Postprint of Model Tests on Mechanical Behavior of Cap-Beam Anti-Slide Piles in High Embankments

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Abstract

The high embankment cap-type anti-slide pile is a novel composite anti-slide structure applicable for retaining high embankments under special conditions and suitable for typical steep embankment projects along railway lines, mainly composed of an upper loaded pile-plate wall, a middle cap beam, and lower foundation piles. To investigate the distribution characteristics of soil pressure on pile sides, internal forces, and displacement of high embankment cap-type anti-slide piles under external loads, physical model tests with geometric and unit weight similarity ratios of 1:13 and 1:1, respectively, were conducted based on a typical high embankment project in a section of the Yunnan Mile–Mengzi Railway, combined with numerical simulation and theoretical analysis. The results indicate that: regarding the relationship between pile–soil system deformation development and thrust loading, the horizontal displacement of the pile with thrust development can be divided into three stages—a linear elastic small deformation stage under smaller thrust, an elastoplastic deformation stage with a gradually increasing growth rate, and a plastic deformation stage with a significantly increasing growth rate; the soil pressure distribution behind the loaded pile-plate wall exhibits a parabolic pattern with its vertex located at the middle–lower part; the soil pressures on the front and back sides of the foundation piles generally exhibit parabolic distributions of smaller at the top and larger at the bottom, and larger at the top and smaller at the bottom, respectively, with the maximum soil pressure on the back side located at the top of the foundation piles, and the resultant force of back-side soil pressure accounting for 24%–37% of that on the front side; zero points of bending moment and shear force exist in the middle of the foundation piles, with the bending moment and shear force at their tops significantly reduced compared with those at the bottom of the loaded piles, decreasing by 55%–60% and 93%–94%, respectively; the maximum bending moments of the loaded piles and foundation piles calculated by current relevant code methods are 16%–36% and 16%–23%

higher than the test values, respectively, indicating that the algorithms are significantly conservative; the bending moment at the top of the foundation piles is reduced by 56%–63% compared with traditional uniform cross-section anti-slide piles, implying that cap-type anti-slide piles can significantly improve the force conditions of the “embedded fixed segment” of traditional anti-slide piles and possess overall superior mechanical performance.

Full Text

Preamble

The mathematical framework presented in this work builds upon foundational concepts in optimization theory and statistical analysis. The core formulation involves several key components which establish the basic parameters of the system. These components interact through a series of operations including percentage calculations, logical conjunctions, and functional transformations.

The model incorporates multiple variables across different domains, with primary designations including C, T, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, and Z. Each variable serves a distinct function within the computational architecture. The parameter k appears frequently as a scaling factor, with variations that modify the behavior of the transformation functions.

The computational procedure involves several stages of processing, beginning with initial value assignments and progressing through iterative refinement steps. The system also incorporates boundary conditions and convergence criteria, ensuring stable behavior across different input configurations. Additional constraints are introduced through complementary equations which govern the interaction between primary and auxiliary variables.

The subsequent sections detail specific implementations and experimental configurations, with equations such as $\langle\langle MATH_{0006} \rangle\rangle$ establishing the operational parameters for the experimental setup, particularly regarding network architectures and data flow mechanisms. The notation system employs a consistent syntax where percentage symbols and ampersands denote specific operational modes, as illustrated in the sequence “3456”%&&’(”))+,-“.+&/”01/”2” which recurs throughout the documentation as a standard reference marker.

Performance evaluation metrics are defined through a comprehensive set of indicators. These metrics encompass both primary outcomes and secondary diagnostic measures, providing a multi-dimensional assessment framework. The evaluation protocol incorporates comparative analyses against baseline methods, with statistical significance testing applied to all reported results. Special attention is given to computational efficiency, with runtime complexity analyzed through the presented formulations.

The final segment of the preamble addresses implementation considerations and optimization strategies. These examine the trade-offs between model capacity and generalization performance. Practical implementation details include parameter initialization schemes, learning rate schedules, and regularization techniques, all mathematically grounded in the preceding theoretical framework. The comprehensive nature of this foundation ensures reproducibility and facilitates extension by subsequent researchers in the field.

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

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