# PHYSICAL PROPERTIES OF SELECTED ROCK MATERIALS

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## 1. Introduction

During the construction works, the working parts of the construction machinery are the most frequently exposed to direct contact with various types of building materials (stone, gravel, soil, asphalt, concrete, etc.), as well as with water. The heavy and various construction machines, used in producing, transport and building-in of those materials, necessary for erecting construction objects aimed for various usage, are subjected to different kinds of extremely heavy loads and stresses. They are most probably simultaneously exposed to processes of intensive wear (especially the abrasive wear) and corrosion and occasionally or constantly to impact loads of different intensities.
The main cause of damages of the construction machinery working parts were the subjects of research of these authors [1, 2], as well as many others [3-6]. The conclusion of majority of authors is that the service life and intensity of wear of the construction machinery mainly depend on physical and mechanical properties of the rock materials and their aggregates with which they come into contact [6-13].
The most significant technical properties of rocks are petrographic, physical, mechanical and technological [2, 14]. Those properties are drastically changed by influence of water, extreme temperatures (either low - frost or high - heat), so knowing those influences is of utmost importance, as well. The properties of rocks are directly influenced by properties of minerals that make their composition. All the minerals that are constituents of rocks can be classified, according to their chemical composition, into seven groups: silicates, carbonates, oxides, sulphates, sulphides, chlorides and hydro-oxides. According to the way of creation, all the rocks can be classified into three large groups: magmatic (eruptive), sedimentary and metamorphic.
Analysis of the rock properties was done for rock materials from four sites in Republic of Serbia: limestone – site "Vučjak", dolomite limestone – site "Samar", calcite-dolomite limestone – site "Gradac" and andesite – site "Šavnik". Obtained results can be useful for analysis of influence of the rock materials' quality on stability of terrain where the construction of an object is done, on possibility for application and proper exploitation of the construction machinery during the production, transport and building-in of those materials and their aggregates.

## 2. Description of investigated rock materials

The petrographic properties of rocks that are of technical importance are the mineral composition, structure and texture. The rock structure implies its shape, size and way of bonding of its mineral grains; it is usually considered separately from the way of its creation; it can be crystallite, porphyritic and clastic. The rock texture implies the placement and distribution of minerals of its composition, as well as the presence of pores

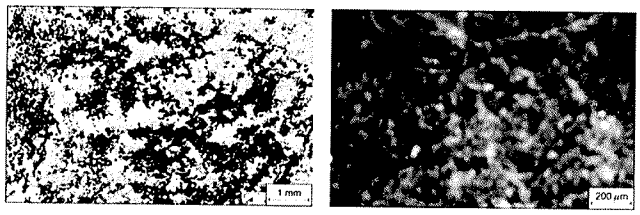
and micro-cracks; it can be massive, fluid, vesicular, striped, breccia and slate, [2, 15]. The tested rocks appearances, macroscopic and microscopic, are presented in Figure 1.
Site "Samar" is mainly consisting of the dolomite marble whose structure is granoblastic. The texture is massive and non-compact.
Site "Gradac" is mainly consisting of the dolomite marble whose structure is granoblastic. The texture is homogeneous and compact.
Site "Šavnik" is mainly consisting of different kinds of andesite. The structure of the rock is hollo-crystallite - porphyritic. The texture is massive.

## 3. Determination of physical properties of rocks

Physical properties of rocks are classified in several groups: optical, hydro-physical, thermal, electrical, radioactive, etc. Optical properties of rocks are usually defined by their color, which is caused by the chemical composition of their constituent minerals. They are divided in light – SAL rocks (rich in aluminum and silicon) and dark – FEM rocks (rich in iron and magnesium). The hydro-physical properties of rocks are specific mass (density), volumetric mass, porosity, compactness, compressibility, water absorption, humidity, capillary, stickiness, swelling, ventilation, [2, 14-15]. Physical properties of rocks directly influence their mechanical and technological properties. All the tests performed within this research are done according to adequate standard [16].

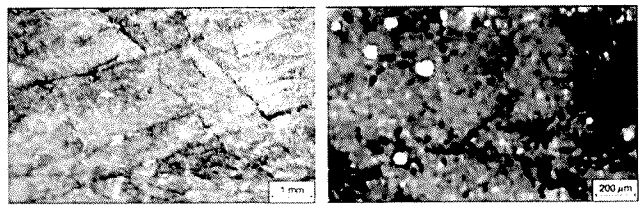
### *3.1 Volumetric mass and specific mass (density) of tested rocks*

The volumetric (volume) mass of rocks is the mass of solid particles with pores and voids in a unit of the total volume. According to values of the volumetric mass, the rocks are classified as *very light* ($\gamma_V$ = 1000-1500 $kg/m^3$), *light* ($\gamma_V$ = 1500-2500 $kg/m^3$), *massive* ($\gamma_V$ = 2500-3000 $kg/m^3$) and *very massive* ($\gamma_V$> 3000 $kg/m^3$).
The specific mas (density) of a rock is the mass of its mineral particles in the volume unit, without the pores and voids. For determination of the rock's density is used the dried powder of the mineral mass, in quantity of about 50 *g*, which has to pass through the sieve with eyelet of 0.09 *mm*, without any residue. Obtained results for four tested types of rocks are shown in Figure 2 and Table 1, [2]. The volumetric mass coefficient values, calculated as the ratio of the volumetric mass and the density of the rock are also presented in Table 2.

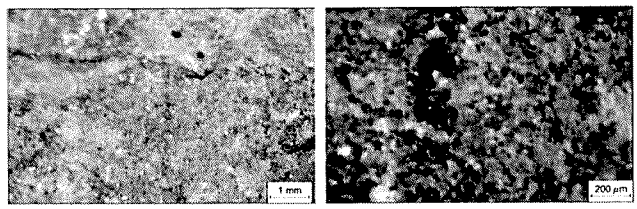



Limestone – Site "Vučjak"

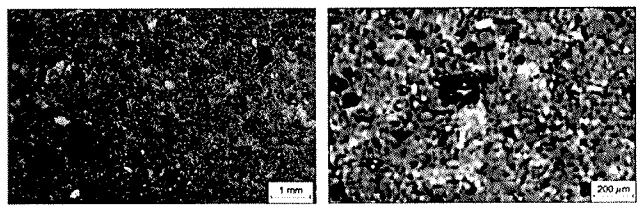
*Figure. 1 Macroscopic (left) and microscopic appearance of tested rock materials*




Dolomite marble – Site "Samar"




Calcite-dolomite marble – Site "Gradac"




Andesite – Site "Šavnik"

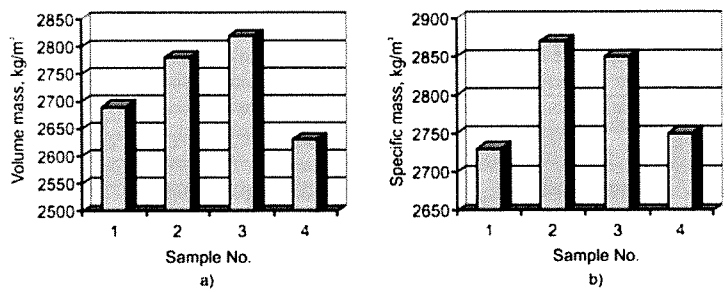



*Fig. 2 Results of a) volumetric and b) specific mass tests. 1 - Limestone, 2 - Dolomite marble, 3 - Calcite-dolomite marble, 4 - Andesite.*

*Tab. 1 Volumetric and specific mass of tested rocks: 1 – Limestone, 2 – Dolomite marble, 3 – Calcite-dolomite marble, 4 – Andesite.*

| Tested property | Type of rock and site | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| **Volumetric mass, *kg/m*$^3$** | 2690 | 2780 | 2820 | 2630 |
| ***Density, kg/m*$^3$** | 2730 | 2870 | 2850 | 2750 |
| **Volumetric mass coefficient** | 0.985 | 0.969 | 0.989 | 0.956 |

*3.2. Porosity of and water absorption of tested rocks*

The rock porosity represents the total empty space within the volume unit, which is not filled with the mineral substance. It depends on the structure and texture of rocks, namely on the size of grains and ways of their packing (aggregation) within the rock. According to the total porosity value, firmly bound (stone) rocks are divided into *poorly porous* (p = 1.0-2.5 %); *porous* (p = 2.5-5.0 %); *quite porous* (p = 5-10 %); *very porous* (p = 10-20 %) and *extremely porous* (p > 20 %), [2].

Analysis of porosity points to the fact that it is the most important physical property of rocks since it directly influences the volumetric mass and water absorption of different types of rocks. The highest difference of porosity is found in different kinds of sandstones, andesite and limestones, because the porosity is influenced by types of voids. The porosity can be isolated, when the voids are mutually isolated, or effective, when the voids in rocks are connected.

*Tab. 2 Results of porosity and water absorption tests: 1 – Limestone, 2 – Dolomite marble, 3 – Calcite-dolomite marble, 4 – Andesite.*

| Tested property | Rock type | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| ***Porosity*, %** | 1.50 | 3.10 | 1.10 | 4.40 |
| **Water absorption, %** | 0.18 | 0.17 | 0.12 | 0.64 |

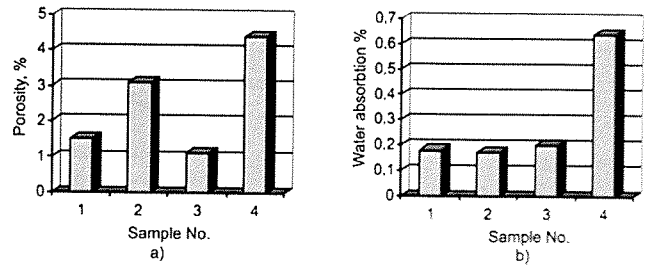



*Fig. 3 Results of a) porosity and b) water absorption tests: 1 - Limestone, 2 - Dolomite marble, 3 - Calcite-dolomite marble, 4 - Andesite.*

The water absorption of rocks is ability of a rock to absorb certain quantity of water, up to its natural humidity. It is defined by the ratio of the water mass and the solid mineral substance mass. Results of experimental investigations of porosity and the water absorption are presented in Table 2 and in Figure 3 [2]. Porosity and water absorption of rocks are important properties when construction of underground and ground objects is concerned, like dams, channels, floodgates, as well as for estimates of the exploitation conditions of the construction mechanization.

## 4. Summary and conclusions

In this paper are tested some physical properties of four types of rocks materials found in Serbia, which are the most frequently used for the road constructions, the volumetric and specific mass (density), porosity and water absorption. The four tested rock materials belong into a group of the massive rocks with various porosities and water absorption. The lowest porosity was exhibited by the calcite-dolomite marble, which can be classified as poorly porous rock material; the same goes for the organogenic limestone, while the dolomite marble and andesite can be classified as porous and moderately water absorbent. Knowing various properties of different building materials, is important for their application in the construction industry, as well as for their manufacturing (processing) and transport. That secures the adequate design, manufacturing and exploitation of the construction mechanization, especially the elements that are in direct contact with the rock materials.

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