Postprint: Super-Large Diameter Shield Machine Selection and Application Effect Analysis for Haizhu Bay Tunnel

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Abstract

Haizhu Bay Tunnel is the first super-large-diameter shield tunnel in the Guangzhou region, whose construction faces complex geological conditions and is known as a "geological museum," making shield machine selection crucial to project success. This study, based on this project, comprehensively considers multiple factors to determine the shield selection scheme and analyzes its application results. The project has a total length of 4.35 km, with a shield tunnel length of 2077 m and a segment outer diameter of 14.5 m, traversing strata such as miscellaneous fill soil, sand layers, silty clay, and moderately to slightly weathered argillaceous siltstone. It also needs to pass under multiple waterways, fault zones, dense building clusters, and grind through numerous piles, making construction extremely difficult. During the shield selection process, the working principles, advantages, and disadvantages of Earth Pressure Balance (EPB) shields, slurry shields, rock tunnel boring machines (TBMs), and dual-mode/multi-mode shields were compared. Considering factors such as ground permeability coefficient, particle gradation, water pressure, and sensitivity of the surrounding environment, a slurry pressure balance shield machine was ultimately selected. For cutter head selection, a comparative test was adopted: one tunnel used a Herrenknecht atmospheric pressure cutter head shield machine, while the other used a China Railway Construction Heavy Industry (CRCHI) pressurized cutter head shield machine. Both shield machines underwent targeted designs, such as optimizing cutter head structure, rationally configuring cutting tools, and setting up flushing and wear detection devices. Application results show that the West line atmospheric pressure cutter head shield machine achieved an average daily advance rate of 4.35 m/d and an average monthly advance rate of 130.5 m/month; the East line pressurized cutter head shield machine achieved an average daily advance rate of 5.31 m/d and an average monthly advance rate of 159.4 m/month. In moderately to slightly weathered strata, the pressurized cutter head shield

machine demonstrated a significant advantage in excavation efficiency, with a monthly advance rate 57 meters higher than that of the atmospheric pressure cutter head shield machine. This project marks the first instance in China where shield machines with different cutter head types were used in the same project and similar strata, with good construction results, validating the rationality of the selection and providing valuable experience for shield selection and construction in similar projects.

Full Text

Selection and Application Effect Analysis of Ultra-Large Diameter Shield Machine for Haizhu Bay Tunnel

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Abstract

Haizhu Bay Tunnel represents Guangzhou's first ultra-large diameter shield tunnel project, confronting exceptionally complex geological conditions often characterized as a "geological museum." Shield machine selection proved critical to project success. This study examines the selection methodology and analyzes its application effectiveness based on this project. The tunnel extends 4.35 km in total length, with a shield-driven section of 2,077 m and a segment outer diameter of 14.5 m. The alignment traverses miscellaneous fill, sand layers, silty clay, and moderately to slightly weathered argillaceous siltstone strata. Construction challenges include crossing multiple waterways, fault zones, dense building clusters, and grinding through numerous pile foundations, representing extreme construction difficulty.

During shield selection, we systematically compared the operating principles, advantages, and disadvantages of earth pressure balance (EPB) shields, slurry shields, rock tunnel boring machines (TBMs), and dual-mode/multi-mode shields. Based on comprehensive evaluation of formation permeability coefficients, particle gradation, water pressure, and surrounding environmental sensitivity, a slurry balance shield machine was ultimately selected. For cutter head selection, a comparative test was implemented: one tunnel used a Herrenknecht atmospheric cutter head shield, while the other employed a CRCHI pressurized cutter head. Both machines underwent targeted design modifications, including optimized cutter head structures, rational tool configurations, and installation of flushing and wear detection systems.

Application results demonstrate that the west-line atmospheric cutter head shield achieved an average daily advance rate of 4.35 m/d and average monthly progress of 130.5 m/month, while the east-line pressurized cutter head shield attained 5.31 m/d and 159.4 m/month, respectively. In moderately to slightly weathered strata, the pressurized cutter head shield exhibited clear efficiency

advantages, achieving 57 m more monthly progress than its atmospheric counterpart. This project marks the first domestic application of different cutter head type shields within the same project under similar geological conditions, with successful outcomes that validate the selection rationality and provide valuable experience for shield selection and construction in analogous projects.

Keywords: ultra-large diameter; shield tunnel; equipment selection; cutter head selection; targeted design; application effect

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