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正态变量相关情况下可靠性灵敏度分析的新方法

A new method for reliability sensitivity analysis with correlative normal variables

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中文关键词: 相关变量 独立变量 可靠性灵敏度 相关系数 变异系数

英文关键词:correlative variable independent variable reliability sensitivity dependence variation coefficient

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中文摘要:

基于独立正态变量情况下可靠性灵敏度分析的线抽样法,提出了一种求解正态相关变量情况下可靠性灵敏度的新方法。在所提方法中,首先将正态相关变量等效变换为正态独立变量,然后利用线抽样方法独立完成等效独立变量情况下失效概率对独立变量的所有分布参数的灵敏度分析,最后依据等效变换前后变量分布参数之间的解析关系和复合函数求导公式,求得失效概率对相关变量所有分布参数的可靠性灵敏度。为了解所提方法的收敛性和精度,文中对所提方法进行了方差分析。算例结果表明,对于线性极限状态情况,所提方法经过一次线抽样即可得到可靠性灵敏度的精确解,而对于非线性极限状态情况,所提方法可以高效求得高精度的近似解。算例结果还表明,变量的相关性会引起失效概率对变量标准差灵敏度正、负符号的改变,这对于工程可靠性设计是非常有意义的。

英文摘要:

Based on line sampling for reliability sensitivity in case of independent normal variables, a new reliability sensitivity analysis method is presented for the structure with correlative normal variables. In this method, the correlative normal variables are firstly transformed into independent normal variables equivalently. Then, the line sampling algorithm is employed to complete the reliability sensitivity of failure probability with respect to all distribution parameters in the space of equivalent independent variables. At last, by use of the distribution parameters relationship between the correlative normal variables and the independent normal variables, the reliability sensitivity of the failure probability with respect to all distribution parameters in the space of the correlative normal variables can be obtained by derivative formula of compound function. In order to investigate convergence and precision of the method, the variance and the variation coefficient of the reliability sensitivity estimation are derived. The results of the examples show that the presented method is accurate for the reliability sensitivity analysis of the linear limit states function with one sampling, and it can efficiently obtain the approximate solution with high precision for the non-linear limit function. The dependence of the variables can change the positive and negative sign of the reliability sensitivity of the failure probability with respect to the standard derivation of the variable, which is demonstrated by an example and is important for reliability design.

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