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Enhanced second-order reliability method and stochastic sensitivity analysis using importance sampling

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Abstract

The enhanced second-order reliability method (eSORM) is proposed in this study in order to improve accuracy in estimating a probability of failure. Conventional SORM additionally approximates an already approximated quadratic performance function to a parabolic surface, indicating that those methods are based on an incomplete second-order Taylor expansion of the performance function. This additional approximation means a loss of accuracy in estimating the probability of failure. The proposed SORM utilizes the importance sampling to calculate the probability of failure of a complete second-order Taylor expansion of the performance function without the parabolic approximation, so it shows better accuracy compared to the conventional SORM methods. The proposed SORM method also utilizes an approximated Hessian of the performance function by using the symmetric rank-one update in Quasi-Newton method, which means that additional function calls are not required except the computation used for MPP search. In addition to the improvement of the accuracy, stochastic sensitivity analysis is performed in the proposed method by applying the importance sampling to the quadratically approximated performance function. Therefore, the second-order sensitivity of the probability of failure as well as the first-order one can be easily computed in the proposed method without additional function calls.