Research and Practice on Key Technologies for Analysis and Prevention of Cutterhead Mud Cake in Ultra-large Diameter Slurry Shields under Atmospheric and Pressurized Conditions - Postprint

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Date: 2025-07-29T19:11:10+00:00

Abstract

Shield tunneling is increasingly applied in underground engineering construction due to its high safety and excellent construction efficiency. During long-distance tunneling in composite strata, large-diameter slurry shields are prone to slag accumulation and poor discharge at the cutterhead front, leading to deteriorated tunneling parameters, severe tool wear, and limited tunneling efficiency. If not controlled in time, it may even cause cutterhead sludging and loss of cutting capability, strata over-excavation, surface heave or settlement, and damage to main drive seals, posing serious threats to construction safety. This paper introduces the sludging conditions associated with two different cutterhead configurations—atmospheric pressure and pressurized—employed in large-diameter slurry shield tunneling through composite strata for the Guangzhou Haizhuwan Tunnel project, analyzes the causes of mud cake formation, and proposes and applies a series of key technologies for mud cake prevention and control; additionally, a comparative study on tool service life, tunneling parameters, and tunneling efficiency is conducted for shield machines with the two different cutterhead configurations, demonstrating that pressurized cutterhead shields exhibit significant advantages in composite strata. The research findings can provide technical references for shield selection and construction in similar projects.

Full Text

Research and Practice on Mud Cake Analysis and Key Prevention and Control Technologies for Super-Large Diameter Slurry Shield Machines with Different Cutter Head Types

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Abstract

Shield tunneling methods are increasingly employed in underground engineering applications due to their high safety and excellent construction efficiency. However, during long-distance excavation through mixed ground conditions, super-large diameter slurry shield machines are prone to spoil accumulation and retention in front of the cutter head. This phenomenon leads to deteriorated excavation parameters, severe cutting tool wear, and reduced advance rates. If not promptly controlled, it can result in mud cake formation that incapacitates the cutting function, ground over-excavation, surface heave or settlement, and damage to main drive seals, thereby posing serious threats to construction safety.

This paper examines the mud cake conditions encountered during the construction of the Guangzhou Haizhuwan Tunnel, where super-large diameter slurry shield machines with two different cutter head configurations—atmospheric pressure and pressurized—were deployed in mixed ground conditions. The study analyzes the causes of mud cake formation and presents a series of key prevention and control technologies that were developed and successfully implemented. Furthermore, a comparative analysis of cutting tool service life, excavation parameters, and advance rates between the two cutter head types demonstrates that pressurized cutter head shield machines offer significant advantages in mixed ground conditions. The research findings provide valuable technical references for shield machine selection and construction in similar projects.

Keywords: super-large diameter; slurry shield; atmospheric pressure cutter head; pressurized cutter head; mud cake prevention

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