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Effects of Shaping Method on Properties of Rock Samples

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Abstract

Non-destructive investigation and analysis of inner structure of rock samples by an X-ray CT is an important instrument for better insight into properties of rock materials related to the geometrical shape and arrangement of individual construction elements, the spatial distribution of pore space included. Study of migration parameters of transfer of granitic rock from micro-scale to real scale in the rock massive required the most detailed visualisation as possible of the pore space of selected granitic samples which is mostly formed by micro-cracks and thus can have crucial effect on transport properties of material. The visualisation of such structures requires minimizing dimensions of testing pieces. However, the method of preparation (shaping) of the testing samples of small dimensions can considerably affect not only their surface properties, but also their inner structure. The paper deals with the visualisation of small cracks in the structure and it compares two completely different methods of preparation of small rock testing samples, i.e. sample preparation by diamond circular saw and high-speed abrasive water jet. The effect of each technology of sample preparation on creation of secondary degradation of the near-surface zone of samples which is not caused by natural processes is examined.

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Keywords: rock cutting method; specimen shaping; high-speed abrasive water jet; X-Ray CT; porosimetry

1. Introduction

Detailed analysis of inner structure of rock specimens is crucial to better understand the properties of rock materials related to the geometrical shape, arrangement of individual construction elements of the studied rock and distribution of pore space inside the rock. Absence or existence of micro-cracks which mainly form the pore space of the rock have significant impact on transport properties of the rock material. The investigation of migration parameters of transfer of granitic rock from micro-scale to real scale in the rock massive is based on as detailed

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visualization of the pore space of selected granitic specimens as possible. The visualization of such structures thus requires minimizing dimensions of testing pieces. Preparation (shaping) of the testing specimens of small dimensions can considerably affect not only the surface properties of the specimens, but also their inner structure.

Effects of different methods of shaping of testing specimens have been already studied in the past. However, the research was focused on comparison of various methods of specimen preparation related to strength properties of standard "big" pieces and preparation of non-conventional shapes. This issue and results obtained so-far are specified in the chapters which follow.

2. Strength properties of rocks and testing methods limitation

Information on strength is essential for the rock description [1]. Elastic modulus, tensile strength, and fracture toughness of rock materials are of increasing importance for design, construction and analysis in the geotechnical engineering [2]. In addition to natural rock and rock-like materials, new geomaterials with unknown properties should be widely tested.

Although tensile stress and failure appears widely around underground tunnels and openings, mine roofs in layered strata, hydraulic fracturing and rock cutting, investigations on tensile strength and deformation of rocks are much less popular than those on compression [3]. Moreover, the tensile deformation properties are still unavailable for most rocks [4] and rock-like materials. One of the reasons is that while the determination of compressive strength of rock materials induces no problems (the uniaxial compressive strength test is the basis of many rock classifications), direct measurement of tensile strength is accompanied by undesirable effects related to problems with forming of test specimens and their gripping to the jaws of press. With regard to tensile loading, the direct test is complicated to be set up, with specimen grips introducing a perturbation in the stress field. Even in an optimal apparatus, slight imperfections caused by the fabricating process during specimen preparation, material heterogeneity, or residual stresses can produce non-uniform stress fields in the specimen [5]. Since gripping problems existed for a long time, a search for alternative test methods has continued over the century [6]. Relatively complicated shaping and gripping resulted in the past in looking for other solutions of laboratory measurement. One way of solving these problems represents the application of indirect method for tensile characteristics determination. Indirect rock tensile tests are usually easier to be performed than the direct one. Therefore, a number of indirect methods (e.g. three point beam bending, hydraulic extension, Brazilian and ring tests) have been accepted widely as an alternative to the direct test for measurement of rock tensile strength. In indirect methods it is generally assumed that the moduli of deformation in tension and in compression are equal. This assumption has been questioned in various papers, but is still largely accepted [7]. For instance, Brazilian test enjoys a wide popularity because of simplicity of the testing procedure and relatively easy interpretation of tested data. It is generally thought that the Brazilian test is a convenient and easy method to estimate the tensile strength of rocks and concrete materials [2]. However, this test has come under a wide range of criticism with regard to the actual mode of failure, assumption of linear elasticity to interpret the test results and the two-dimensional approximation of a really three–dimensional stress field. The estimation of Brazilian tensile strength by the conventional method could lead to erroneous results [8]. Therefore some researchers struggle to eliminate the imperfections of Brazilian test by its modification (for instance [2]). However, it is believed that the direct tension test represents the only reliable method of determination of deformation properties of rock [9].

Fortunately, the development of new methods of material separation enables to form standard test specimens for various strength tests from geomaterials like natural rocks, rock composites and concretes as well. Recently, non-conventional methods based on different principles of material separation are applied more frequently in addition to classical methods of separation by mechanical tools, especially for difficult-to-machine materials. In some cases, they are the only methods for manufacturing a desired test specimen. The technology of high-speed abrasive water jet (AWJ) is almost predestined for such operations.

3. Shaping of rock specimens with abrasive water jets

Effects of high-speed abrasive water jets (jets with abrasive particles addition) during disintegration of materials are well known to technical public. The principle of disintegration is based on high-energy transmission to