Post-print of Technical Summary on Secant Line Launching Deviation Correction Technology for Small Radius Shield Machines

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Abstract

Aiming at the technical challenge of high-precision attitude control during the initial phase of small-radius shield tunneling, this paper, based on a specific case study, innovatively integrates quantitative analysis and mechanical mechanisms to systematically summarize seven deviation correction strategies encompassing collaborative application of active articulation and overcutting cutters. The following conclusions are drawn: 1) Controlling the pressure differential of thrust cylinders is the most direct means of shield attitude control; when the thrust differential threshold $\Delta P>100$bar (taking an excavation diameter of 6280mm as an example) still fails to achieve correction effects, other auxiliary correction measures should be employed; 2) Fully leveraging the advantages of active articulation, the articulation stroke differential should be gradually increased in three steps, corresponding to 40%, 60%, and 80% of the design value; 3) When attitude remains uncontrolled, the overcutting cutter should be activated using a semi-circumferential overcutting pattern with an overcut length of 40mm, resulting in significant improvement of the shield head attitude and achieving an overcutting correction efficiency of 82%; 4) Rationally selecting segment erection positions, strictly fitting the tunnel axis according to segment taper, while appropriately retracting thrust cylinders and adjusting the contact surface between cylinder shoes and segments to eliminate lateral stress on segments; 5) Promptly conducting secondary grouting on the outer arc side of segments that have just exited the tail shield, with the grout initial setting time controlled at approximately 6h being appropriate, to prevent segments from shifting overall toward the tunnel exterior under lateral force components during correction, thereby avoiding segment damage and misalignment. Engineering applications demonstrate that this technical system successfully corrected the maximum attitude deviation exceeding the limit of 203mm in the initial section to within 50mm; from launch to ring 14, the shield attitude improved significantly, and by ring 27, the attitude was restored to within allowable limits, significantly

enhancing the safety, efficiency, and precision of small-radius shield launching, and possessing important promotional value.

Full Text

Preamble

Technical Summary on Deviation Correction for Small-Radius Secant Launch of Shield Machines

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Abstract

Addressing the technical challenge of high-precision attitude control during the launch phase of small-radius shield tunnels, this study innovatively integrates quantitative analysis with mechanical mechanisms to systematically summarize seven deviation correction strategies, including the collaborative application of active articulation and overcutting cutters. The key conclusions are as follows: (1) controlling the thrust pressure differential of the cylinders is the most direct method for shield attitude control—when a thrust differential threshold of $\Delta P >$ 100 bar (for an excavation diameter of 6280 mm) fails to achieve correction, auxiliary measures should be implemented; (2) the advantages of active articulation should be fully leveraged by gradually increasing the articulation stroke differential in three stages at 40%, 60%, and 80% of the design value; (3) if attitude remains uncontrolled, activating the overcutting cutter in a semi-circumferential overcut mode with a 40 mm overcut length significantly improves shield head attitude, achieving an overcut correction efficiency of 82%; (4) segment assembly positions should be rationally selected to strictly fit the tunnel axis according to segment taper, while appropriately retracting thrust cylinders to adjust the contact surface between cylinder shoes and segments, thereby eliminating lateral stress; and (5) secondary grouting should be promptly applied to the outer arc side of segments immediately after they exit the shield tail, with grout initial setting time controlled at approximately 6 hours to prevent outward shifting of segments under lateral force components during correction, which could otherwise cause damage and misalignment. Engineering applications demonstrate that this technical system successfully corrected launch-section attitude deviation from a maximum of 203 mm to within 50 mm, with shield attitude improving significantly by ring 14 and restored to allowable tolerances by ring 27, substantially enhancing the safety, efficiency, and precision of small-radius shield launches and demonstrating significant value for broader promotion.

Keywords: shield machine; secant launch; small radius; deviation correction

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