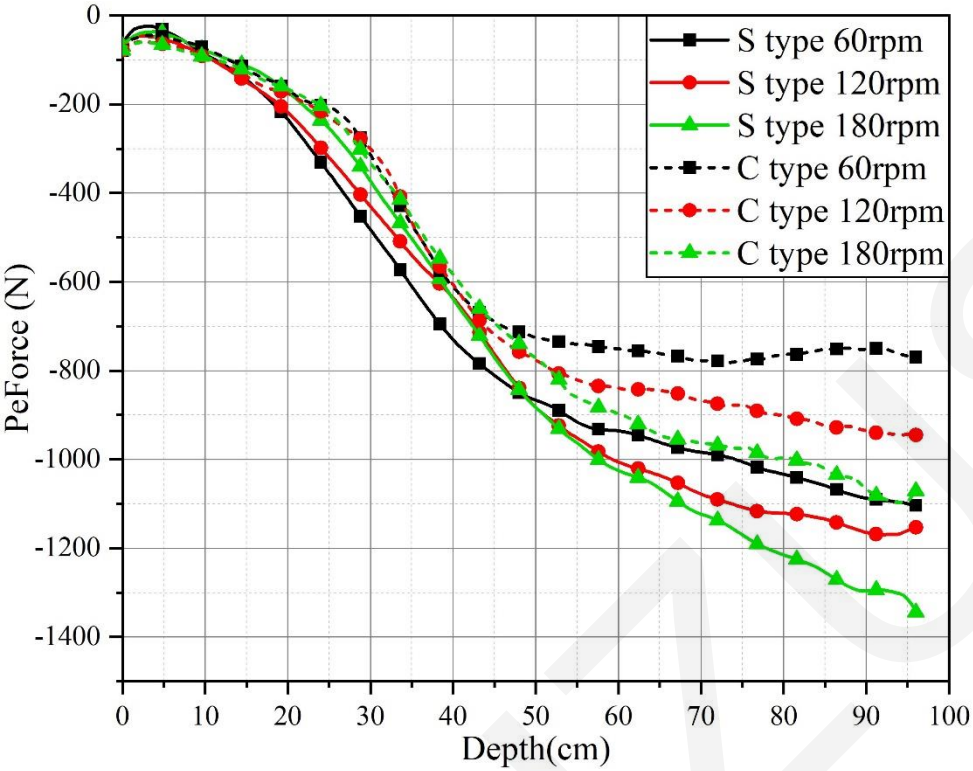


Meshes of S-type bit drilling simulation used in CEL analysis

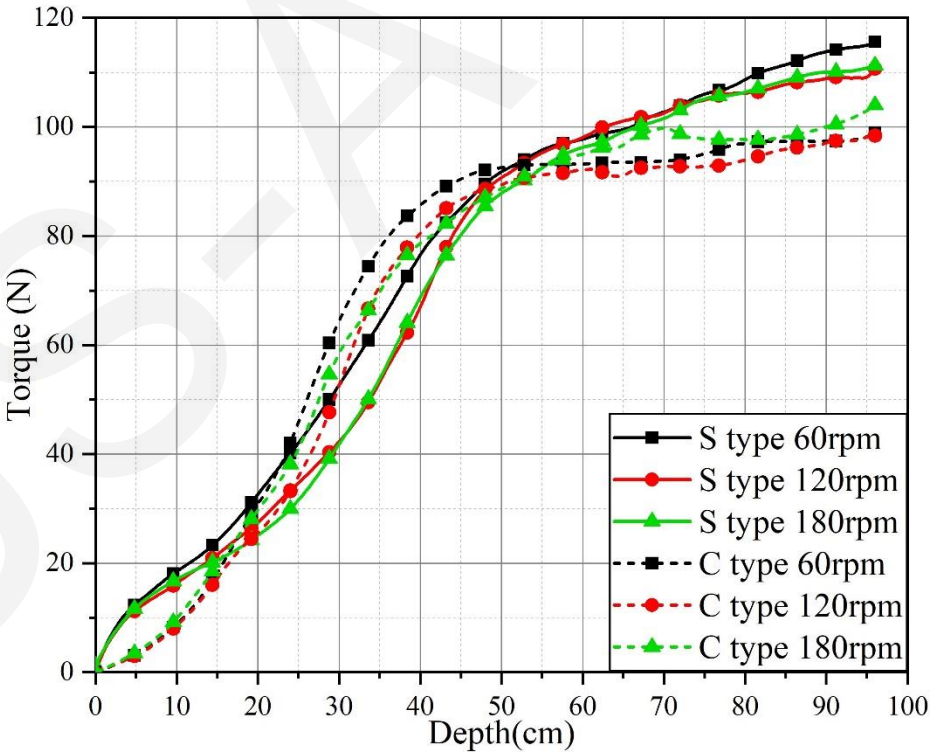
Parameter Type	Data
Mass Density	1440 kg/m^3
Young's Modulus	5×10^5 Pa
Poisson's Ratio	0.32
Cohesive Yield Stress	5×10^3 Pa
Friction Angle	20°
Mass Density	7800 kg/m^3
Young's Modulus	2.1×10^9 Pa
Penetration	20 mm/s
Rotation	60 rpm 120 rpm 180 rpm

Parameter setting in Abaqus

Comparison of bits by FEM simulation

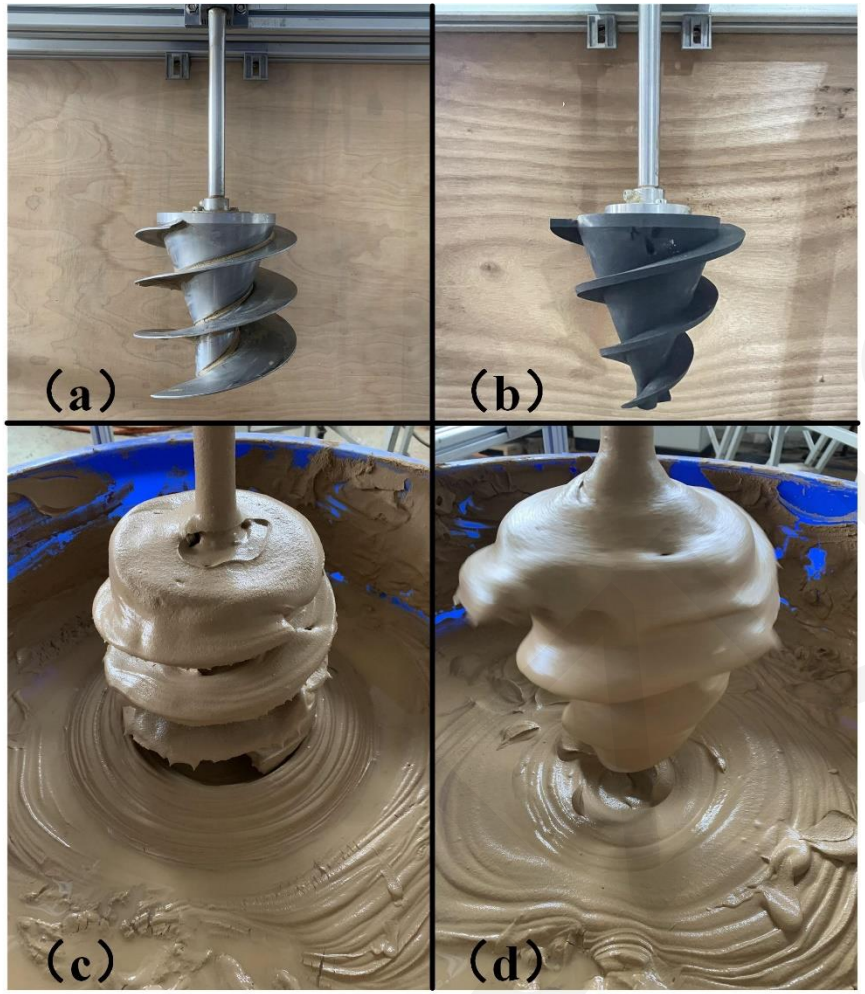


The penetration forces of S-type and C-type bits in the drilling simulation

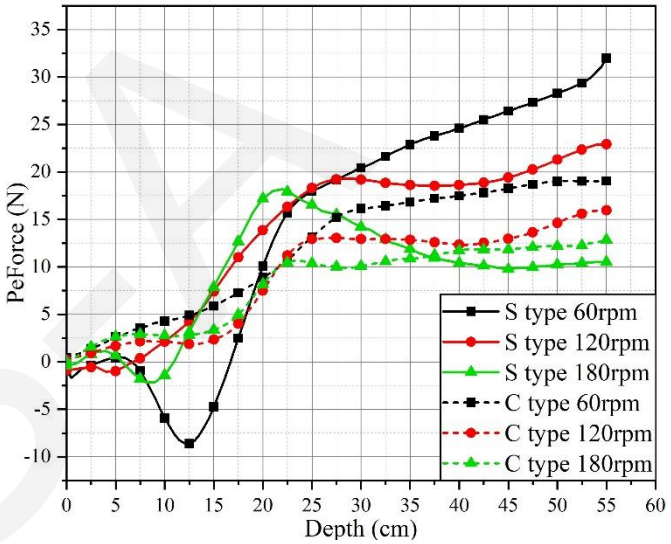


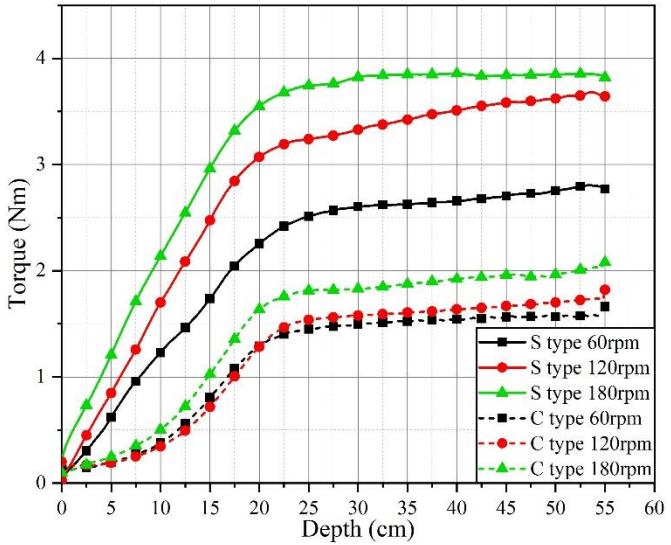
The torques of the S-type bit (left) and C-type bit (right) in the drilling simulation

Drilling resistance test



Test procedure for the two types of drill bits





The penetration forces and torques of bits

Conclusions

In this study, the designed self-propelling drill bit has the ability to convert the soil debris discharging process into propulsive force while drilling.

1. The range of soil stress response caused by the self-propelling drill bit is smaller than that of a conventional conical bit.

2. The self-propelling drill bit can reduce penetration resistance by discharging.

3. The propulsive force of the self-propelling drill bit increases with the rotation speed.

4. The torque of self-propelling drill bit was greater than that of the conical drill bit.

JZUS-A