Neural Network-Based Multi-Objective Optimization Design of Ultra-High Box-Type Counterfort Retaining Walls Postprint

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Abstract

In recent years, with China' s complex and diverse geological conditions and increasingly constrained engineering land availability, ultra-high box-type counterfort retaining walls have garnered significant attention in ultra-high cut-fill slope projects due to their composite advantage of "box weight reduction + counterfort stiffness enhancement." However, practical engineering applications often face tight construction schedules, leading to an alternating operation mode between retaining wall construction and dynamic compaction reinforcement. Existing research still lacks systematic investigation into the dynamic response mechanism and stability evolution law of this type of retaining structure under dynamic compaction impact loads, making it difficult to guide field construction. Traditional mechanical models struggle to satisfy the force analysis requirements of their internal complex structures, and structural optimization design is time-consuming, while neural networks provide an innovative solution to this challenge through a data-driven approach. This study combines an actual project in Longgang District, Shenzhen to investigate the mechanical behavior characterization of ultra-high box-type counterfort retaining walls under unloading effects and dynamic compaction vibration effects, and obtains force analysis results under various working conditions of dynamic compaction energy levels, unloading plate lengths, and unloading plate positions by integrating field test data and numerical simulation results; by adopting Sobol sequence sampling technology to acquire high-quality data samples, constructing a surrogate model based on BP neural network and Bayesian optimization algorithm, employing multiple strength and stability index requirements as constraints, and introducing a genetic evolutionary algorithm for global search and optimization solution in the parameter space, it predicts the stability evolution law of retaining walls under dynamic compaction, achieving efficient, accurate, and automated optimization design of ultra-high box-type counterfort retaining wall structures.

The research results reveal the dynamic response mechanism of ultra-high box-type counterfort retaining walls under dynamic compaction impact, effectively guiding field construction. Based on the proposed multi-objective optimization design method, retaining walls can minimize concrete usage while effectively controlling strength and stability, significantly reducing engineering costs, and providing precise and efficient guidance for the optimization design of retaining wall structures under dynamic compaction.

Full Text

Multi-Objective Optimization Design of Ultra-High Box-Type Buttressed Retaining Walls Based on Neural Networks

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Abstract

In recent years, ultra-high box-type buttressed retaining walls have gained prominence in high cut-and-fill slope projects due to their composite advantage of "box weight reduction + buttress stiffness enhancement," a trend driven by China's complex geological conditions and increasingly constrained construction land. However, practical engineering applications often face tight construction schedules, resulting in alternating operations between retaining wall construction and dynamic compaction reinforcement. Existing research lacks systematic investigation into the dynamic response mechanisms and stability evolution patterns of this retaining structure under dynamic compaction impact loads, making it difficult to guide field construction. Traditional mechanical models struggle to meet the demands for analyzing internal forces in such complex structures, and structural optimization design is time-consuming. Neural networks offer an innovative data-driven solution to this challenge.

This study investigates the mechanical behavior characterization of ultra-high box-type buttressed retaining walls under the combined effects of unloading and dynamic compaction vibration, using a practical project in Longgang District, Shenzhen. Through integration of field test data and numerical simulation results, force analysis outcomes were obtained for various working conditions involving different dynamic compaction energy levels, unloading plate lengths, and unloading plate positions. By employing Sobol sequence sampling technology to acquire high-quality data samples, a surrogate model was constructed based on BP neural networks and Bayesian optimization algorithms. Using multiple strength and stability index requirements as constraints, a genetic evolutionary algorithm was introduced to perform global search and optimization in the parameter space, predicting stability evolution patterns of retaining walls under dynamic compaction and achieving efficient, accurate, and automated optimization design of ultra-high box-type buttressed retaining wall structures.

The research results reveal the dynamic response mechanism of ultra-high box-type buttressed retaining walls under dynamic compaction impact, providing effective guidance for field construction. Based on the proposed multi-objective optimization design method, retaining walls can significantly reduce concrete usage while effectively controlling strength and stability, substantially lowering engineering costs and providing precise and efficient guidance for structural optimization design of retaining walls under dynamic compaction.

Keywords: retaining wall; structural optimization design; dynamic compaction; surrogate model; neural network

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