Postprint: Study on Muck Conditioning Technology for Deep-Buried Shield Tunnel Crossing Through Full-Face Sand Layer

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Abstract

This paper, taking the EPB shield tunneling of Guangzhou Metro Line 18 through full-face sandy strata under great overburden as the engineering background, summarizes the key technologies for muck conditioning during construction and draws the following conclusions: 1) When the shield traverses water-rich sandy strata, the high water content, high groundwater pressure, and strong permeability of the muck make screw conveyor blowout likely to occur. Therefore, anti-blowout devices should be installed at the screw conveyor outlet, and corresponding muck conditioning measures should be adopted according to stratum conditions to prevent blowout. 2) During shield tunneling in water-rich sandy strata, muck conditioning represents both a critical challenge and a key focus of the construction process. Empirically, the fine particle content in typical strata should exceed 30% to impart adequate fluidity and water-sealing capacity to the muck. In this project, however, the fine particle content of the stratum was only 11%–14.5%, yet no blowout occurred and the screw conveyor discharged muck smoothly, demonstrating that the foam-only injection method employed for muck conditioning is feasible for the given interval stratum conditions. Consequently, suitable muck conditioning methods should be determined through testing and other means based on stratum conditions during construction. 3) As sandy strata are prone to collapse when disturbed, the shield should pass rapidly through sandy sections by increasing advance rate and maintaining stable construction parameters, thereby avoiding excessive stratum disturbance. Simultaneously, muck discharge volume must be strictly controlled, and the quality of synchronous grouting and secondary grouting ensured to maintain surface settlement within acceptable limits.

Full Text

Abstract

This paper investigates the critical muck conditioning technologies employed during the construction of Guangzhou Metro Line 18, where an Earth Pressure Balance (EPB) shield tunnel was advanced through deeply buried, full-face sand strata under challenging hydrogeological conditions. The study synthesizes field observations and construction performance data to derive key technical insights for similar tunneling projects.

First, tunneling through water-rich sand layers presents significant challenges due to the high moisture content, elevated groundwater pressure, and strong permeability of the excavated material, which collectively predispose the screw conveyor to water gushing. Effective mitigation strategies include the installation of anti-gushing devices at the screw conveyor outlet and the implementation of targeted muck conditioning measures calibrated to specific ground conditions. These interventions are essential for preventing blowouts and ensuring safe, continuous material discharge.

Second, muck conditioning emerges as both a primary technical challenge and a critical success factor in water-rich sand strata. Conventional empirical guidelines stipulate that fine particle content must exceed 30% to impart adequate flowability and water-sealing properties to the excavated material. However, this project successfully maintained stable excavation operations with a natural fine particle fraction of only 11% to 14.5% by employing foam injection as the sole conditioning agent. This outcome demonstrates that site-specific conditioning protocols, validated through field testing, can supersede generic empirical thresholds and achieve optimal performance.

Third, given the collapse potential of sand strata under mechanical disturbance, rapid tunnel passage is advisable to minimize ground deformation. This is accomplished by optimizing advance rates while maintaining stable operating parameters throughout the excavation cycle. Concurrently, rigorous control of excavation volume, combined with high-quality synchronous and secondary grouting operations, ensures that surface settlements remain within acceptable engineering tolerances.

Keywords: EPB shield; water-rich sand strata; gushing; muck conditioning

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