Experimental Study on Mix Ratio of Slurry Shield Muck-Based Double-Fluid Grout in Silty Clay Strata Postprint

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Abstract

Slurry shield tunneling generates substantial waste soil, which not only occupies site space but also causes environmental pollution and additional disposal costs. To achieve resource utilization of waste soil and reduce construction costs, waste soil was utilized as a bentonite replacement to prepare synchronous two-component grouting slurry. Through microscopic analysis, performance testing, and other methods, the feasibility of using slurry shield tunneling waste soil from silty clay strata as a bentonite replacement in two-component slurry preparation and the characteristic effects of relevant factors were investigated. It was found that the clay components contained in this waste soil and the bentonite slurry injected to the cutter head during excavation can fulfill the role of bentonite in the original slurry. Meanwhile, the influence laws of waste soil content and sodium silicate Baumé degree on two-component slurry performance were revealed; waste soil content and sodium silicate Baumé degree exert significant effects on the bleeding rate, fluidity, initial setting time, and compressive strength of the two-component slurry. Waste soil content and fly ash-cement ratio demonstrate significant interaction effects on slurry fluidity, while waste soil content and sodium silicate Baumé degree show significant interaction effects on initial setting time. A practical two-component slurry mix ratio suitable for silty clay strata was proposed: Solution A (cement 116.69 kg/m^3, fly ash 378.28 kg/m^3, waste soil 116.69 kg/m^3, sand 798.32 kg/m^3, water 409.06 kg/m^3, silica fume 20.95 kg/m^3, water reducer 2.99 kg/m^3), Solution B (28°Bé sodium silicate), with a Solution A to Solution B volume ratio of 25:1. Application of this mix ratio in silty clay strata can reduce waste soil pollution and disposal costs, providing a reference for similar projects.

Full Text

Preamble

Title: Experimental Study on the Proportion of Cement-silicate Grouting Based on SPB Shield Tunneling Waste in Silty Clay Strata

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Abstract

Slurry shield tunneling generates substantial waste slurry, which not only occupies valuable site space but also creates environmental pollution and incurs additional disposal costs. To achieve resource utilization of this waste material and reduce construction expenses, this study investigates the use of waste slurry as a replacement for bentonite in synchronous grouting double-liquid slurries. Through microstructural analysis and performance testing, the feasibility of utilizing slurry shield tunneling waste from silty clay strata as a bentonite substitute in double-liquid grouting was examined, along with the characteristic effects of relevant factors. The findings reveal that the clay components inherent in the waste slurry, combined with the bentonite slurry injected to the cutter head during tunneling, can effectively fulfill the functions originally served by bentonite in the grout mixture. Furthermore, the study elucidates the influence patterns of waste slurry content and water glass Baume degree on the performance of double-liquid slurry, demonstrating that both parameters significantly affect bleeding rate, fluidity, initial setting time, and compressive strength. Notably, significant interactive effects were observed between waste slurry content and fly ash-cement ratio on slurry fluidity, as well as between waste slurry content and water glass Baume degree on initial setting time. A practical double-liquid slurry formulation suitable for silty clay strata is proposed: Liquid A (cement 116.69 kg/m^3, fly ash 378.28 kg/m^3, waste slurry 116.69 kg/m^3, sand 798.32 kg/m^3, water 409.06 kg/m^3, silica fume 20.95 kg/m^3, water reducer 2.99 kg/m^3) and Liquid B (28°Bé water glass), with a volume ratio of 25:1 (A:B). This formulation can reduce pollution and disposal costs associated with waste slurry when applied in silty clay strata, providing valuable reference for similar engineering projects.

Keywords: slurry shield tunneling; waste slurry reuse; double-liquid slurry; response surface methodology; proportion optimization

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