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Rock discontinuity surface roughness variation with scale

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ABSTRACT:
Rock discontinuity surface roughness refers to local departures of the discontinuity surface from planarity and is an important factor influencing the shear resistance. In practice, the Joint Roughness Coefficient (JRC) roughness parameter is commonly relied upon and input to a shear strength criterion such as developed by Barton and Choubey [1977]. The estimation of roughness by JRC is hindered firstly by the subjective nature of visually comparing the joint profile to the ten standard profiles. Secondly, when correlating the standard JRC values and other objective measures of roughness, the roughness idealization is limited to a 2D profile of 10 cm length. With the advance of measuring technologies that provide accurate and high resolution 3D data of surface topography on different scales, new 3D roughness parameters have been developed. A desirable parameter is one that describes rock surface geometry as well as the direction and scale dependency of roughness.

In this research a 3D roughness parameter developed by Grasselli [2001] and adapted by Tatone and Grasselli [2009] is adopted. It characterizes surface topography as the cumulative distribution of local apparent inclination of asperities with respect to the shear strength (analysis) direction. Thus, the 3D roughness parameter describes the roughness amplitude and anisotropy (direction dependency), but does not capture the scale properties. In different studies the roughness scale-dependency has been attributed to data resolution or size of the surface joint (see a summary of researches in [Tatone and Grasselli, 2012]). Clearly, the lower resolution results in lower roughness. On the other hand, have the investigations of surface size effect produced conflicting results. While some studies have shown a decrease in roughness with increasing discontinuity size (negative scale effect), others have shown the existence of positive scale effects, or both positive and negative scale effects. We hypothesize that roughness can increase or decrease with the joint size, depending on the large scale roughness (or waviness), which is entering the roughness calculation once the discontinuity size increases. Therefore, our objective is to characterize roughness at various spatial scales, rather than at changing surface size. Firstly, the rock surface is interpolated into a grid on which a Discrete Wavelet Transform (DWT) is applied. The resulting surface components have different frequencies, or in other words, they have a certain physical scale depending on the decomposition level and input grid resolution. Secondly, the Grasselli Parameter is computed for the original and each decomposed surface. Finally, the relative roughness change is analyzed with respect to increasing roughness wavelength for four different rock samples. The scale variation depends on the sample itself and thus indicates its potential mechanical behavior.

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