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DETERMINATION OF WATER ABSORPTION PROPERTIES OF NATURAL BUILDING STONES AND THEIR RELATION TO POROSITY

ABSTRACT

It is known that rock-water interaction has important effects on the physicomechanical properties of rocks. In this study, 20 rock with different origins were used. The water absorption properties of rocks were determined by immersion and capillarity-effected water absorption experiments. The rocks are classified according to the water absorption properties of the capillary effect. The relationships between water absorption properties and porosity properties of rocks were evaluated by regression analysis. The results obtained are given in the form of regression equations.

Keywords: Building Stone, Water Absorption, Capillarity, Porosity

1. INTRODUCTION

Many research has been done on the effect of rock-water interaction on the physicomechanical properties of rock materials. These investigations were carried out on moisture content, water absorption by weight and capillary affected water absorption of rocks. The weakening effect of the water on rocks has been studied in detail for various rocks, especially sandstone, limestone, tuff and shale [1, 2, 3, 4, 5 and 6]. As a result of these studies, it was determined that as the degree of water saturation increases, the strength of rock decreases, and sediment rocks are more susceptible to water than magmatic and metamorphic rocks. In addition, two main causes have been attributed to the weakening effect of the water on rocks, chemical sensitivity and changes in capillary forces [7, 8, 9 and 10]. The effect of water and moisture absorbed by the capillary effect on the degradation of natural building stones has been studied by many researchers. It has been reported that water and moisture absorbed by the capillary effect are the most important factors in the degradation of building blocks [11 and 12].

Several experimental procedures were proposed in the literature [9] to determine the water content of the rocks. In this study, the water saturation state of the rocks was determined water absorption by weight and capillarity effected water absorption experiments. In the experiments, 20 rock with different origins were used. The relationships between water absorption and physical properties of rocks were evaluated by regression analysis. The results obtained from these evaluations are described as regression equations.

2. RESEARCH SIGNIFICANCE

It is known that rock-water interaction accelerates degradation in rocks and has a weakening effect on the mechanical properties of rocks. Therefore, determination of the water absorption properties of the rocks

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used as building stones is of great importance in terms of determining their usage areas. Porosity is the determining factor in the water absorption properties of rocks. Therefore, the relationships between the water absorption properties of the rocks due to porosity are investigated and the relations between them are defined by the regression equations.

3. MATERIAL AND METHODS

3.1. Description of Material

Water absorption experiments were carried out on 20 different rocks. Experimental samples were taken from the stone processing plants in block form. The specimens were prepared in the laboratory as cores 54x72mm (Figure 1).

Figure 1. Examples of specimens used in the experiment

4. METHODS AND RESULTS

Some physical properties of the samples were determined in accordance with the ISRM [13] standard and their results are summarized in Table 1. In the literature, several procedures were proposed to determine the water absorption properties of rocks. In this study, the methods proposed in ISRM [11] and TS EN 1925 [14] standards were used. The method proposed by ISRM [13] is based on the immersion of the sample into the water. In this experiment, rock samples were placed in water at room temperature and atmospheric pressure for 48 hours. The samples removed from the water were weighed on a 0.01g precision scale. The wet samples were dried for 24 hours at 105°C and weighed again. The water absorption capacities of the samples were calculated using the following equation. Calculation results are presented in Table 2.

$$W_{atm} = (M_{wet} - M_{dry})/M_{dry} \times 100\ \% \quad (1)$$

Where W_{atm} represents the percent water by weight, M_{wet} saturated weight and M_{dry} dry weight of the sample

When porous rocks come into contact with rain or surface waters, they tend to get water into their body due to capillarity. Capillary water absorption is related to the balance between the surface tension of the liquid and the absorption at the pore surface. In this study, capillary effect water absorption was carried out in accordance with TS EN 1925 [13] using the following equation.

$$C_{coefficient} = \left(M_{dry} - M_{wet}\right)/At_i^{0.5} \quad g/m^2s^{0.5} \qquad (2)$$

Where W is the water absorption coefficient due to capillary effect, M_{dry} is the dry weight, M_{wet} is the water absorption weight, A is the area of the surface in contact with water, and t_i is the time during which the successive weight is measured from the beginning of the experiment.

Table 1. Physical properties of specimens [15]

S. Code	Rock Type	Locations	P (%)	ρ_{dry} (gr/cm^3)	ρ_{wet} (gr/cm)
TK	Tuff	Tomarza-Kayseri	20.353	1.834	2.038
TS	Tuff	Tomarza-Kayseri	21.984	1.686	1.906
TKV	Tuff	Tomarza-Kayseri	23.853	1.747	1.985
TSI	Tuff	Tomarza-Kayseri	28.716	1.518	1.805
TG	Tuff	Tomarza-Kayseri	16.629	1.890	2.056
AG	Granite	Ortaköy-Aksaray	0.743	2.635	2.642
KR	Granite	Kaman-Kırşehir	0.980	2.658	2.668
AA	Andesite	Gölbaşı-Ankara	7.974	2.190	2.270
SL	Andesite	Sille-Konya	8.417	2.186	2.270
EFT	Andesite	Efl.pınar-Konya	16.516	2.031	2.196
GL	Andesite	Gölbaşı-Konya	8.624	2.227	2.313
CL	Andesite	Beysehir-Konya	5.672	2.421	2.478
BB	Beige	Kemalpaşa-Bursa	0.499	2.623	2.627
AF	Marble	İscehisar-Afyon	0.311	2.682	2.685
YO	Beige	Sarıkaya-Yozgat	0.566	2.752	2.757
LR	Travertine	Finike-Antalya	7.068	2.328	2.398
BS	Travertine	Beyşehir-Konya	5.844	2.421	2.479
KL	Travertine	Beyşehir-Konya	4.075	2.251	2.291
GD	Travertine	Gödene-Konya	7.433	2.448	2.522
MT	Travertine	Mut-Mersin	1.015	2.557	2.567

P: Porosity
ρ_{dry}: Dry density
ρ_{wet}: Wet density
SH: Schmidt hammer index

During the test, care was taken to keep the water level and ambient temperature constant. Two different time periods were used in experiments depending on the water absorption rates of the rocks. As a result of the trial work, it was found that for samples with high water absorption rate, 1, 3, 5, 10, 15, 30, 60, 480, 1440 minutes, for samples with low water absorption rate, 30, 60, 180, 480, 1440, 2880, 4320 minutes were selected. The experiments were carried out perpendicular to the anisotropic planes of the samples. The measurement and calculation results are given in Table 2.

4. EVALUATION AND DISCUSSION

In Table 2, the water absorption contents of the rocks vary between 0.11–18.92% and the capillary water absorption coefficients vary between 0.495–401.782 gr/m^{2}s$^{0.5}$. Based on these data, the rocks were classified into 5 different categories according to the water absorption coefficients depending on the capillary effect, considering the time-dependent water absorption properties (Table 2). In order to determine rock-water interaction, the relationship between porosity and water absorption properties of rocks were investigated. Linear, exponential, exponential and logarithmic relations were used in determining

relations. The regression equations giving the greatest correlation coefficient were determined.

Table 2. Water absorption values of specimens

S.Code	W(%)	C(gr/m^{2}s^{0,5})	Classification*
TK	11.09661	401.782	Very high water-absorbing rock
TS	13.04168	190.513	Very high water-absorbing rock
TKV	13.65459	205.575	Very high water-absorbing rock
TSI	18.92230	344.706	Very high water-absorbing rock
TG	8.798722	56.140	High water-absorbing rock
AG	0.282077	0.740	Very low water-absorbing rock
KR	0.368718	0.637	Very low water-absorbing rock
AA	3.641457	5.8995	Moderate water-absorbing rock
SL	3.850051	11.230	Moderate water-absorbing rock
EFT	8.133685	18.402	Moderate water-absorbing rock
GL	3.873180	7.522	Moderate water-absorbing rock
CL	2.343438	7.483	Moderate water-absorbing rock
BB	0.190487	0.495	Very low water-absorbing rock
AF	0.115802	0.560	Very low water-absorbing rock
YO	0.205697	0.570	Very low water-absorbing rock
LR	3.036411	9.753	Moderate water-absorbing rock
BS	2.414399	5.999	Moderate water-absorbing rock
KL	1.810845	3.197	Low water-absorbing rock
GD	3.036729	9.753	Moderate water-absorbing rock
MT	0.396757	1.006	Low water-absorbing rock

*C<1.0: Very low
1<C<10: Low
10<C<50: Moderate
50<C<100: High
C>100: Very high

Strong relationships between porosity, which has a decisive influence on the water absorption properties of rocks, and water absorption by weight and capillary effect, were found (Figure 3a). Relationships between water absorption properties of rocks and porosity were found to be stronger when the high water-absorbing rocks were excluded (Figure 3b).

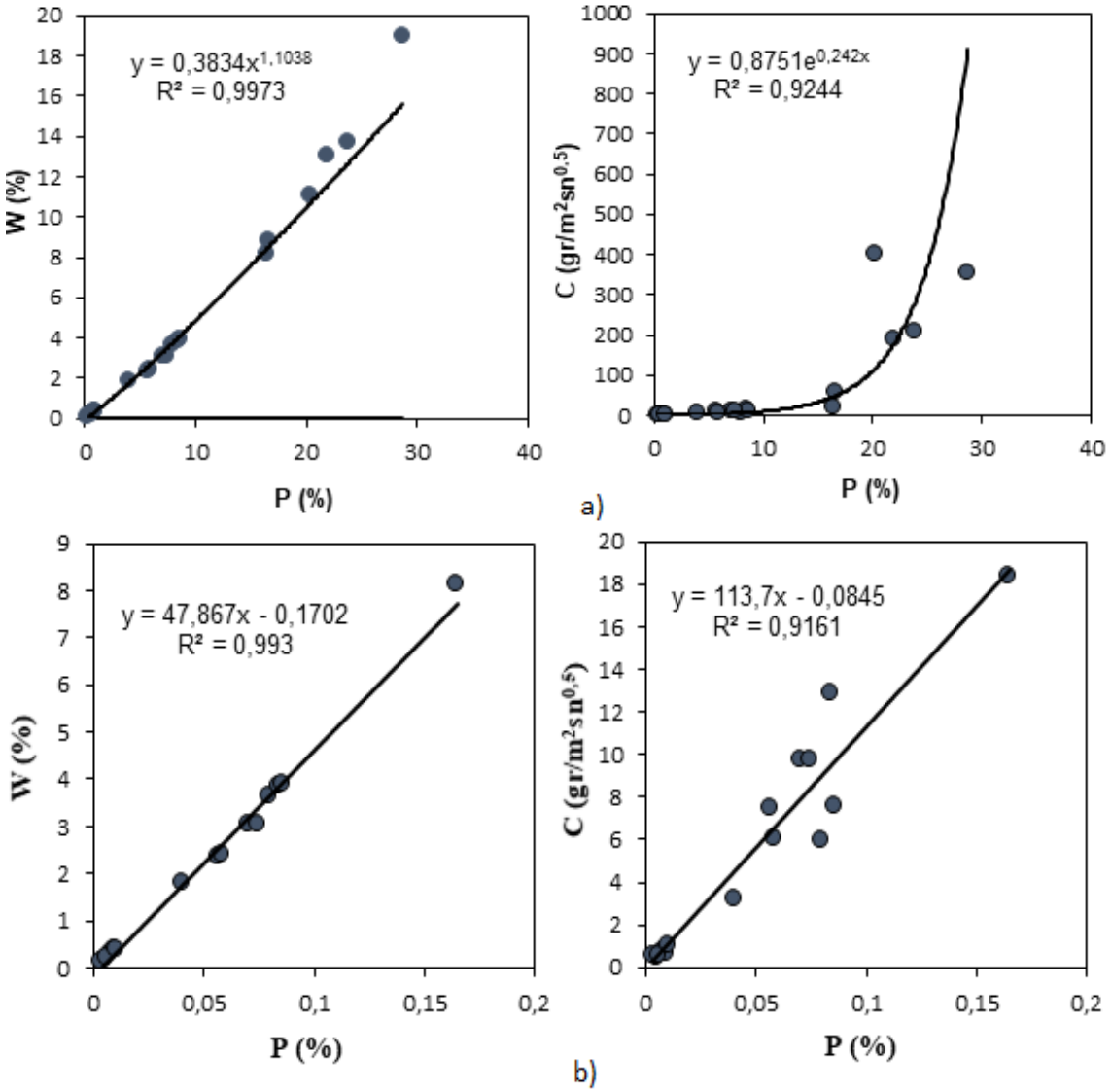

Figure 3. Water absorption properties (a-total specimens and b-except for high water absorption specimens) versus porosity

There was a strong correlation between the water absorption coefficient due to the capillary effect and the water absorption value by weight under the atmospheric pressure (Figure 4a). Excluding high water-absorbing rocks, it appears that the relationship is strengthened (Figure 4b).

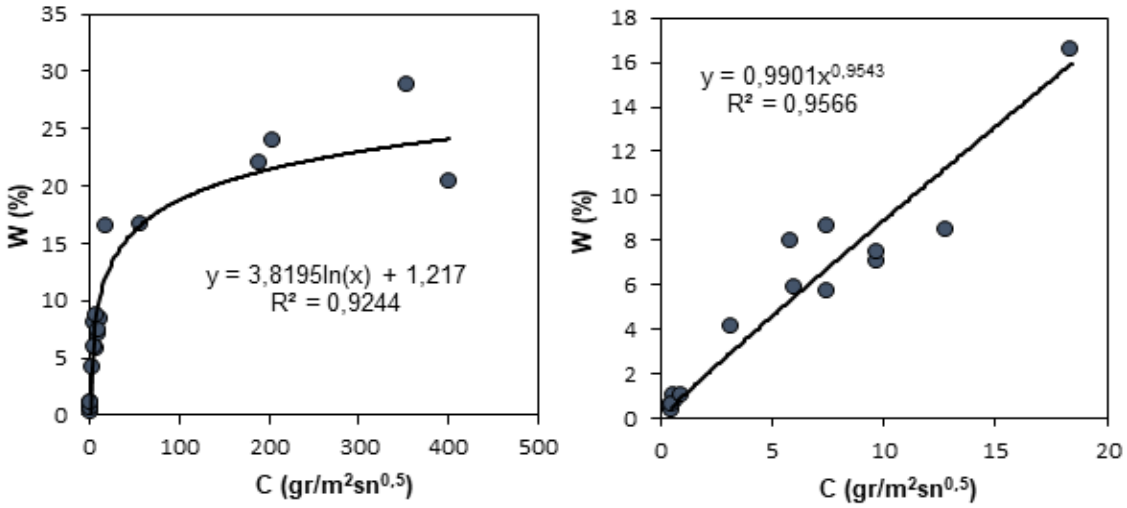

Figure 4. The relationship between water absorption properties of rocks (a-total specimens, b-except for high water absorption specimens)

5. CONCLUSION

In this study, it was aimed to determine the relationships between water absorption properties and porosity properties of sedimentary, magmatic and metamorphic rocks. The main results obtained from this study are listed below.

- The samples used in the experiment are classified as Tuff>Andesite>Travertine>Granite>Marble depending on the water absorption state depending on the capillary effect. In addition, a classification of C<1.0: Very low, 1<C<10: Low, 10<C<50: Moderate, 50<C<100: High and C>100: Very high, is proposed.
- It is determined that there are significant relationships between water absorption values and porosity of the samples. These relationships are summarized below.

Parameters	Regression Equations	R^2
P - W	$W=0.3834P^{1.1038}$	0.9973
P - C	$C=0.8751e^{0.242P}$	0.9244
C - W	W=3.8195 ln (C)+1.217	0.9244

- The strongest correlation was obtained between the water absorption values of the rocks and the porosity values. When high water-absorbing rocks were not included in the analyses, it was found that the relations with water absorption were strengthening.

NOTICE

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