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Bending Strength of RPC Using Ahlat Stone as Aggregate

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***Abstract*:** *Ahlat is a district of Bitlis have booked a significant amount, known as the local name Ahlatstone ignimbrites in the past, in the region of Nemrut crater formed by the explosion of the spread of volcanic lava cooling of the region formed by the pyroclastic rocks. Since time immemorial, especially in Ahlat intensively used in Seljuk architecture ignimbrite (Ahlatstone) is now used by the people of the region continues. Wherein Ahlatstone natural independently macro and micro pores due to size, or premises with an insulating non-load bearing lightweight concrete and stone wall parts can be used . Because it provides sound and heat insulation, plaster and insulation for exterior applications also have to make. In winter, the temperature inside the enclosure, whether by preventing the ingress of hot air and cool summer living area, creating a high energy saving. With these features Ahlatstone, structure provides thermal control requirements. Ahlatstone weight is less than the mass of the building, not burden. Both need to be lighter in the presence of independent space. Ahlatstone increases the seismic resistance. Ahlatstone with a constant load of the building because the building will affect the easiest reduced seismic forces and provide a positive effect on the structural system of the building. Fire -resistant building design can be used safely. However Ahlatstone very low due to the compressive strength of the current use of the area has been limited, mainly stone walls in the area, tombstone, mosques and domes are used in construction. The purpose of this study, our geological heritage Ahlatstone contributing to the promotion of the concrete construction industry is to expand the use of sectoral. The goal of this study is investigate of bending strength of Ahlat stone as aggregate in reactive powder concrete.*
Keywords – *Ahlat, Ahlat stone, RPC, bending strength*

I. Introduction

Lake Van Basin with its traditional historical fabric bears the traces of many civilizations such as The Ottoman, The Seljukian and The Urartian. In order to convey our historical heritage to the posterity, the involvement to be applied historical structures, to know the properties of materials together forms the first step of the involvements to protect the historical structures.

Ahlat is a historical town and a district in Turkey's Bitlis Province in Eastern Anatolia Region. Ahlat and its surroundings are known for the large number of historic tombstones left by the Ahlatshah dynasty. The center town of Ahlat is situated on the northwestern coast of the Lake Van.Lake Van is the largest lake (3600 km2) in Turkey and the fourth largest one in the World (Fig.1).

Fig.1.1- Location map of Ahlat

The medieval Muslim cemetery of Ahlat is located nearby the town of Ahlat, Bitlis Province Turkey, and is known for its many Islamic tombs (kümbets) and tombstones dating to the 13th-16th centuries when the area was under control of various Muslim states. There are hundreds of richly carved tombstones and several

tombs. During the middle ages, Ahlat was the largest city in the Van region and one of the largest cities of Minor under Turkish control. In the 12th century it was the capital of the Ahlatshahs. One of the historic legacies of the medieval period is the extensive remains of the cemetery. The town eventually declined and depopulated in the 16th century. Today the cemetery is tentatively listed in the List of World Heritage Sites in Turkey [1]. There are numerous historical structures in the region that built by many civilization that lived in the region. The structural properties of these historical structures are directly related with by standing throughout the centuries. In this study the properties of Ahlat Stone were given. The goal of this study is investigate of bending strength of reactive powder concrete (RPC) by using Ahlat stone as aggregate.

II. Properties Of Ahlat Stone

In order to transferring cultural heritage to the next generations, we need to know structural properties of these structures. Historical structures are made of local brick and/or natural stone masonry. Ahlat stone is a natural stone in the region (Fig.2). Natural stones are extensively being used as construction materials. Natural stones qualified as geological heritage are various and also plenty in Turkey, based on its complex geological framework. Some unique stones have been used in Anatolia since antic times, particularly for large and prestigious buildings. Most of the natural stones are typical geoheritages of the country. However they have been no documented at international level, yet. In addition, economic and scientific terminologies on the Turkish natural stones are completely different and people do not have correct geological knowledge about them. The rocks that known in regionally name as Ahlat Stone have been occurred from the spreading with cooling in kilometers in the region of lava zone by the explosion of volcanic Nemrut Crater. Ahlat stones are geoheritages qualified natural stones that has been included micro and macro sized pores that independently each other and has high thermal and sound insulation and also durable to the effects of earthquake and fire. Ahlat Stone can be called as natural brick. These stones have various colors like brown, dark brown, ash. However dark brown colored stones are widely used at the buildings in the region. Soft Ahlat stone can be given into desired shape by hand or by machine. Ahlat Stone has been used in the construction of residential, mosques, cupolas, tombstone, tombs and belts especially in Seljuk architecture in the past. The current use of the areas of Ahlat Stones has been limited due to its compressive strength is low from more amount of gaps, therefore Ahlat stones have been used such as in the construction of masonry structures like mainly stone wall, tombstone, arches, mosque and tombs. They can be used also as cover materials in structures [2,3]. These stones have various colors like brown, dark brown, ash. However dark brown colored stones are widely used at the buildings in the region.

Fig. 2.1- Ahlat stone

The usage of Ahlat stone in different historic structures were given in Figure 3.

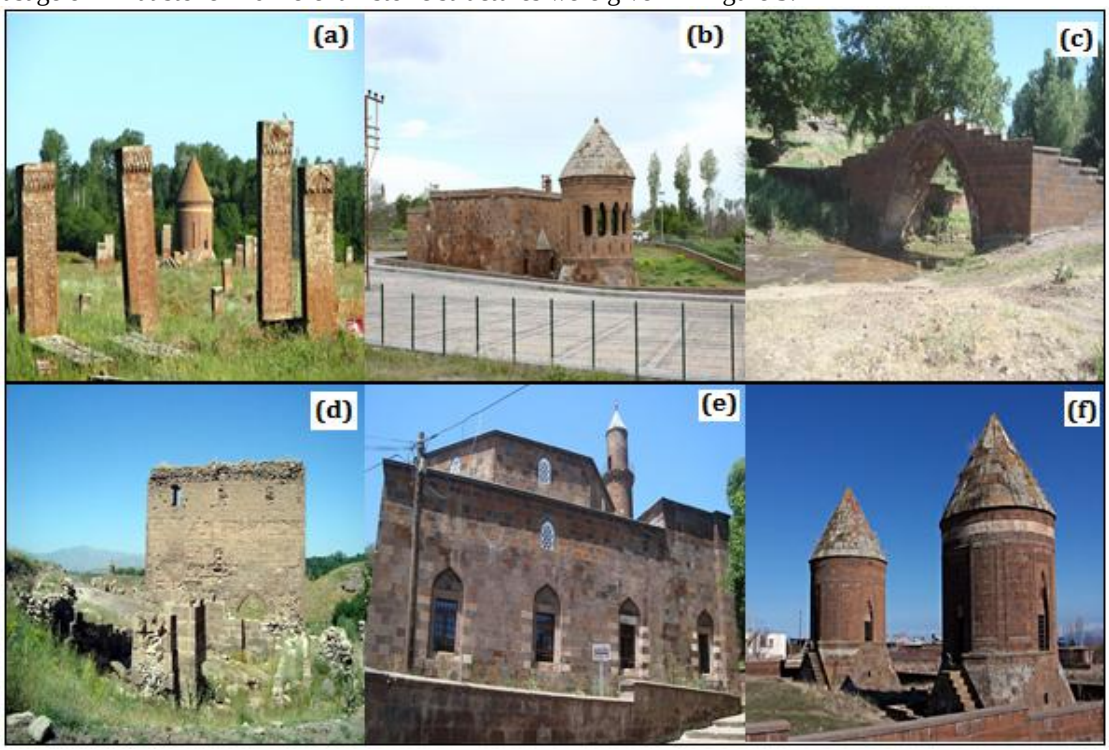

Fig. 2.2-: Using of Ahlat Stone (a)Tombstone, (b)Tomb, (c) Bridge, (d) Castle, (e) Mosque, (f) Twin Tomb

Natural stones such as tuff and ignimbrite are used extensively as building material all over the world because of their light weight, softness, and perfect insulating properties. Natural stones at the earth's surface are subject to the corruptive physical and chemical aspects of weathering [4]. Construction stones are classified according to their mineralogy, occurrence, mechanical and physical properties and processing types. Generally mechanical and physical properties are more important depending on the stones usage aim [2]. Some properties of the Ahlat stone are given in the Table 1. Moreover, it should be underlined that varying material property values of ignimbrite are stated in some of the commercial web sites of Ahlat stone suppliers such as compressive strength (in between 10-45 Mpa), unit weight (in between 19 – 25 kN/m3). Elastic modulus ignimbrite is reported to be 4500-5000 Mpa in various sources.

Table 1. Properties of Ahlat Stone (Ignimbrite) (Şimşek 2004)

Property	**Value**	**TS 1910 – TS 2513 Limits**
Compressive Strength (Mpa)	10.90	50.00
Flexural Strength (Mpa)	1.60	5.00
Water Absorption by Volume(%)	31.05	1.80
Unit Weight (kN/m^3)	19.05	-
Specific Gravity (kN/m^3)	26.20	2.55
Porosity (%)	27.29	-
Fullness Ratio (%)	72.71	-
Abrasion (cm^3 / 50cm^2)	27.70	15.00

Ignimbrites are highly heterogeneous throughout the region as they involve various amounts of pumice, volcanic glass and lithic material and they are pyroclastic flow units controlled by gravity and laminar flow system within high temperatures. Therefore, it is possible to identify different ignimbrite levels separated by different colors, textures, structural features and welding degrees in the Ahlat (Bitlis) region. The results of chemical analyses are presented in Table 2.

Table 2.Results of chemical analyses of two different Ahlat stone

Chemical Analyses	N1	N2	Average
SiO_2	65.98	66.12	66.05
Al_2O_3	15.98	15.91	15.95
Fe_2O_3	4.84	4.82	4.83
MgO	0.25	0.51	0.38
CaO	1.63	1.82	1.73
Na_2O	5.80	5.39	5.60
K_2O	4.92	4.90	4.91
TiO_2	0.43	0.36	0.40
P_2O_5	0.05	0.06	0.06
MnO	0.12	0.11	0.12
Sum	100.00	100.00	100

III. Material And Method

In this study three type bending strengths will be calculated. Compressive strength will be calculated for only natural Ahlat stone, fibreless reactive powder concrete and fibrous reactive powder concrete by using Ahlat stone as aggregate.

Natural Ahlat stone was used in this study which is mined from rock quarries present in Ahlat region. Each sample including three pieces in totally 6 pieces were used to determine of bending strength of Ahlat stone for 7 and 28 days which has 50*50*50mm dimensions.

Three of the samples were taken in to 7 days natural weather conditions and the other three samples were taken in to 28 days natural weather conditions. Bending strength was determined at the end of the 7 and 28 days by using compressive test to samples. The average of the compressive tests was given in Table 3.

Table 3: The results of compressive test of natural Ahlat Stone for 7 and 28 days

Sample	Curing Time (Day)	Bending Strength (MPa)
Ahlat stone (50x50x50 mm)	7	0.63
Ahlat stone (50x50x50 mm)	28	2.70

IV. Bending strength of samples

The amounts of material which enter to the mixture of the samples for fibrous RPC for flexural strength were given in Table 4.

Table 4. Quantities of mixture of samples for flexural strength (kg/m^3

Sample Type	C	Silica Fume	Ahlat stone	Steel fiber	SA	Water	Total (kg/m^3)
Fibreless RPC	768	192	1040	-	120	272	2392
Fibreous RPC	704	176	992	152	120	248	2392

Quantities of the mixture for each sample for each cast of fibreless RPC that used in Lab was given in Table 5.

Table 5. Quantities of the mixture for RPC which weighed in Lab

Sample Type	C	Silica fume	Ahlat stone	Steel fiber	SP	Water	Total (gram)
Fibreless RPC	576	144	780	-	90	204	1794
Fibreous RPC	528	132	744	114	90	186	1794

The bending strength of test results was given in Table 6.

Table 6. Flexural strength of RPC

Type	Cement	Silica fume	Ahlat stone	Steel fiber	SP	W	W/B	SF/C	Unit weight (kg/m³)	Flexural strength (Mpa)		
										7 day	28 day	Combined
Fibreless RPB	768	192	1040	-	120	272	0.28	0.25	2392	3.33	4.86	4.68
Fibrous RPB	704	176	992	152	120	248	0.28	0.25	2392	6.75	7.08	5.76

V. Conclusion

Wherein Ahlat stone natural independently macro and micro pores due to size, or premises with an insulating non-load bearing lightweight concrete and stone wall parts can be used. Because it provides sound and heat insulation, plaster and insulation for exterior applications also have to make. In winter, the temperature inside the enclosure, whether by preventing the ingress of hot air and cool summer living area, creating a high energy saving. With these features Ahlat stone, structure provides thermal control requirements. Ahlat stone weight is less than the mass of the building, not burden. Both need to be lighter in the presence of independent space. Ahlat stone increases the seismic resistance. Ahlat stone with a constant load of the building because the building will affect the easiest reduced seismic forces and provide a positive effect on the structural system of the building. Heat resistance is high is resistant to fire. Fire -resistant building design can be used safely.

It is not suitable that using Ahlat stone in structural system of masonry structures because of very low compressive strength of Ahlat Stone. Ahlat stone was obtained very high compressive strength by using RPC method. Thus, Ahlat stone can be used in structural system element (column, beam element etc) of multi-storey building has been made possible with this study. In this study all materials in the mixture are local materials. The using of local materials is the reason of preferences of production cost.

The effects of earthquakes on structures which built Ahlat Stone should be investigated. Investigation about Ahlat Stone should be contributed to the widespread use in regional, national and worldwide.

The sum of SiO_2 + Al_2O_3 + Fe_2O_3 more than 70% was called as natural pozzolan material In Turkish Code (TS25) [5]. The sum of these elements in Ahlat Stone is 86%. In this context, Ahlat Stone can be evaluated as natural pozzolan.

The maximum flexural strength of fibrous RPC which content Ahlat stone was obtained as 7.08 Mpa. The result of experiments shows that Ahlat stone can used in buildings and rigid pavements. All results for samples were given in Table 7.

Table 7. The flexural strengths of all samples

Type	Flexural strength (Mpa)		
	7 day	28 day	Combined
Control	0.63	2.70	-
Fibreless	3.33	4.86	4.68
Fibrous	6.75	7.08	5.76

Acknowledgements

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