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IMPACT OF BUILDING STONE TYPE ON SELECTION OF MATERIALS FOR THE CONSTRUCTION MACHINERY PARTS

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Abstrakt

Results of experimental investigations of four types of rock aggregates are presented in this paper. Those aggregates were analyzed from the aspect of their influence on wear of the working parts of different machines used for their preparation and deposition on roads. The four most important types of building stones, limestone, dolomite marble, calcite-dolomite marble and andesite, exploited from deposits in Republic of Serbia, were considered, since those aggregates are convenient for certain layers of the driveway constructions on roads, streets, airports and as the base layer on railways. In selection of rocks for depositing on roads, it is necessary to know both their general and specific properties. For that purpose, it was necessary to conduct the mineralogical-petrographic and physical-mechanical investigations. In addition, the wear resistance was checked both on samples taken directly from the rock material as well as from the stone aggregates.

Kľúčové slová:

Rock materials;
Aggregates;
Minerals;
Working parts;
Civil engineering mechanization.

1 Introduction

During the construction of various civil engineering objects machines and their elements are subjected to different types of loads, especially elements that are in direct contact with rock materials. The service life of construction machines' parts is directly dependent on properties of parts' materials, the type of rock materials and exploitation conditions. Those machines and parts are in operation exposed to different types of wear and corrosion, even to occasional impact loads. Some parts of construction machines are in contact with various kinds of rocks (stones), sand, soil, asphalt, concrete and even exposed to influence of water.

It is important to know the physical and mechanical properties of the rock minerals, both for their exploitation, and processing and building-in. Different elements of construction mechanization, rocks and third objects take part in this very complex tribo-mechanical process, it is to properly select material for the construction machines' working parts, as well as the technology for reparation of the damaged and worn machine parts.

Rocks (stones) mainly consist of seven groups of minerals: silicates, carbonates, oxides, sulphates, sulfides, chlorides and hydroxides. Mineral masses in the Earth's crust can be found in form of compounds (solid rocks) or in the dispersed form. According to strength, the rocks are categorized into weak, solid and exceptionally solid rocks, since minerals can be in the crystal, crystallite or amorphous form. Rock properties can be significantly changed due to action of water, frost or heat. The most important properties of rocks are petrographic, physical, mechanical and technological (Janjić, 1982). Experimental investigations of rocks provide for data for estimates of their suitability for application in construction and other branches of economy.

In this paper are analyzed properties of stones were used from four sites in Serbia: limestone in the village of Korman-"Samar" (Figure 1), dolomite marble in the village of Gradac-"Straževica" (Figure 2), calcite-dolomite marble in the village of Vlakča-"Vučjak" (Figure 3) and andesite in the village of

Velika Bisina-"Šumnik" near Raška (Figure 4). The left-hand sides of figures present the macroscopic appearance of the structure (magnification 10×), while on the right-hand side are presented the microscopic appearance of the sock (magnification 50×). The most exploited (over 70%) is limestone from the "Vučjak" site, (Iazić et al., 2013, Lazić et al., 2015).

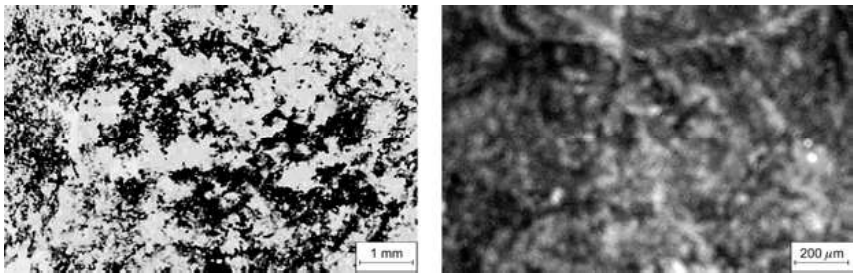

Fig. 1: Appearance of limestone rock structure

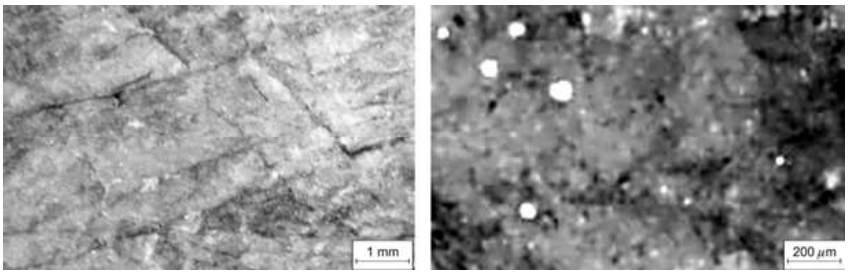

Fig. 2: Appearance of dolomite marble rock structure

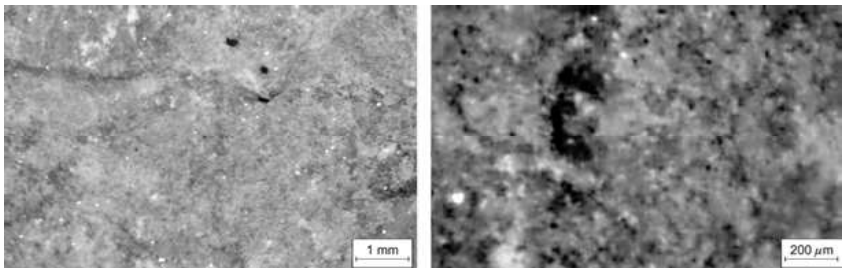

Fig. 3: Appearance of the rock structure of calcite-dolomite marble

2 Experimental testing of certain rock properties

The most important properties of rocks are petrographic, physical, mechanical and technological, (Arsić et al., 2013). Petrographic properties of rocks that have technically significant are: mineral composition, structure and texture of rocks. The rocks' petrographic properties was carried out visually, microscopically and with the help of comparators.

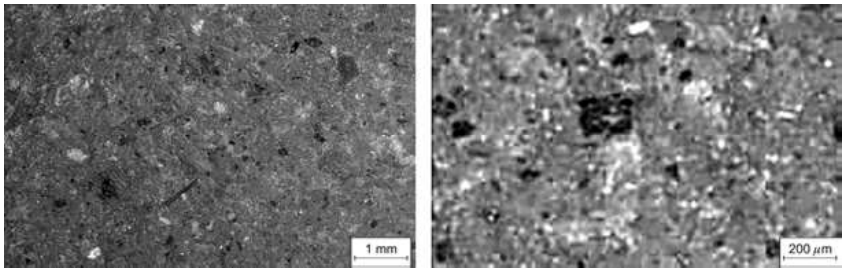

Figure 4: Appearance of the rock structure of andesite

Tab. 1: Volumetric masses and porosity of tested samples of different types of rocks

Tested rock physical properties	Limestone[1]	Dolomite marble[2]	Calcite-dolomite marble[3]	Andesite[4]
Bulk density with pores, $\gamma_v = m_s/V$	2690	2780	2820	2630
Specific mass without pores and voids, $\rho_s = m_s/V_s$	2730	2870	2850	2750
Density coefficient, $i = \gamma_v/\rho_s$	0.985	0.969	0.989	0.956
Bulk density with pores, $\gamma_v = m_s/V$	2690	2780	2820	2630
Porosity, $p = [1-(\gamma_v/\rho_s)]\cdot 100,\%$	1.50	3.10	1.10	4.40
Water absorption, $w = (m_v - m_s)/m_s \cdot 100,\%$	0.18	0.17	0.12	0.64

[1]Limeston – Vucjak; [2]Dolomite marble; [3]Samar Calcite-dolomite marble; [4]Gradac Andesite – Šavnik

The most tested mechanical properties of rocks are the compressive strength, hardness, elasticity, toughness and wear resistance. The tests of the mechanical properties of rocks are defined by the corresponding standards, (Serbian standards, 2002). The test of the impact strengths of stone materials were performed in three mutually perpendicular directions (I-I is parallel to the direction of rock layering, II-II is perpendicular to the previous direction and lies in the plane of layering, and III-III is perpendicular to the direction of propagation of the rock layering). From results in Table 2 one can conclude that these rocks are of a relatively low impact strength, while a similar conclusion was drawn from the appearance of the fracture surface, which is rough and has sharp edges.

Tab. 2: Impact toughness of tested rock types

Impact toughness, MPa	Limeston e	Dolomite marble	Calcite-dolomite marble	Andesite
Direction I-I	22.40	17.00	27.20	13.40
Direction II-II	24.20	20.60	26.10	17.20
Direction III-III	28.80	24.60	28.30	22.40
Medium value	25.13	20.73	27.20	17.67

Considering the elasticity of rocks, the tests have shown the following mean values for samples of rock material-limestone: Poisson's coefficient m = 0.36, modulus of elasticity E = 50247 MPa, shear modulus G = 18608 MPa and bulk modulus K = 59714 MPa.

Experimental determination of rock strengths was performed on at least 3 prismatic samples cut from the rock in three mutually perpendicular directions. The compressive strength was determined on dry and water-saturated samples in the form of a cube with an edge length of 40±1 mm. The average compressive strength value of limestone samples from the Vučjak deposit (15 samples, 5 per each direction) was 131 MPa. The compressive strength results after 25 freezing cycles were obtained on cube samples of edge length 100±1 mm, Table 3.

The tensile, bending and shear strengths, as well as wear resistance, were tasted as well. Results of those tests cannot be presented here due to the limited length of this paper.

Tab. 3: Compressive strength of tested rock types

Rock types	Compressive strength, MPa			Softening coefficient, K_{sof}
	Dry samples	Water saturated samples	Samples after 25 freezing cycles	
Limestone	131	123	117	0.94
Dolomite marble	150	136	130	0.91
Calcite-dolomite marble	161	140	138	0.87
Andesite	195	186	184	0.95

5 Conclusion

The assessment of the most important physical properties of the tested four rock materials led to the conclusion that those are smooth and homogeneous rocks of medium to high hardness. The compressive strength values are on average 10-40 times higher than the shear, flexural and tensile strength, while the wear resistance was good for most tested materials. The obtained results enable the assessment of the quality of materials and indicate the complex problem of material selection for the working parts of construction machinery according to the stones' properties. Those results of rock materials properties, as well as the complex operating conditions of the tribological system, must be taken into account when selecting materials and technology for the working parts of construction machinery.

References

[1] Arsić, D., Mutavdžić, M., Nikolić, R.R., Lazić, V., Hadzima, B. (2020, January). Physical properties of selected rock materials. SEMDOK 2020, Zuberec, Slovakia.

[2] Janjić, M. (1982) Engineering geology with geology fundametals, Scientific Book, Belgrade (In Serbian)

[3] Lazić, V., Mutavdžić, M., Nikolić, R., Aleksandrović, S., Milosavljević, D., Krstić, B., Čukić, R. (2013, May). Influence of various types of rock aggregates on selection of the working parts materials in civil engineering. The 13th International Conference on Tribology. Kragujevac, Serbia.

[4] Lazić, V., Arsić, D., Nikolić, R., Hadzima, B., Mutavdžić, M. (2015) Experimental determination of mechanical characteristics of four types of stones and their influence on the construction machinery parts wear. Advanced Materials Research. 1100, 178-184.

[5] https://doi.org/10.4028/www.scientific.net/AMR.1100.178

[6] Serbian standards (2002)-JUS B.B8.001 up to JUS B.B8.086. https://iss.rs/sr_Cyrl/project/show/iss:proj:160