岩石力学与工程学报 » 2012, Vol. 31 » Issue (12) :2508-2517 DOI:

岩体结构面三维粗糙度系数表征新方法

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A NEW REPRESENTATION METHOD FOR THREE-DIMENSIONAL JOINT ROUGHNESS COEFFICIENT OF ROCK MASS DISCONTINUITIES

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摘要 岩体结构面粗糙度系数JRC影响着岩体的变形、破坏以及渗流特性，其数据采集与评价取值问题一直是岩石力学领域的热点和难点。目前研究方法多集中于二维，无法体现JRC的三维特性；即使现有的三维评价方法，也多数仅从几何数据单方面入手，没有考虑JRC的各向异性。鉴于此，提出基于光亮面积百分比BAP的岩体结构面三维粗糙度系数表征新方法。首先，运用三维激光扫描技术，建立岩体结构面三维数字模型；其次，通过模拟虚拟光源，在岩体结构面表面产生光亮与阴影，并生成图片；然后，基于图像分割技术，设置灰度阈值，提取大于灰度阈值的光亮部分面积，并计算岩体结构面的光亮面积百分比；最后，结合R. Tse和D. M. Cruden提出的JRC计算公式，考虑剪切或渗流方向，得出岩体结构面三维粗糙度系数估算公式。以鱼简河水库工程为例，实验结果表明：(1) 在光源照射角度相等的情况下，光亮面积百分比与岩体结构面三维粗糙度系数成正比关系。(2) 通过对比分析，光源照射角度过大(70°～85°)或过小(5°～35°)时，易产生误差，入射角介于35°～70°范围内时为最佳入射角。(3) 基于该工程数据推导出JRC3D与BAP之间的估算公式。通过验证，试样Y10，Y11，Y12根据R. Tse和D. M. Cruden公式所得到的JRC3D分别为16.47，16.81，16.69，根据新估算公式计算的JRC3D分别为17.20，17.40，17.17，具有较好的一致性。

关键词： 岩石力学 岩体结构面 粗糙度系数 三维激光扫描技术 图像分割技术

Abstract： Joint roughness coefficient(JRC) has influence on the deformation，failure and seepage properties of rock mass discontinuities；and the measurement and estimation of JRC are always focal，but difficult problems in the field of rock mechanics. The majority of the current research methods which have been based on the analysis of two-dimensional(2D) profiles rather than three-dimensional(3D) surface topography lead to erroneous results. On the other hand，the existing 3D evaluation methods only depend on the geometry data，but the anisotropy properties of JRC are ignored. Therefore，a new representation method for 3D JRC based on the brightness area percentage(BAP) was proposed. Firstly，with the help of laser scanning technique，the 3D digital model of rock fracture surfaces was established. Secondly，a light source was simulated；and there would be some brightness and shadows produced on the model surface. In addition，the simulated results were saved as picture format. Thirdly，in order to obtain the value of BAP of each specimen，the image recognition technique was introduced and the brightness area in the picture was identified. Lastly，combination with the results from formula proposed by R. Tse and D. M. Cruden and taking the direction of shear or seepage into account，an empirical formula was found between BAP and 3D joint roughness coefficient(JRC3D). Taking the data of Yujian River Reservoir project for example，the experimental results show that：(1) In the case of equal light source angle，generally，JRC3D are positive proportional to BAP. (2) A comparative analysis of results from different incidence angles was performed；after an extended evaluation，35°－70° was chosen as the most appropriate incidence angle. (3) The evaluation formula for relationship between BAP and JRC3D based on the engineering data of Yujian River Reservoir was derived. The predictions(17.20，17.40，17.17) of JRC3D made with this equation agreed well with the results(16.47，16.81，16.69) obtained in equation proposed by R. Tse and D. M. Cruden.

Keywords： rock mechanics rock mass discontinuities joint roughness coefficient(JRC) three-dimensional laser scanning technique image recognition technique

Received 2012-04-28;

引用本文:

葛云峰1，2，唐辉明2，黄 磊2，王亮清2，孙淼军2，范怡静2.岩体结构面三维粗糙度系数表征新方法[J] 岩石力学与工程学报, 2012,V31(12): 2508-2517

GE Yunfeng1，2，TANG Huiming2，HUANG Lei2，WANG Liangqing2，SUN Miaojun2，FAN Yijing2.A NEW REPRESENTATION METHOD FOR THREE-DIMENSIONAL JOINT ROUGHNESS COEFFICIENT OF ROCK MASS DISCONTINUITIES[J] , 2012,V31(12): 2508-2517