Postprint: Study on Shield-Ground Interaction Model and Solution Considering Active Articulation

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Abstract

Shield-soil interaction has always been a research hotspot in both academic and industrial communities. For active articulated shields, the presence of active articulation devices exerts a non-negligible influence on shield-soil interaction. In view of this, a shield-soil interaction model considering active articulation is proposed, with model solution implemented based on a time-incremental process. On this basis, case study validation is conducted relying on the Binzhong section of the Fuzhou Binhai Express Line, and the influence laws of active articulation on shield diving phenomenon, soil pressure on shield shell, and resultant moment of thrust cylinders are further investigated. The main conclusions are as follows: 1) The computational model considering active articulation and its solution method can more accurately reflect shield-soil interaction during continuous excavation; 2) The increase of pitch articulation angle significantly improves the shield diving phenomenon; 3) When the ground subgrade coefficient is small, the articulation angle is approximately linearly correlated with the resultant moment of soil pressure on shield shell, and as the subgrade coefficient continues to increase, the relationship gradually transitions to nonlinearity; in upper-soft lower-hard ground, there are certain differences in the resultant soil pressure moments generated by different pitch articulation directions, which become more pronounced as the articulation degree increases; 4) Within the range of small-angle correction, giving the shield a certain articulation angle can effectively reduce the required moment of thrust cylinders, thereby achieving efficient attitude control. The above research findings can provide theoretical support for subsequent shield axis deviation calculation and attitude control strategies.

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Full Text

A Shield-Strata Interaction Model Considering Active Articulation and Its Solution

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Abstract

Shield-strata interaction has long been a research focus in both academic and engineering circles. For shield machines with active articulation, the influence of articulation devices on shield-strata interaction cannot be overlooked. This paper proposes a shield-strata interaction model that explicitly considers active articulation and implements its solution through a time-increment process. Building upon this framework, a case study verification is conducted using the Binzhong section of the Fuzhou Binhai Express Line, with further investigation into how active articulation affects shield pitching phenomena, earth pressure distribution on the shield shell, and the resultant moment of thrust cylinder forces. The main conclusions are as follows: (1) The computational model and its solution method, which incorporate active articulation, can more accurately capture shield-strata interaction during continuous excavation; (2) Increasing the pitch articulation angle significantly mitigates shield pitching tendencies; (3) When the ground subgrade reaction coefficient is relatively small, the articulation angle exhibits an approximately linear relationship with the resultant moment of earth pressure on the shield shell, though this relationship becomes increasingly nonlinear as the subgrade reaction coefficient grows. In upper-soft lower-hard strata, different pitch articulation directions produce distinct earth pressure resultant moments, with these differences becoming more pronounced as articulation magnitude increases; (4) Within the range of small-angle corrections, imposing a certain articulation angle on the shield can effectively reduce the required thrust cylinder moment, thereby enabling efficient attitude control. These research findings provide theoretical support for subsequent calculations of shield alignment deviation and the development of attitude control strategies.

Keywords: shield tunneling; shield attitude; active articulation; shield-strata interaction; incremental process

Note: Figure translations are in progress. See original paper for figures.