СПИСАНИЕ НА БЪЛГАРСКОТО ГЕОЛОГИЧЕСКО ДРУЖЕСТВО, год. 79, кн. 3, 2018, с. 137–138
REVIEW OF THE BULGARIAN GEOLOGICAL SOCIETY, vol. 79, part 3, 2018, p. 137–138
National Conference with international participation "GEOSCIENCES 2018"

Compressive strength of sandstones and argillites from the Iskar Gorge

Якост на натиск на пясъчници и аргилити от Искърския пролом

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Keywords: point load test, rebound hammer, Iskar Gorge.

Introduction

Considerable areas of the Iskar Gorge are made of Paleozoic–Mesozoic sandstones and argillites, which are exposed by active tectonic movements. Different gravitational processes (rockfalls, scree and landslides) occur periodically along the slopes (Ivanov, Nankin, 2009; Ivanov et al., 2009). Their occurrence is determined by the actual condition of the rock mass, which is dependent on weathering degree, fracturing and mechanical properties. The current work shows the preliminary findings from field and laboratory tests on the most widespread sandstones and argillites.

Methodology

The uniaxial compressive strength (UCS) was determined by applying two alternatives to the classical method – point load test (PLT) and rebound hammer method (RHM). The PLT was conducted in laboratory on air dry specimens and the RHM was carried out in-situ directly on the slope. Both techniques are relatively simple for implementation (Fig. 1). The obtained data represents indirect estimation of UCS, based on standard correlation coefficients (ASTM D5731-08, ASTM D5873-14).

Results

The total number of tested sandstones and argillites samples is 98 from six sites (Table 1). The obtained data show relatively wide range of UCS. Variation for sandstones is from 31.4 to 156.5 MPa and for argillites the values are between 6.5 and 163.3 MPa. Main reasons for the dispersion are mineral content, weathering degree, bedding thickness and density of joint systems. The data is statistically processed and average values and standard deviation are derived. The average UCS for sandstones is 95.4 MPa from PLT and 53.2 MPa from RHM. The average UCS for argillites is 44.3 MPa from PLT and 28.4 MPa from RHM. Overall the sandstones have considerably higher compressive strength compared to argillites. Also, the values from PLT are mostly higher than those obtained from RHM. The average bulk density of the tested sandstones is 2.59 g/cm^3 (range 2.44–2.65 g/cm^3), while argillites have 2.66 g/cm^3 (range 2.60–2.72 g/cm^3). According

Fig. 1. Implementation of RHM and PLT: *a*, RHM application on site; *b*, PLT of sandstone; *c*, sandstone after failure; *d*, argillite after failure

Table 1. Estimation of UCS of sandstones and argillites

Rock type	Sandstones					Argillites			
Region	Novi Iskar		Svoge	Tserovo		Vlado Trichkov		Lukovo	Svoge
Estimated UCS (MPa)	point load test	rebound hammer test	point load test	point load test	rebound hammer test	point load test	rebound hammer test	point load test	point load test
Min. value	35.2	35.4	71.5	64.8	31.4	6.5	19.8	58.5	10.2
Max. value	145.6	64.9	156.5	134.0	69.3	38.0	33.4	163.3	39.7
Average	83.2	49.2	105.6	97.3	57.2	20.0	28.4	91.8	21.3
St. deviation	31.7	8.5	36.9	24.2	8.8	9.0	7.3	29.3	11.1
No of tests	16	5	12	11	9	14	8	15	8

to Kamenov and Iliev (1963) the UCS for various sandstones is 86–110 MPa, while mudstones have about 21 MPa, which is corresponding rather well with values found from the current study.

Discussion

The applied methods for determination of UCS have advantages, like rapid execution, no need for specimen preparation and economic viability. However, they also have shortcomings – variable accuracy, dependent on correlation coefficients and way of conducting the experiments. Regarding the compressive strength, the nature of failure is distinct for two types of rock. Sandstones fail in brittle manner with little deformation, while argillites exhibit elasto-plastic deformation behavior. The lower values estimated from the RHM in comparison to PLT are possibly due to the different nature of testing. RHM is a non-destructive method and the weathered rock surface decreases the results and is more applicable for fresh surface. At PLT the rock specimen is split after testing, which mobilizes the inner less weathered part of rock sample. Both methods could provide useful information if applied properly. The results are going to be included in geomechanical models necessary for assessment of slope stability and geological risk.

Conclusions

The main conclusions from the conducted study are:

– Sandstones possess significantly higher compressive strength than argillites. Major reasons are the high quartz content in sandstones, type of structural bonds and jointing. The higher UCS of sandstones predetermine higher angle of internal friction, leading to formation of high and steep slopes. The detached blocks from rock mass reach dimensions of 1–2 m^3.

– Argillites have strong anisotropy, presence of clay particles and very thin bedding resulting in higher fracturing of the rock mass into much smaller pieces (0.001–0.01 m^3).

– The preliminary hazard assessment, based on compressive strength estimation, is that slopes composed of sandstones have higher probability of rockfalls affecting people, buildings and infrastructure, compared to slopes in argillites, because of the different geomorphology and dimensions of detached blocks.

Acknowledgements: The study was financed by project № 72-00-40-301/10.05.2017, Support for Young Scientists and Scholars by the Bulgarian Academy of Sciences.

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