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Research on Full-Probability Design Method Based on the Direct Probability Integral Method

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ABSTRACT

Accurate calculation of the failure probability of structural components was crucial for full-probability level structural design. However, current design codes typically use uniform design factors, which fail to accurately reflect the true failure probability of structures. In this paper, based on the direct probability integral method (DPIM) and combining different design parameter iterative calculation strategies, the full-probabilistic design methods for single-parameter and multi-parameter were proposed, and their accuracy advantages in structural reliability design were verified by engineering examples. Furthermore, this study compares the partial factor method, the design value method, the direct probability design method, and the single-parameter full-probabilistic design method which combines the DPIM and the dichotomous search method, in the reinforcement design of cable-stayed bridges. Reliability calibration was carried out using the Monte Carlo Simulation (MCS) method. The results show that the errors of the partial factor method, the design value method, and the direct probabilistic design method were 11.52%, 4.39%, and 1.89%, respectively. In contrast, the single-parameter full-probability design method combining the DPIM and the dichotomous search method achieves an error of only 0.32%, demonstrating higher precision. Additionally, the application of a multi-parameter full-probability design method, which combines the DPIM and simulated annealing algorithm, was investigated for the cross-sectional sizing and reinforcement design of T-type simply supported bridges. The results show that the error for this method was 7.38%, which falls within the acceptable range for engineering design. Therefore, the full-probability design method based on DPIM demonstrates significant advantages in handling the randomness and nonlinearity of complex structures, offering new theoretical support and technical approaches for enhancing the precision and engineering reliability of structural design.

KEYWORDS

Direct probability integral method; reliability-based design optimization; full-probability design method; assigned probability; dichotomous search method; simulated annealing algorithm

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