The Anisotropy of Surface Morphology Characteristics of Rock Discontinuities

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1. Introduction

Rock discontinuities in the form of cracks, joints, bedding planes, schistosity planes etc. are commonly found in rock masses in the upper part of the earth’s crust (Pollard and Aydin, 1988). Discontinuities in rock masses influence the stability of rock engineering structures as well as thermo-hydrological characteristics of rock masses, which have become a field of interest in relation to radioactive waste disposal projects (Aydan and Kawamoto, 1990). There have been numerous experimental and numerical studies for the characterization of the surface morphology of discontinuities and for relating the surface morphology parameters to their thermo-hydro-mechanical properties in recent years (Sezaki et al., 1993). Most of the studies regard the surface morphological parameters as isotropic. Considering fracture propagation or sedimentation process, these parameters are likely to be anisotropic. This aspect has not been yet investigated although there are some reports regarding the anisotropic frictional characteristics (LaFountain and Dunn, 1974; Aydan and Kawamoto, 1990; Huang and Doong, 1990; Kimura et al., 1993).

The purpose of this study is to present a procedure to quantify surface morphological characteristics of discontinuities together with the consideration of their anisotropy. First, a brief outline of the surface morphology parameters is given. Then, several actual examples together with measured profiles are described and the possible causes of anisotropy are discussed. And then, a procedure to evaluate the anisotropy of surface morphology parameters is given. Finally, the application of the proposed procedure to an actual discontinuity is described and its validity is checked.

2. Surface Morphology Parameters

The characterization of the surface morphology of rock discontinuities is
merely a geometrical procedure. In other words, it is an identification procedure of the topography of the discontinuity surfaces, which specifically involves; height, shape, and periodicity of protrusions, and the ratio of surface area over the base area.

It will be appropriate if a function, which can represent the topography of discontinuity surfaces, can be found. This is extremely difficult not only because of finding an appropriate function but also because of the enormous efforts required in measuring and processing data. As a result of this, most of available techniques are based on linear profiles and various characterization parameters are proposed (Myers, 1962; Sayles and Thomas, 1977; Tse and Cruden, 1979; Thomas, 1982; Türk et al., 1987). The parameters associated with linear profiles are: height of asperities, inclination of asperity walls, length of asperity wall relative to base length, and periodicity of asperities.

These parameters are briefly explained in the followings:

Centre-line average height (CLAH) is defined as:

\[
\text{CLAH} = \frac{1}{L} \int_{x=0}^{x=L} |\phi| \, dx, \tag{1}
\]

where

\( L \) : measurement length

\( x \) : distance from origin

\( \phi \) : height of the profile from the reference base line.

Mean standard variation of height (MSVH) is defined as:

\[
\text{MSVH} = \frac{1}{L} \int_{x=0}^{x=L} \phi^2 \, dx. \tag{2}
\]

Root mean-square of height (RMSH) is defined as:

\[
\text{RMSH} = \left[ \frac{1}{L} \int_{x=0}^{x=L} \phi^2 \, dx \right]^{1/2}. \tag{3}
\]

Ratio of profile length (RPL) is defined as:

\[
\text{RPL} = \frac{1}{L} \int_{x=0}^{x=L} ds = \frac{1}{L} \int_{x=0}^{x=L} \left( 1 + \left( \phi \right)^2 \right)^{1/2} \, dx. \tag{4}
\]

Weighted asperity inclination (WAI*) is defined as:

\[
\text{WAI}^* = \frac{1}{L} \int_{x=0}^{x=L} \frac{d\phi}{dx} \, dx \quad \text{WAI} = \tan^{-1} (\text{WAI}^*). \tag{5}
\]

Weighted asperity inclination difference (WAID*) is defined as:

\[
\text{WAID}^* = \frac{1}{L_p} \int_{x=0}^{x=L_p} \frac{d\phi}{dx} \, dx - \frac{1}{L_n} \int_{x=0}^{x=L_n} \frac{d\phi}{dx} \, dx \quad \text{WAID} = \tan^{-1} (\text{WAID}^*) \tag{6}
\]

where \( p \) and \( n \) stand for adjectives positive and negative respectively. Furthermore, \( L = L_p + L_n \).