УДК 2

A METHOD FOR CLUSTERING ROCK DISCONTINUITIES WITH MULTIPLE PROPERTIES BASED ON AN IMPROVED NETTING ALGORITHM

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Summary. *Clustering analysis is fundamental for determining dominant discontinuity properties in rock engineering. This study proposes an improved netting algorithm for identifying discontinuity sets based on multiple discontinuity properties. The new method is believed to be a potentially useful tool for rapidly obtaining dominant discontinuity sets in rock engineering.*

Rock discontinuities are a key factor in controlling rock mass stability. The dominant properties of discontinuities play an important role in the analysis of the deformations and strengths of rock masses. The distribution of discontinuities is complex and random after long-term and uncertain geological activity. Clustering analysis can group random discontinuities into several dominant sets in a specific geological range. The dominant properties of discontinuities are determined to further evaluate the rock mass stability. Therefore, the clustering analysis of rock discontinuities is fundamental for stability evaluation in rock engineering.

Rock discontinuities in the same set have similar properties because their tectonic periods and formation are almost identical. Generally, two methods were considered to identify discontinuity sets in previous studies. One way is to cluster discontinuities according to orientation, and the other is to consider several discontinuity properties, including orientation. In geotechnical investigations of dam foundations, tunnels, and slopes, the discontinuity orientation (dip direction and dip) is not the only factor influencing stability. For example, open and closed discontinuities with similar orientations have very different effects on seepage rates and stability. Therefore, a clustering method considering multiple properties of rock discontinuities is essential for identifying discontinuity sets, and it is more applicable in engineering practice.

The netting algorithm is an unsupervised clustering algorithm based on similarity. The similarity matrix is obtained by calculating the similarity between all data points. In the matrix network, each data point is regarded as a node, and the nodes are connected through longitude and latitude lines to perform clustering. This method has performed well in clustering discontinuity orientations. However, the clustering analysis of multiple discontinuity properties has not been developed. Therefore, this paper develops an improved netting algorithm to cluster discontinuities with multiple properties and obtain dominant discontinuity sets.

To cluster rock discontinuities with multiple properties quickly and accurately, a clustering method based on an improved netting algorithm is proposed, and its main steps are as follows.

1. To obtain sufficient rock discontinuity data, as many systematic measurements as possible should be taken in the field.

2. The orientation is transformed into polar coordinates, and the unit normal vector is expressed in three-dimensional Cartesian coordinates. The properties of rock discontinuities, including trace length, spacing, aperture, infilling material, infilling percentage, roughness, water permeability, and rock strength, are normalized to eliminate the influence of the dimensions on subsequent calculations.

3. The subjective weights are calculated based on the G1 method, and the objective weights are calculated based on EWM. The subjective and objective preference coefficients are obtained based on the optimization model. Then, the combined weights of the discontinuity properties are determined using the additive synthesis method.

4. The similarities between the rock discontinuities are calculated, and a similarity matrix R is established based on the calculation results.

5. The similarity matrix R is restructured. All elements above the diagonal line are deleted because of symmetry. The elements on the diagonal line are replaced with the classified object numbers O_i.

6. The λ-cutting matrix R_λ is constructed by choosing a confidence level λ.

7. The λ-cutting matrix R_λ is restructured. All "1" entries are replaced by the node number "*", and all "0" entries in R_λ are ignored.

8. Clustering grouping is performed in Rλ. The node "*" determines the longitude line and the latitude line on the diagonal line, and the samples connected by the same node become a group.

9.According to the clustering results, the effectiveness evaluation index V_{XB} is calculated. When the rationality of the results is not appropriate, steps (6–9) are repeated by choosing different confidence levels λ.

10. The dominant discontinuity sets are determined based on the clustering results.

Identifying discontinuity sets and determining dominant discontinuity properties are fundamental for rock mass stability evaluation. Clustering analysis with multiple discontinuity properties has a stronger significance than considering only orientation, which better reflects the comprehensive contributions of discontinuity properties to the deformations and strengths of rock masses. Therefore, this paper proposes a new method for clustering discontinuities with multiple properties based on an improved netting algorithm.

In the new method, ten discontinuity properties are considered clustering factors. Meanwhile, a novel weighting method is used to weigh each property, combining the advantages of subjective and objective weighting methods. The results obtained by the proposed method are unique and repeatable. The initial number of sets and the initial clustering centers are not needed in advance; all data are considered potential clustering centers simultaneously. This reduces the subjectivity of human intervention and achieves global optimization. In addition, a distinctive advantage is that the proposed method could effectively filter the noise data to improve the accuracy of the clustering results, and the rejection rate was approximately 26 %.Moreover, the proposed method is believed to be a potentially useful tool for rapidly obtaining dominant discontinuity sets in rock engineering.

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BIM 技术与可持续发展的融合-绿色建筑

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Summary. *Green building is one of the important contents of sustainable development, and the research and application of BIM technology plays an important role in realizing the life cycle of green building, this paper analyzes the integration of BIM technology and sustainable development – green building and explores the significance of BIM technology to the sustainable development of green buildings.*

21 世纪以来，建筑业成为中国国民经济的支柱产业。中国建筑业快速发展，建造能力不断增强，产业规模不断扩大，带动了大量关联产业，对经济社会发展、城乡建设和民生改善做出了重要贡献。与此同时，建筑行业的迅猛发展，消耗了巨大的自然资源，淡水、可耕地、天然材料、不可再生能源等日益枯竭，带来温室气体、污染物等的排放量大幅增加。在中国，建筑的总能耗已经占到全社会总能耗的 25.5%左右，建筑造成的恶劣空气质量也危及到了公众日常生活与健康。为应对能源危机、人口增长等问题，绿色、低碳等可持续发展理念逐渐深入人心，而以有效提高建筑物资源利用效率、降低建筑对环境影响为目标的绿色建筑成为全世界的关注重点。环境友好型绿色建筑成为世界各国建筑发展的战略目标。

随着国家政策文件的出台，为行业贯彻实施创新驱动发展战略，培育和发展工程建设领域"新技术、新产业、新模式、新业态"，促进工程建设行业转型升级，推动绿色城镇化、