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边坡稳定的有限元可靠度计算及敏感性分析

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摘要 假定边坡岩土体为满足Mohr-Coulomb屈服准则的理想弹塑性体，以基于滑面应力分析的弹塑性随机有限元理论为基础，采用增量初应力法及偏微分技术，求解边坡体中的应力以及应力对基本变量的导数；建立考虑滑面方向的功能函数，基于一阶可靠性分析方法，对整个边坡的可靠度进行分析，计算边坡的整体可靠指标，为边坡的稳定性评价及防治提供重要依据。由于边坡稳定的有限元可靠度计算工作量较大，故应进行参数的敏感性分析。推导基本变量相关时在原始空间中求解可靠指标对参数敏感性的计算公式，其优点是无需求解转换矩阵，计算更加简单直接。考虑到基本变量的单位不同，提出可靠指标对随机变量分布参数的相对敏感性分析计算公式，并将之用于边坡稳定的有限元可靠度分析。算例分析结果表明：该方法与基于有限元强度折减法得出的可靠指标基本一致；一阶可靠性方法所求可靠指标比均值一阶可靠性方法的稍大；参数c，j 对可靠指标的相对影响比其他参数的影响要大得多；随着c，j 间负相关系数的增加，其对可靠指标的影响也相应增加。

关键词 边坡工程；有限元；可靠度分析；可靠指标；敏感性分析

分类号

FINITE ELEMENT RELIABILITY COMPUTATION AND SENSITIVITY ANALYSIS OF SLOPE STABILITY

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Abstract

In the finite element analysis，the soil is assumed to obey realistic elastoplastic and Mohr-Coulomb yield criterion. Based on the technique of sliding surface stress analysis and on the theory of elastoplastic finite element，the stress and the derivatives of the stress of the basic stochastic variables for the slope are computed by using partial differential technique and incremental initial stress method. In the reliability analysis，the limit state function is set up which can consider the direction of the sliding surface. And then the reliability indices of the whole slope are computed using the first order reliability method(FROM). In order to improve the efficiency of the computation of the reliability indices，it¢s necessary to carry out sensitivity analysis. Therefore，the formulas of the sensitivity of reliability indices to the basic parameters in the original space when they are correlated are derived. The advantage is that the transforming matrix，which is needed in the computation in the transformed space，is now unnecessary in this method. Considering the differences of the units of each parameter，the relative sensitivity

formulas are suggested. An example is given to illustrate that the reliability indices calculated by this paper are the same as those of strength reduction method(SRM)；and reliability indices got from FORM are a little larger than those of mean first order reliability method (MFORM). Through sensitivity analysis，it¢s concluded that the effects of parameters c，j are much larger than the others；and their effects on the reliability indices increase when the negative coefficient of correlationship of c，j become large.

Key words slope engineering；finite elements；reliability analysis；reliability indices；sensitivity analysis

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