Abstract

Behavior of a rock mass is chiefly controlled by sliding on the discontinuities particularly at shallow depth where contact planes of a natural unfilled rock discontinuity often portray dissimilar roughness characteristics. Some researchers investigated shear behavior of un-matching discontinuities through laboratory experiments using mimicked/replica discontinuities. However, the investigation of 'real' natural rock discontinuities with un-matching contact planes, frequently observed at shallow depth, does not seem to have gained much attention. With a due need, this study first compared shear behavior of 'real' natural discontinuities of three distinct rock types (i.e., granite, quartzite and sandstone) from India and their replicas, based on laboratory investigations. Subsequently, shear behavior of 'real' natural un-matching discontinuities of these three rocks was explored in detail under constant normal load condition. The study also evaluated the efficacy of the criteria existing in the literature in estimating shear strength of the concerned 'real' natural rock discontinuities.

A total of 15 rock samples with 'real' natural discontinuities and their replicas were compared one to one at three increasing normal stresses within a range of 0.22-0.71 MPa. Shear behavioral patterns, peak shear strengths and peak shear displacements of the investigated natural rock discontinuities show considerable dissimilarity compared to those of their replicas. In case of granite and quartzite specimens, the contribution of roughness component towards peak friction angle is greater than that of their replicas. In case of sandstone specimens, unlike granite and quartzite specimens, the contribution of the roughness component towards peak friction angle is, in general, almost similar to that of their replicas.

In order to understand the shear behavior of 'real' natural rock discontinuities with reference to surface morphology, direct shear tests were performed on 53 encapsulated rock samples. A total of 193 direct shear tests were performed in this regard. Influence of surface morphology on shear behavior, shear stress fluctuations over displacement, variation of joint roughness coefficients with the increase in normal stresses and observations on peak friction angle were critically analyzed. Influence of cycles of shearing on peak shear strength was also examined. Most of the obtained behavioral patterns look different from typical shear stress-shear displacement graphs in the literature that are based on direct shear test results of matching planes of contact of a rock discontinuity. Plausible reasons behind the uniqueness of the results were explained.

In order to appraise the efficacy of the existing criteria in estimating shear strength of 'real' natural rock discontinuities, a total of 196 shear strength data determined through laboratory investigation was compared with the shear strength estimated by different shear strength criteria (i.e. Barton, 1973; Aydan, 1996; Tatone and Grasselli, 2009; Ghazvinian et al., 2012; Lee et al., 2014; Tang et al., 2014; Xia et al., 2014; Jang and Jang, 2015; Kumar and Verma, 2016; Yang et al., 2016 and Zhang et al., 2016 models) shortlisted based on their simplicity in calculating the input parameters. It was found that the prediction efficiency of a particular shear strength criterion differs with the change in rock type. Criteria proposed by Yang et al. (2016) and Xia et al. (2014) were found to be the most efficient in estimating peak shear strength of the concerned rock discontinuities.

Keywords: *Granite, Quartzite, Sandstone, Joint and bedding plane, Discontinuity-replica, Direct shear test, Constant normal load, Shear behavior, Surface roughness component, Peak friction angle, Shear strength criteria*