

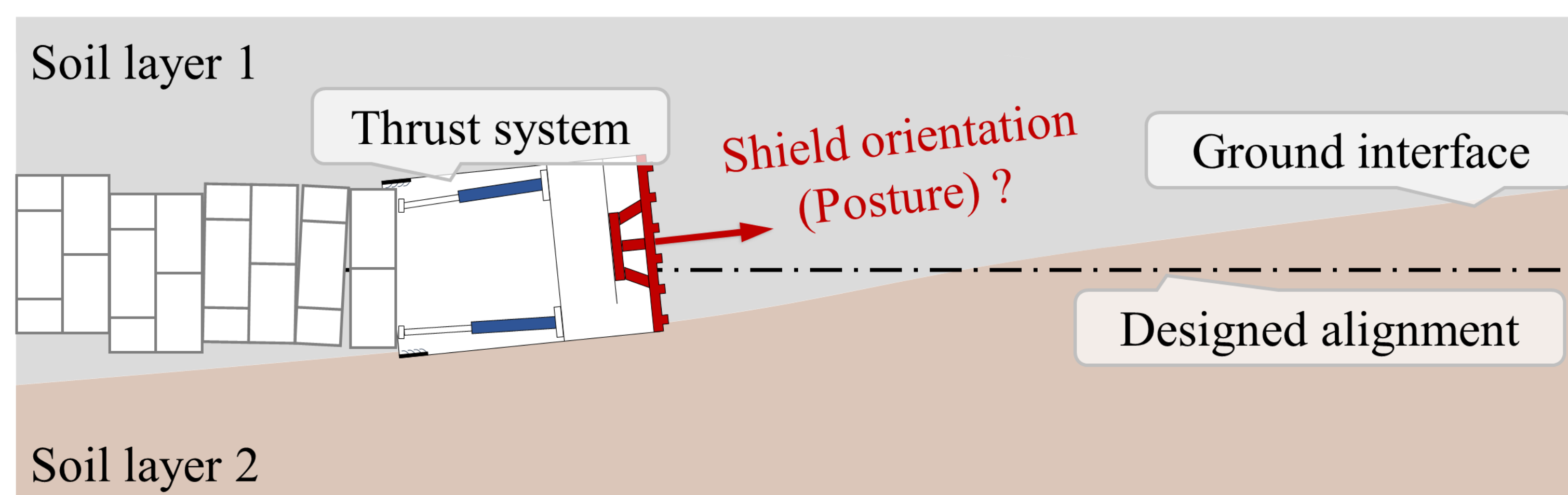
A High-fidelity Finite Element Model for Earth Pressure Balance Shield Tunneling under Complex Geological Conditions



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Introduction

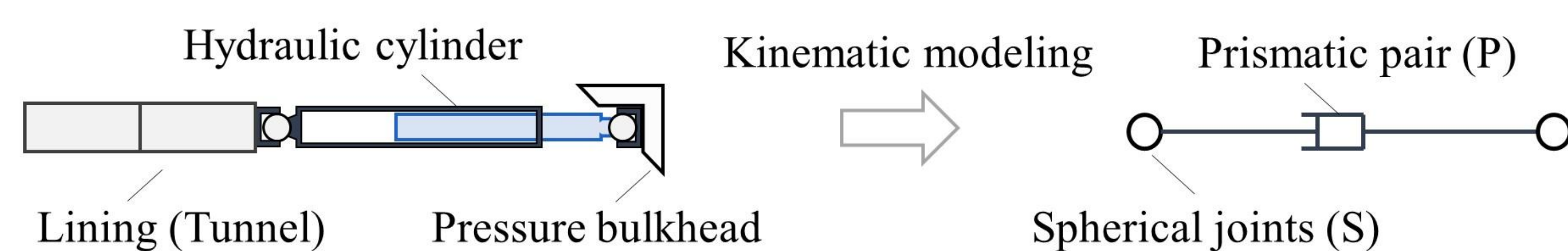
- Shield-ground interaction delineates the coupled ground responses and shield kinematics during tunneling and is closely associated with construction risks.
- However, its underlying mechanisms remain insufficiently understood, particularly under complex geological conditions, which hinders the further development of automated tunneling systems.



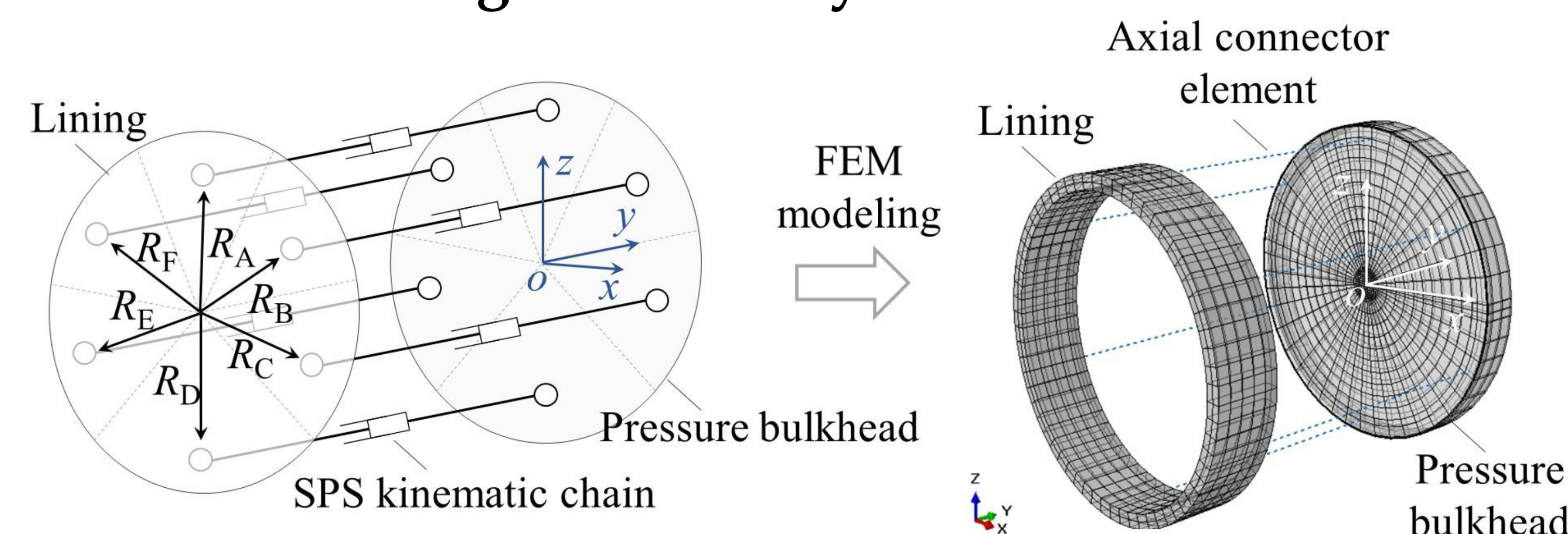
Methods

Step I: FEM modeling for shield tunneling

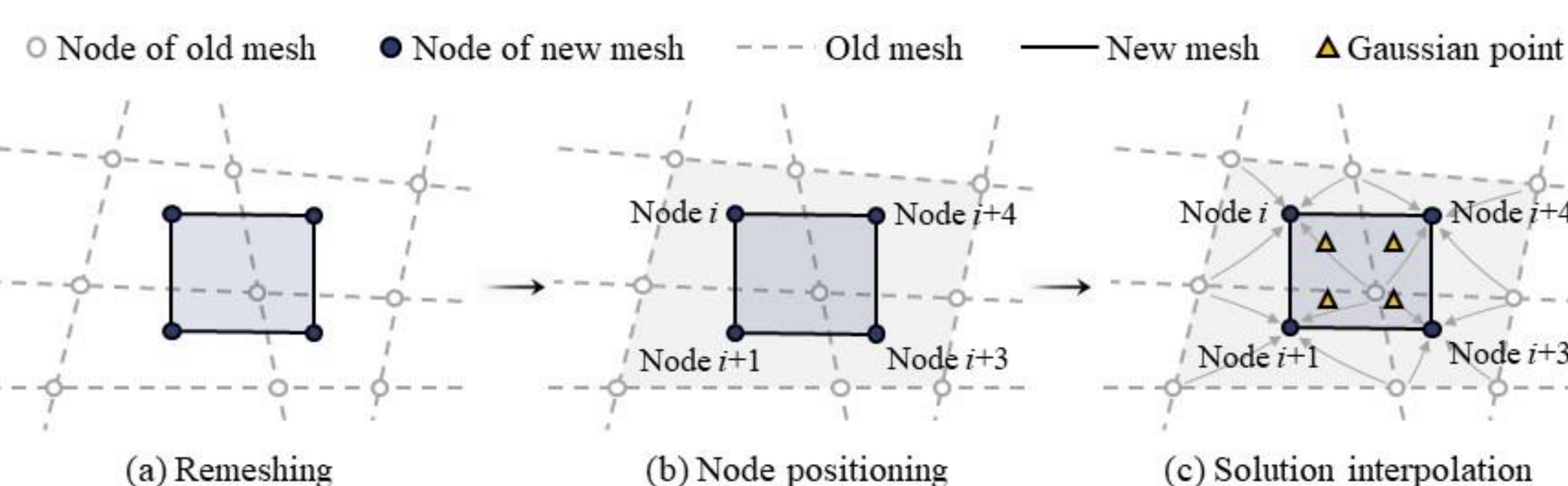
A. Parallel mechanism modeling for thrust system



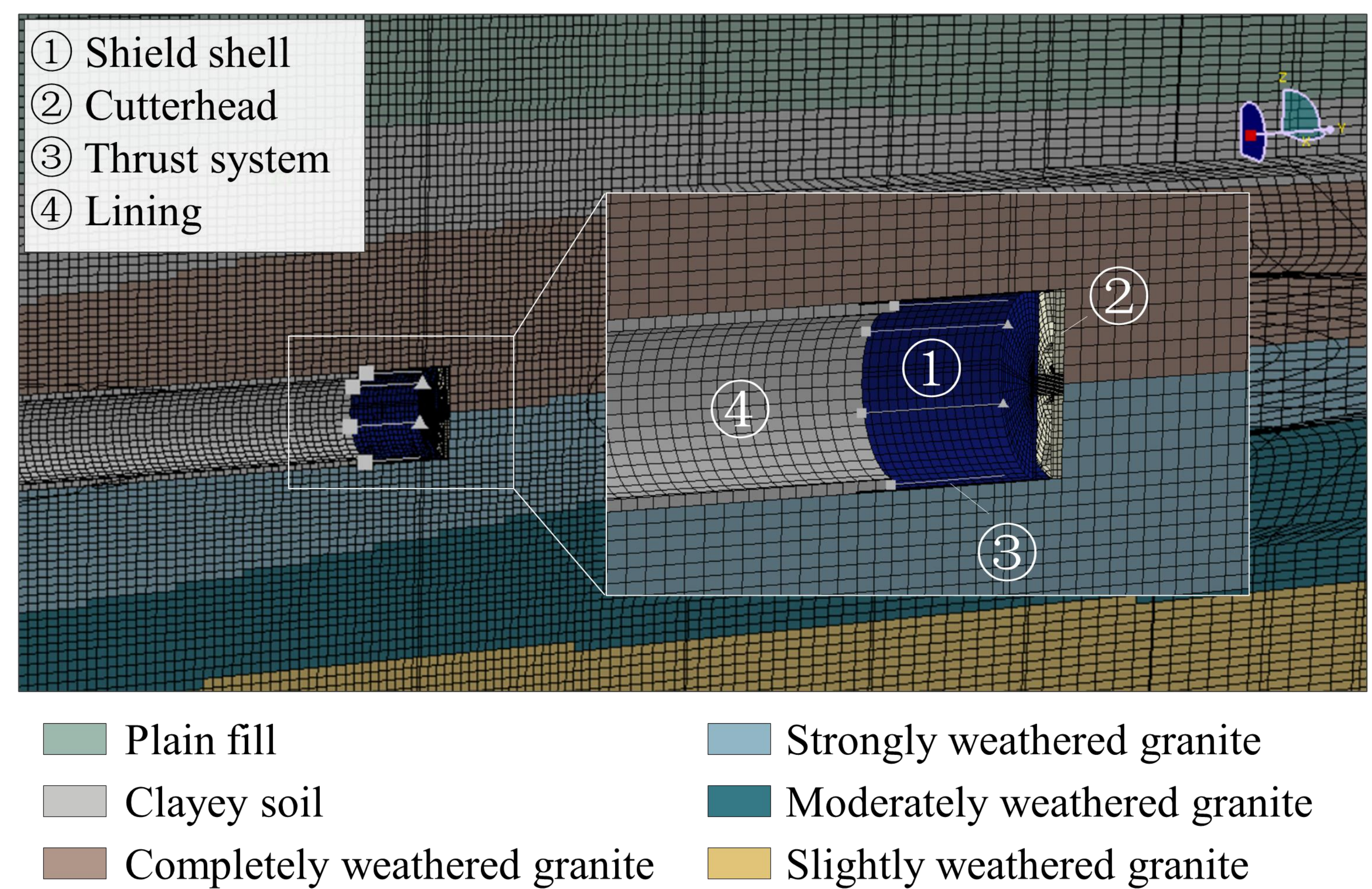
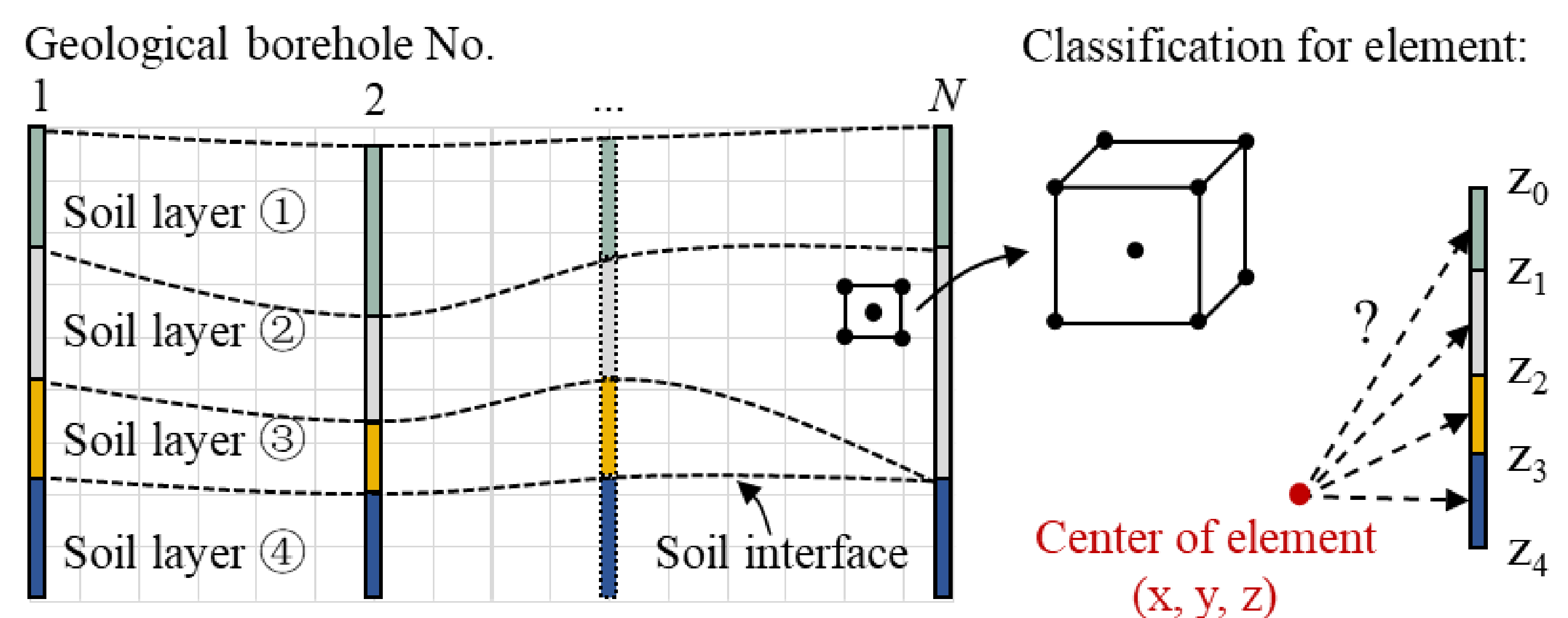
B. FEM modeling for thrust system



C. Mesh-to-mesh solution mapping



Step II: Geological information mapping



Results and Conclusions

- A high-fidelity 3D FEM framework is developed for EPBM shield tunnelling in complex geological conditions.
- The proposed model can accurately reproduce ground deformation, shield posture evolution, and shield shell mechanical response, with good agreement with field observations.
- The spatial heterogeneity of ground conditions governs the development of asymmetric deformation, stress redistribution, and soil-arching effects during the shield tunneling.
- Steering motion generates pronounced asymmetric earth pressure on either side of the shield tail, demonstrating the critical role of shield eccentric loading in the shield posture evolution.