Abstract

The shear strength of the concrete-rock interface is a key factor in assessing the stability against sliding of concrete dams founded on rock. While several studies have shown that both surface roughness and the initial cohesion contribute to the shear strength, most of the recommendations for the stability assessment of dams propose conventional values for the mechanical parameters of the dam-foundation interface (i.e. friction angle and cohesion). Moreover, most of the criteria proposed in the literature in order to determine the shear strength of rough joints are based on direct shear tests conducted on joints without initial bonding. Another major difficulty lies in the quantification of surface roughness by means of an objective parameter able to describe the three dimensional aspect of surface roughness as well as the anisotropy observed experimentally. In this context, one of the primary objectives of this thesis is to better understand the shear behavior of bonded rough joints and to relate the shear strength to the morphological parameters of the concrete-rock interface.

Due to the complexity of the shear behavior of bonded joints and because few studies have been carried out on cohesive samples, it was decided to perform several experimental campaigns on different types of geometries with an increasingly complex roughness (smooth, bush-hammered, tooth-shaped asperities and natural surfaces). For this purpose, more than thirty direct shear tests were performed on bonded samples at three levels of normal stress. The influence of the shear displacement rate on the shear behavior of joints was also investigated. Prior to the shear tests, a morphological tool was developed in order to provide an objective quantification of surface roughness based on surface measurements obtained with a laser profilometer.

Based on the shear test results, two different shear behaviors were observed for the natural joints according to surface roughness and the level of normal stress. Thus, an analytical expression was proposed in order to quantify the contribution from the different modes of failure to the shear strength. It is shown that this expression is able to well predict the shear strength of natural joints. Furthermore, a new roughness parameter was proposed in order to quantify the morphology of natural joints and to account for the different levels of surface roughness involved in the shearing mechanism. This parameter was found to be well correlated with the shear strength of joints sheared at a normal stress less than 0.6MPa.

On the other hand, numerical simulations of the direct shear tests were conducted by using a 3D finite element code and by incorporating the reconstructed joint surface obtained from the laser profilometer. Two different models were used: a cohesive-frictional model for the pre-peak phase and a contact law for modeling the residual shear behavior. The mechanical parameters of the concrete-granite interface (c,Φ) were obtained from the results of the experimental campaigns on bush-hammered samples. The comparison between the numerical results and the experimental data showed a good agreement in the residual phase. The use of a cohesive-friction model, on the other hand, allowed to mimic the overall shape of the shear stress curve.

Key words: concrete dams, concrete-granite interface, roughness, sliding stability, cohesive bonds, normal stress, F.E. simulations