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岩体地下结构围岩稳定非概率可靠性的凸集合模型分析方法

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摘要 在岩体地下结构围岩稳定可靠性分析中，由于岩体的物理力学参数本身的特点，通常只能在岩体分类的基础上给出其变化的区间，要得到其概率密度分布函数和隶属函数是非常困难的。采用传统的统计概率和模糊概率模型得出的概率结论只具有理论上的意义。针对岩体地下结构围岩的特点，引进非概率的可靠性分析方法，采用凸集合模型描述基本参数的不确定性，将结构功能函数转化为仿射函数，对于给出了设计安全域的地下结构，利用仿射函数在凸集合域上求得响应输出区间，通过比较设计安全域和响应区间，确定其可靠性；对于没有明确给出设计安全域的结构，通过分析功能函数在凸集合模型上的均值与离差关系，给出其可靠性度量的非概率指标。在非概率凸集合模型分析方法中不必拟合概率密度函数和隶属函数，所需信息量少、准确度高，实例分析展示了凸集合模型分析方法的实用性。

关键词 隧道工程；岩体地下结构；围岩；非概率可靠性；凸集合模型；仿射函数

分类号

NON-PROBABILISTIC RELIABILITY CONVEX MODEL METHOD FOR STABILITY ANALYSIS OF SURROUNDING ROCK MASS OF UNDERGROUND STRUCTURE

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Abstract

In reliability analysis of stability of surrounding rock mass for underground engineering，due to the particular characteristics of physical and mechanical parameters of rock mass，the variation interval of these parameters can only be obtained based on rock mass classification，while it is very difficult to obtain probability density function and subjection function of these parameters for rock mass. Therefore，the stability and reliability of surrounding rock mass，calculated by traditional probabilistic statistics model and fuzzy probability model，only has theoretical significance. Based on the characteristics of surrounding rock

mass of underground engineering，the convex model is adopted to simulate uncertainties of rock mass parameters and to change state equation into affine function. For the underground structure with specified design safety margin，the response output interval of structure can be calculated through affine function whose independent variable is defined in convex set. The stability and reliability of the surrounding rock mass of underground structure can be determined by comparing design safety interval with response output interval. For the underground structure without design safety margin，non-probabilistic stability reliability index is defined through the analysis of ratio of average value in limit state equation to its deviation on convex set. Probability density function and subjection function need not be fitted in non-probability convex model methods. Therefore，non-probability convex model methods need less information than traditional stability reliability analysis method. The analysis results of non-probability methods are more accurate than that of traditional method. The results of engineering analysis show the convex model method of non-probabilistic reliability is feasible.

Key words tunnel engineering；underground rock mass structure；surrounding rock mass；non-probabilistic reliability；convex model；affine function

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