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CERTAIN PHYSICAL PROPERTIES OF THE BUILDING STONES FROM ELAZIG-TUNCELI-ERZINCAN-BAYBURT PROVINCES

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Abstract

In this study, certain physical properties of Korpe Stone (Elazıg), Karakocan Stone (Elazıg), Hozat (Tunceli), Erzincan andesite (Erzincan) and Bayburt stones found in four provinces and used as building construction materials are subjected to analysis. These stones are used as building elements in the region, while also being praised by the public for their ease of processing and their thermal properties. The objective is to determine the kind of properties the stones that are used in the region actually have as building elements. In order to determine the physical properties of the stones, samples were taken from two separate quarries for each stone. Following the tests carried out on the samples, The thermal conduction coefficients of Karakocan Stone (0.44 W/mK), Korpe Stone (0.71 W/mK) and Bayburt Tuff (0.74 W/mK) were lower than the others, whereas the pressure stresses of Korpe Stone (52.6 MPa) and Erzincan Andesite (62.8 MPa) were higher than the others and compared with similar building materials.

Keywords: Korpe stone, Karakocan stone, Hozat stone, Erzincan andesite, Bayburt tuff, building material

1. Introduction

Energy costs, price increases in building materials and the increase in the need for housing can render it rather more effective to use local stones as building materials. Stones are generally used as carrier elements, while on the other hand rarely used as a filling element. In this context, the following stones can be shown as examples: Ahlat stone of Bitlis province, Malazgirt stone of Mus province, Karacadag stone of Diyarbakir, Urgup stone of Nevsehir, "*karga sabunu*" stone of Sanliurfa province (Bicer, 2019-a, b, c). From an economic point of view, it can be concluded that using stone at certain distances from the quarry is more suitable than fabricated building elements such as block brick, perforated brick, and briquette. Stones can be easily cut with a saw just as a piece of wood due to the moisture in their growth when they are newly extracted from the quarry. In addition, these stones can be drilled, and carved with hard objects.

A number of studies have been carried out on building blocks. These studies can be summarized in two groups. The first group consists of studies on the formation, deterioration and protection of stones. The example studies carried out in this context can be shown as follows: Gevrek & Kazanci (1991), ignimbrite formation; Kazanci & Gurbuz (2014), the geological formation of the natural stone of Turkey; Pivko (2003), the historical formation of stones in the world. In addition, Akilli (1987), carried out studies on the factors that cause the destruction of stone artifacts. Gurdal (1982), carried out researches on the deterioration and protection of natural stones used in monuments and buildings. The studies conducted by Akin vd. (2014), within the scope of "the sensitivity of Ahlat Stone under atmospheric effects" can be shown as an example in this context.

The second group consists of studies on the use of stones as building materials. In this context, the following studies can be shown as examples: Bakis vd. (2014), the use of the Ahlat stone with a geological heritage quality in the construction sector; Bicer (2019-a) Ahlat & Malazgirt stones; Bicer (2019-b), building blocks used in Southeastern Anatolia Region provinces; Bicer (2019-c), thermal and mechanical properties of stones used as building materials in Elazig, Malatya, Adiyaman and Nevsehir provinces.

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In this study, certain physical properties of the following stones were subjected analysis: Korpe stone used in the center of Elazig province; Karakocan stone located in Karakocan district of Elazig province; Hozat stone located in Hozat district of Tunceli province; Andesite stone found in Erzincan province and Bayburt tuff located in Bayburt province (Fig. 1). Stones have been used as a structural element in regional structures for many years and have been accepted as a reliable building element by the public. Erzincan andesite stone, on the other hand, was mostly used as pavement and building siding material in the region. It is unclear whether the stones are actually a durable building material or they are used because of its affordability and ease of supply. This study has been carried out to shed light on this matter.

Figure 1. Location of provinces in the East Anatolia Region of Turkey

2. Material and Methods

2.1. Material

The samples of 150x60x20 mm^3 for thermal tests and 100x100x100 mm^3 for compressive strength and abrasion tests were prepared from block masses taken from two different quarries of each region under investigation (Fig. 2).

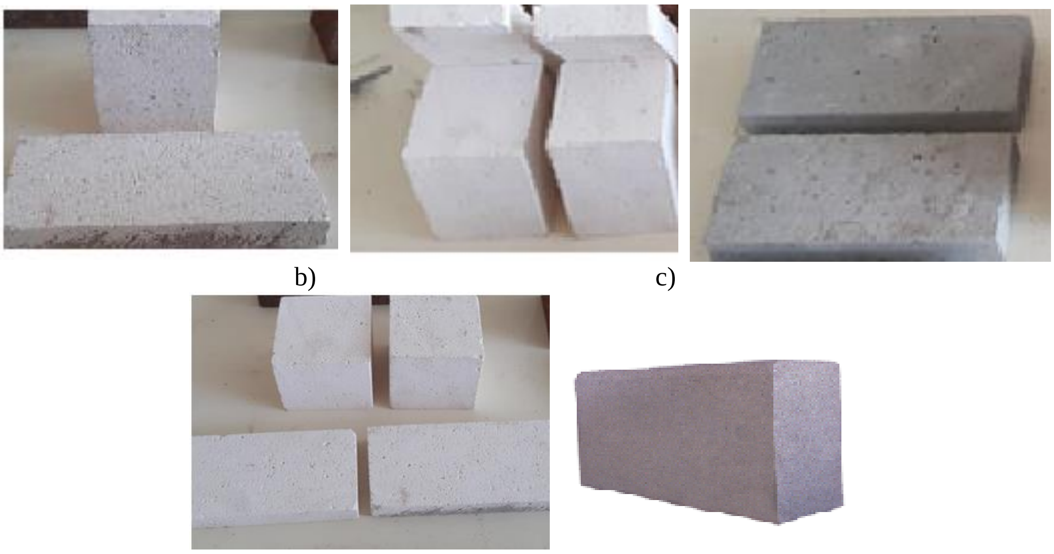
Korpe Stone: The quarries are located in the village of Korpe, with a distance of 15 km to Elazig province, and possess enriched reserves. The stones are used as minarets, stairs, tombstones and cobblestones, especially in building constructions.

Karakocan Stone: It is located in Karakocan district of Elazig province. This stone is a white colored limestone.

Hozat Stone: Located in the town of Hozat in Tunceli province, the stone is in the organic sedimentary stone class. It has a whitish color.

Erzincan Andesite Stone: The quarries are composed of external igneous andesite stone formed by volcanic lavas located in the Karatepe locality of Erzincan province. In this region, it is used in a wide range from sidewalks to curbs, from mosque fountains to siding and decorative construction works.

Bayburt Stone (Tuff): It is located in the province of Bayburt and known in terms of widespread use in different areas and having large reserves. Stones can be used as wall-covering and surface covering as well as restoration, bridge, mosque fountain.



a) b) c)

d) e)

Figure 2. Samples stones a) Korpe, b) Karakocan, c) Bayburt tuff, d) Hozat, e) Erzincan andesite stone

2.2. Testing Methods

Thermal conductivity, specific heat capacity and thermal diffusivity tests:

The measurements were made with the "Isomet 2104" brand device, which measures in transient mode and works with the hot wire method. With this device, which takes the measurements as per the DIN 51046 norm, the thermal conductivity coefficient was measured at 22-25 ºC and from 3 different points on each sample. Then, the arithmetic mean of these 3 values was taken, accordingly. The device performs the measurement process with the following parameters: the measurement of the heat transfer coefficient with an accuracy of 5% in the range of 0.02-6 W/mK - the volumetric specific heat capacity with an accuracy of 15% in the range of $4.0x10^4$- $4.0x10^6$ J/m^3K (Isomet 2104, 2011), (Vysnıauskas & Zıkas, 1988). Measurement results are given in Table 2.

Unit weight test:

The dry weights of the samples were measured on a scale with an accuracy of 1% and unit weight parameters were identified by determining the sample volumes.

Compressive, tensile strengths and volume abrasion tests:

The strength tests were performed on the samples in accordance with TS 699 standard (TS 699/T1, 2016). The compressive strength tests of the samples were carried out with the "Ele International" branded device with 3000 kN loading capacity, equipped with a digital control panel, having adjustable loading speed and bearing the ability to apply force in one axis. Compressive strength results are converted into tensile strength according to TS 500 with the following Eq. (1) (TS 500, 2000).

$$f_{ctk} = 0{,}35.\sqrt{fck} \quad (1)$$

In here, f_{ck}: compressive strength (MPa) and f_{ctk}: tensile strength (MPa)

Water absorption test:

The purpose of this test is to investigate the presence of a dry volume in which the ice crystals formed in the freezing process of the building materials that are in direct contact with water can have the opportunity to expand (TSE 4045, 1984), Dincer vd. (2012). This property provides assurance against freezing in the material. The dry weight (W_k) of each sample was determined, accordingly. Then, the water level was gradually raised in a water bowl where the samples were placed. Additionally, water was added to the container so that all the samples were in water, as deemed required. The change in the weight of the samples against time can be seen in Figure 3. After the samples were kept in water for 48 hours, they were removed from the water and wiped. Then, the water-impregnated weights (W_d) of the samples were determined, and the water absorption rate was calculated by Eq. 2.

$$\text{Water absorption percent} = \frac{Wd - Wk}{Wk}\,.100 \quad (2)$$

Drying ratio:
The objective of the drying rate test is to investigate the breathability presence of samples (Gürdal, 1982). After the samples were kept in a water container for 48 hours, they were removed from the water and wiped with a wet cloth and then left to dry naturally at 22 °C room temperature. The rates were calculated with Eq. (3) for a drying period of 24 hour. Since drying is ensured through evaporation from the surface of the material, we can see the movement of water from the material depth to the surface through capillary channels. In other words, moisture is drained from the body by means of its vapor permeability resistance, thus drying in this direction

$$\text{Drying ratio} = \frac{Wd - Wk}{Wd}\,.100 \quad (3)$$

3. Results and discussions

The following results were obtained in this study, carried out to investigate the thermal and mechanical properties of certain stones that are used in the center and districts of Elazığ, Tunceli, Erzincan and Bayburt provinces located in the Eastern Anatolia Region, while also having large reserves. The chemical analysis results of the stones can be seen in Table 1.

Table 1. The chemical composition of the samples, (%)

Component / Material	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Loss of ignition	Undefined
Korpe (Elazig)	5.05	0.31	.0.30	52.34	0.82	40.84	0.34
Karakocan (Elazig)	49.46	12.77	2.1	6.10	1.33	5.66	2.58
Hozat (Tunceli)	.0.33	-	-	54.75	1.07	42.11	1.74
Andesite (Erzincan)	63.42	10.45	.4.81	8.06	2.88	9.24	1.21
Bayburt tuff (Bayburt)	69.08	12.10	.1.38	2.33	0.88	13.4	1.03

Korpe stone is extremely resistant to cold and heat. During the removal from the furnace, the moisture content is conferred to be high, and it is easy to process. The strength increases after the moisture is removed from its body.

When Table 2 is examined, it can be seen that Korpe stone with a 0.71 W/mK average thermal conductivity coefficient and 2.54×10^{-7} m^2/s thermal diffusivity coefficient, it looks better than similar materials as can be seen in Table 3 within the scope of both continuous and time dependent regimes. Moreover, considering 52.6 MPa compressive and 5.4 MPa tensile strength, it presents values close to high strength natural building stones. Also, it has approximately equivalent strength with artificial materials such as concrete briquette, brick, and aerated concrete. With volume abrasion ratio of 1.2%, it shows that it can be used as a construction element subject to excessive wear such as stairs and parquet (Table 4).

Table 2. Thermal properties of stones

Material	Unit weight (kg/m^3)	Thermal conductivity (W/mK)	Specific heat capacity Cp(J/kgK)	Thermal diffusivity $a.10^7(m^2/s)$
Korpe	2390	0.71	1038	2.54
Karakocan	1280	0.44	1027	3.36
Hozat	2200	1.80	884	9.25
Erzincan	2650	1.65	1112	5.20
Bayburt	2173	0.74	1045	3.25

Table 3. The physical properties of some building materials and natural stones (Toksoy 1998].

Material	Unit weight (g/cm^3)	Thermal conductivity (W/mK)	Specific heat capacity $C_p(J/kg^oC)$	Thermal diffusivity $a.10^{-7}(m^2/s)$
Concrete	1906	0.814	879	4.91
Granite	2643	1.73-3.98	816	13.15
Limestone	2483	1.16	906	5.68
Common brick	837	0.692	837	5.16
Sandstone	2235	1.855	712	11.65
Marble	2603	277	808	3.94

Table 4. Mechanical properties of stones

Material	Compressive strength (MPa)	Tensile strength (MPa)	Water absorption (%)	Volume abrasion (%)
Korpe	52.6	2.54	1.55	1.2
Karakocan	8.2	1.00	17.5	4.9
Hozat	21.0	1.60	5.54	6.9
Erzincan	62.8	2.77	1.58	0.36
Bayburt	29.1	1.89	7.95	1.4

Karakocan stone looks better than concrete, granite, limestone, marble and plain brick with its heat conduction coefficient and thermal dissipation value (0.440 W/mK, $3.36x10^{-7}$ m^2/s) (Table 2). It is a great advantage that stone can be easily processed compared to many building elements, while also being able to be opened, drilled, cut, carved, and allowing the use of nails and screws in electrical and plumbing channels.

In terms of energy saving, Hozat stone ((with 1.80 W/mK (Thermal conductivity**),** 884 Cp(J/kgK) **(**Specific heat capacity) was not found to have significant superior values compared to similar building materials. However, the compressive and tensile values (21 MPa, 1.60 MPa) are approximately equivalent to artificial materials such as briquette, brick and aerated concrete. In terms of abrasion resistance, Hozat stone does not possess the required strength (6.9%) (Table 4). Based on this reason, it prevents the same from being used as a structural element subject to excessive wear such as stairs and parquet. The fact that the stone is easy to obtain, with a high affordability characteristic, seems to be the reason for preference.

Erzincan andesite stone looks better with its 1.65 W/mK average thermal conductivity coefficient compared to granite, sandstone and marble from similar materials as can be seen in Table 2 and Table 3. With volume abrasion of 0.36%, these stones are used extensively in the facade of the building and as pavement and road covering, also for curbstone.

Bayburt tuff, with its thermal conductivity value of 0.74 W/mK, is better than granite, sandstone, marble and limestone and close to concrete values, while it has lower values compared to these materials in terms of diffusion coefficient ($3.25x10^{-7}$ m^2/s) (Table 2).

In the water absorption experiments performed on the samples, the water absorption rates that are slightly different were obtained. However, the results are well below 30% critical value (Table 4). Considering the climatic conditions of the region, there is no cracking of the materials, dusting on the surface and crusting or dispersion of the total mass due to freezing. The time-based weight changes of the samples can be seen in Fig. 3.

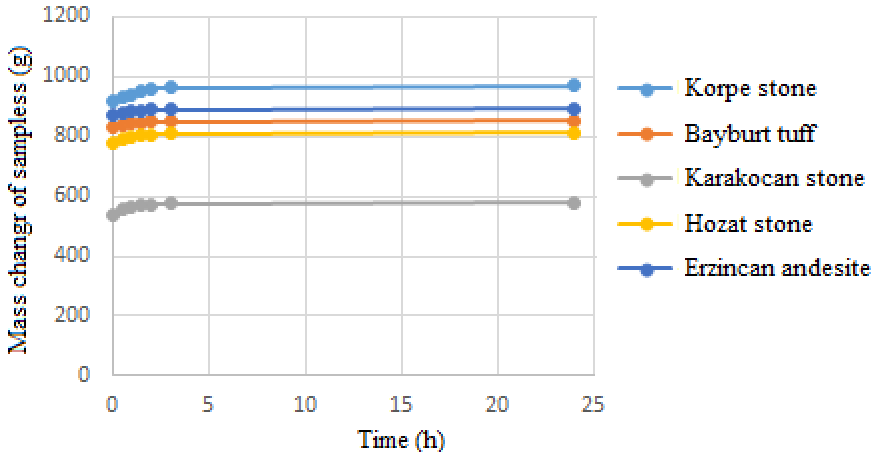


Figure 3. Mass change of samples in water absorption

In the drying experiment, the change in weights of the samples against time can be seen in Figure 4. Examining of the Fig. 4, it can be seen that the stones have limited respiration ability.

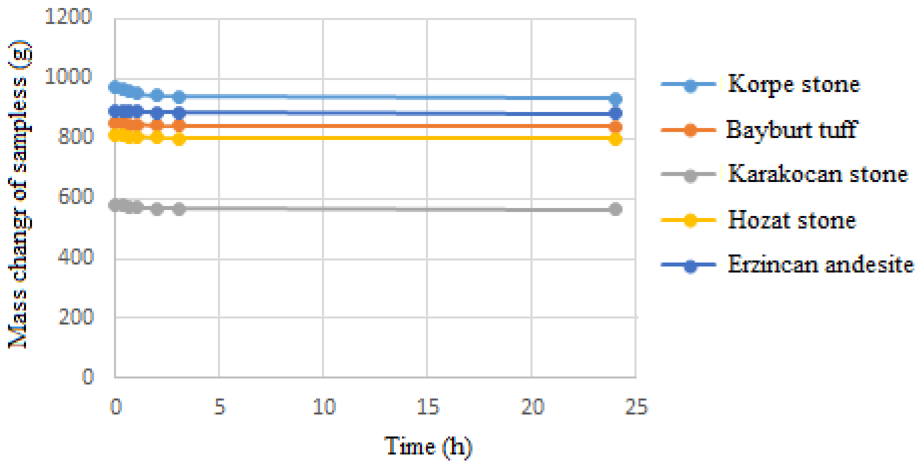


Figure 4. Mass change of samples in the drying test

The preference reasons for using Erzincan andesite stone can be summarized as follows: The low cost of stones; convenient accessibility of stones; rich reserves of stones; energy saving advantages; the use of stones as partition load-bearing elements in buildings instead of bricks or briquettes; being used as building exterior, road and paving stone thanks to its strength values

4. Conclusions

It has been accepted as a reliable building material by the local people. Following the research and tests carried out on the stones used, based on the following reasons;

- ✓ These stones are rich in reserves and can be used for many years.
- ✓ The accessibility of stones are convenient, while also being within a high affordability range,

- ✓ Karakocan, Korpe and Bayburt stones possess low thermal conductivity coefficient (0.44 W/mK, 0.71 W/mK and 0.77 W/mK). Use of the same instead of bricks in building exterior walls is of importance in terms of energy saving.

- ✓ Examining the stones, it can be seen that Körpe stone (52.6 MPa, compressive strength, 1.2% volume abrasion rate), Bayburt stone (29.1 MPa compressive strength, 1.4% volume abrasion rate), Hozat stone (21 MPa compressive strength) and Erzincan andesite stone (62.8 MPa compressive strength, 2.36% volume abrasion rate) in particular prove that they can be used as load-bearing wall materials, as well as wear-resistant flooring material.

- ✓ The stones can be used in humid environments thanks to their water absorption rate of less than 30%. They also possess breathability characteristics, albeit it is relatively low.

These stones are preferred to be used as building materials in the region and neighbouring provinces based on the reasons as mentioned above.

References

1. **Akıllı, H. (1987),** Taş eserlerin tahribatına neden olan etkenler, *Rölöve ve Restorasyon Dergisi*, 6, 129-135.
2. **Akın, M., Özvan, A., Dinçer, İ., Oyan, V. & Tapan, M. (2014).** Ahlat Taşı'nın atmosferik etkiler altındaki duyarlılığı, *III. Uluslararası Ahlat-Avrasya Bilim, Kültür ve Sanat Sempozyumu Bildiriler Kitabı* (Editörler Doğru M. ve Aksoy E.), 60-69, 22-24 Eylül Ahlat- Bitlis.
3. **Bakış, A., Işık, E., Hattatoğlu, F. & Akıllı, A. (2014).** Jeolojik miras nitelikli Ahlat Taşı'nın inşaat sektöründe kullanımı, *III. Uluslararası Ahlat-Avrasya Bilim, Kültür ve Sanat Sempozyumu Bildiriler Kitabı* (Editörler Doğru M. ve Aksoy E.), 46-59, 22-24 Eylül Ahlat- Bitlis.
4. **Bicer, A. (2019-a).** Ahlat ve Malazgirt yapı taşlarının bazı fiziksel özellikleri, *Fırat Üniversitesi Müh. Bil. Dergisi*, 31(2), 301-307.
5. **Bicer, A. (2019-b).** Some physical properties of the building stones from Southeastern Anatolia Region, *Bartın University International Journal of Natural and Applied Sciences,* 2(1), 9-15.
6. **Bicer, A. (2019-c).** Some physical properties of the building stones from Elazıg-Nevsehir region, *Nevşehir Bilim ve Teknoloji Dergisi,* 8(2), 96-102.
7. **Dinçer, İ., Özvan, A., Akın, M., Tapan, M. & Oyan, V. (2012).** İgnimbiritlerin kapiler su emme potansiyellerinin değerlendirilmesi: Ahlat Taşı örneği. *Yüzüncü Yıl Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, 17 (2), 64-71.
8. **Gevrek, A.İ. & Kazancı, N. (1991).** İgnimbrit: oluşumu ve özellikleri, *Jeoloji Mühendisliği Dergisi*, Ankara.38, 39-42.
9. **Gürdal, E. (1982).** Anıtlarda ve yapılarda kullanılmış doğal taşların bozulmaları ve korunmaları, *Rölöve ve Restorasyon Dergisi*, 27-33.
10. **Isomet 2104 (2011).** Applied Precision Ltd, Instrument products department, Bratislava-Slovakia
11. **Kazancı, N. & Gürbüz, A. (2014).** Jeolojik Miras Nitelikli Türkiye Doğal Taşları, *Türkiye Jeoloji Bülteni*, 57: 1.
12. **Pivko, D. (2003).** Natural stones in earth's history. *Acta Geologica*,.58, 73-86.
13. **TS 699/T1 (2016).** The test and experiment methods of natural building stones, TSE, Ankara.
14. **TS 500 (2000).** *Turkish Standard,* Ankara.
15. **TSE 4045 (1984).** Yapı malzemelerinde kapiler su emme tayini *Turkish Standard*, , Ankara.
16. **Toksoy, M. (1988).** Thermal conductivity coefficients of industrial materials, *Journal of Engineers and Machinery*, 347, 12-15.
17. **Vysnıauskas, V.V. & Zıkas, A.A. (1988).** Determination of the thermal conductivity of ceramics by the Hot-Wire Technique. *Heat Transfer Soviet Research*, 20 (1), 137-142.