Abstract

The ongoing process of weathering in nature, which is slow yet intricate, alters rocks and hence rock discontinuity surfaces at shallow depth where most engineering works are confined. Although it is apparent that weathering influences shear behavior of rock discontinuities, the issue has received limited attention of previous researchers. Moreover, no study seems to have been able to discriminate the influence of weathering on the shear behavior of discontinuities from the influence of other factors (e.g. joint roughness coefficient (JRC), infilling material, water etc.). In line with this, the shear behavior of natural, unfilled and planar weathered joints of quartzite (from Ghatsila in the state of Jharkhand, India) and granite (from Balasore in the state of Odisha, India) with reference to weathering grade was investigated under constant normal stress in dry condition.

It became evident from the study that in case of planar joints with fine asperities (as investigated in this study), degree of weathering that influences joint wall compressive strength (JCS), plays a key role to determine the resistance to shearing, and this influence becomes prominent at high normal stresses. Although unfilled-planar joints of both the rock types portray similar nature of shear behavioral patterns irrespective of weathering grade, the peak friction angle decreases about 22% and 14% as weathering grade intensifies from Grade II to Grade III in case of granitic and quartzitic joints, respectively. Microscopic observations substantiate that the influence of mineral alteration to reduce the joint surface strength and friction angle is less in quartzite than in granite.

Efficiencies of the common and simple JRC-JCS models existing in the literature in predicting the shear strength with reference to weathering grades of rock joints do not seem to have been evaluated by previous researchers. In line with this, based on a total of 119 direct shear tests performed on the weathered quartzitic and granitic joints, a peak shear strength criterion (i.e. a modified JRC-JCS model) was proposed. Subsequently, the efficacies of the proposed criterion and three other apparently useful JRC-JCS models including Barton's model were evaluated in estimating the peak shear strength of rock joints with reference to a particular weathering grade as well as in regard to different weathering grades considered together. Additionally, the peak shear strength data for weathered granitic joints available in the literature was also taken into account in order to evaluate the applicability of the proposed criterion to weathered rock joints. The proposed JRC-JCS model proved to be more efficient than three other considered JRC-JCS models in estimating the peak shear strength of granitic and quartzitic joints.

Deterioration of shear strength parameters of carbonate joints under the influence of acid rainwater is a serious concern in rock engineering. Considering this, limestone specimens with planar joints collected from the Lanjiberna limestone mine (in the state of Odisha, India) were investigated. Depreciation of shear strength parameters of the joints concerning short-term exposure to a simulated typical acid rain (i.e. pH 4 solution) condition was evaluated. A total of 24 direct shear tests were performed on natural limestone joints and their degraded equivalents. Both peak shear strength and peak friction angle of a degraded joint are found to be less than those of its natural counterpart. The drop in peak friction angle is found to be 8-10% and 14-19% due to submergence of the joints in pH 4 solution for 5 days and 10 days, respectively. It was ascertained that the deterioration of the asperity strength due to the short-term exposure of the planar joint surfaces to the pH 4 solution overrides the effect of insignificant macroscopic change of the surface roughness caused by solution induced micro-cavities and hence, controls the degradation of the shear strength parameters. The shear strength criterion proposed in this study was evaluated with reference to the investigated natural joints of limestone. The proposed equation was found to be quite efficient in estimating peak shear strength of natural limestone joints as well.

Keywords: Quartzite; Granite; Limestone; Natural joints; Weathering; Shear behavior; Peak shear strength criteria