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Development of Method for Restoration of Historical Kutahya Castle

Ahmet Gokdemir[1], Busra Oflas Yuksel[2]
Gazi University Faculty of Technology, Department of Civil Engineering, Ankara, Turkey[1]
Graduate School of Natural and Applied Sciences, Gazi University, Ankara, Turkey[2]

Abstract: Throughout history, it is seenthat some locations have affected and directed the fateof the region due to population, geographical features, economic values, religious beliefs and similar factors. Kutahya, one of the settlements that gets the most out of the opportunity provided to itself, is home to as history based on BC VII century and an extraordinary civilization created by this past. [1]. One of the historical structures which Kutahya province owns is Kutahya Castle. In this study, the importance of the historical Kutahya Castle in Kutahya history, its characteristic features, the types of materials used during the construction and the structural analysis of these materials were examined. The samples were taken from the regions which will give information about the varied periods of the structure in general. SEM and EDS analyzes were carried out on the stones which is taken from these historical buildings in laboratory environment and the data base was prepared for the restoration works to be performed with the results of this analysis.
Keywords:EDS, historic buildings, Kutahya Castle, restoration, SEM,stone

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I. INTRODUCTION

Today, interdisciplinary studies are rapidly increasing in the solution of scientific and technical problems. One of the areas where different disciplines of science can work together is the conservation and repair works of historical buildings. It is the determination of the properties of the original materials which must be done in the protection and repair works of historical buildings. Then mortars and plasters with these properties should be produced and applied correctly. Protection and repair work with selected materials without any research can cause serious deterioration problems in historical buildings. In recent years, many studies have been done on the properties of mortars and plasters used in historical buildings, and have been an important resource for the researchers[2].

II. KUTAHYA CASTLE

"Kahraman" (2011) according to the definition of EvliyaCelebi,Kutahya Fortress is a pentagonal shaped, strong and ornamented structure on a blue and reddish rocky rock, it stands as a ring on a hill, and its four sides are surrounded by steep rock. He said that the walls of the fortress walls were the abyss. Furthermore, according to EvliyaCelebi, the Kutahya fortress had 70 bastions and the bastions of the fortress were placed at quite frequent intervals[3].

The different types of bricks seen on the walls of the castle, the date of construction and the craftsmanship of the belief that it is different. The bastions of the fortress are generally in good condition, but the bushes on the east side have not survived to the present. Although the bastions of the fortress are in good condition, very few towers on the east side of the city have survived.

2.1. Historical Development of Kutahya Castle

During the Roman period, Kutahya was a bishopric while the Romans dominated the city and built a castle within a two-storey fortress surrounded by bastions. This castle is the basis of the Kutahya Castle. It is said that this city was the first place where Kutahya was founded and in the following years it was said that the city expanded and expanded downwards. Later in 1080 the fortress was captured by "Kutalmısoglu Suleyman Shah". It was also used in Germiyanogulları and Ottoman periods. Fatih Sultan Mehmet repaired and expanded the castle. During the reign of Sultan Selim 3, the guards of this fortress were bound to the Selimiye Quarry of the Nizam-ı Cedid organization. In these periods, the fortress was used as a prison for a while [4].

No information was found about the castle in the travels of the ancient sources and travellers. There were no buildings belonging to the castle before the Turkish period. However, the castle bastions, some cisterns and warehouses and similar remnants do not become definite but provide some clues from the previous periods [4].

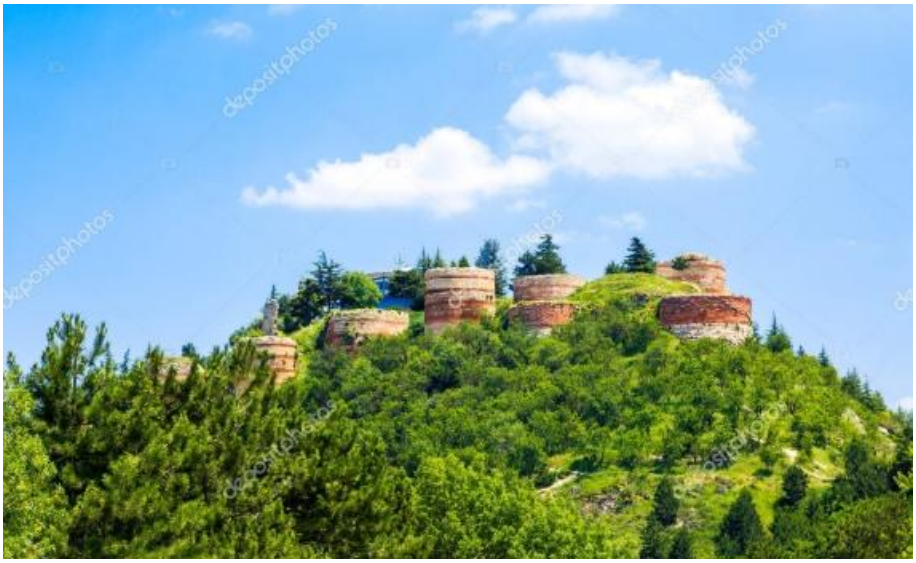

Figure 1: Castle of Kutahya

2.2. Parts of the Castle

Kutahya Fortress, which had been inhabited since ancient times, was fortified by the walls built by Byzantines in the 5th century and by the repair and annexes made by the Seljuks, Germiyanogulları and Ottomans. The fortress consists of three sections, the upper, the inner and the lower fortress; and the frequently placed bastions consist of rubble-cut stone mix and brick rows [5].

III. PREVIOUS STUDIES

Kurugol and Tekin (2010), located in different climate conditions in different provinces of Turkey, the Byzantine era brick materials used in the castle structures built physically, their study investigated the chemical and mechanical properties of Kutahya Castle gave what was taking place and they referred to the following topics:

The fact that the brick rows in the bricks and the walls of the fortress are different, makes us think that the horoscopes are an indication of the renewal of the masters by different masters at different periods. The bushes were built on 5-7 rows of brick and 5-10 rows of various natural stones. Some bushes include 1 or 2 rows of bricks, which show that there is no regular use of bricks, or that different techniques are applied to the castle.

These bricks, which are commonly used in the castle, are generally square and rectangular in shape, and the edge lengths of square bricks vary between 23/32 cm and their thicknesses are between 3,5 / 5,5 cm. Rectangular bricks are usually half of the square-shaped bricks [6].The data obtained from this experimental study on Byzantine bricks indicate that the historical castle bricks in various regions largely protect their originality against the corrosive effects of the time and have superior mechanical properties in place, and that these are produced by appropriate techniques. Despite the various atmospheric and physico-chemical influences that have been affected in the long process, these bricks have been able to preserve their original state to this day [6].

Minerals determined by XRD analysis show that bricks are cooked at low temperatures. On the other hand, the pozzolanic properties of the bricks also support this. Yoros, Amasra and KutahyaCastle' s mortars in the mortar as bricks broken and used in the dust, pozzolanic character of these bricks contribute to the contribution of the mortar suggests. Mortar analyzes are also required for this [6].

Kutahya Castle bricks have low unit weights and high porosity, and their mechanical properties are lower than the other castle bricks. As a result of the ultrasound measurements, it was determined that the mechanical properties of the bricks could also be estimated by non-destructive methods [6].

Zengin (2013), in his study on the physical and mechanical properties of settlements in Kutahya province, discussed the following subjects:

To date, many studies and investigations have been carried out on whether or not the Kutahyafault is active. In all these studies, it was emphasized that Kutahyafault was active. However, there are no significant and destructive earthquakes recorded during the instrumental period in this zone, which has a length of about 50 km.Therefore, the fact that this fault zone has been stored in energy for a long time is reached. In order to estimate the magnitude of earthquake that Kutahyafault breaks in the form of a single piece, approaches and relations which are proposed in previous studies and which take into account the magnitude of the earthquake

and the length of the surface fracture are used.Considering the general distribution of this relation and the data used in this relation, it is considered that Kutahya settlement area is under the risk of earthquake having magnitudes (Ms) which can vary between 6,5 and 7,2 in case of breakage of Kutahyafault [7].

As a result of the evaluations, Kutahya settlement area has liquefaction potential at different depths, M = 7,2 and 6,5 magnitude earthquakes which are expected to occur on Kutahyafault and the biggest horizontal ground acceleration values that will affect Kutahya settlement area will reach to 400 gal and 800 gal values. Liquefaction is expected to occur in different parts of the settlement area [7].

The 25-meter-high 900-year-old sign of the Kutahya Fortress at the south of the study area, which collapsed in January 2012, caused collapse of the shear strength of the material under the influence of excessive precipitation in the region. Material damage occurred due to this instability that did not cause any loss of life in the region [7].

"Ozbudak (2018)", in his study on the city image, examines the following issues:

The city has a development in east-west direction along the skirts bounded by the Yellice mountain. The traditional texture of the fortress and the foothills replace the central growth areas; they are perpendicular to each other, leaving them to the modern urban fabric where mass scales grow, streets and boulevards [8].

The historical surroundings of the city around the fortress have been illustrated, photographed, or written in the same way by travellers and researchers visiting the city from past to present. This shows that the city creates a common image in the perceptive mind of the city. This image consists of a high mountain in the backdrop, a castle on the hill in front of it, minarets rising on the skirts of the castle, residential buildings and natural vegetation. Although the city has different areas to create images in minds, it shows the most commonly expressed common image feature. The fact that different people express the same image in their minds shows that this common image is important for the city [8].

With restoration works, buildings are renewed and renewed with different functions. However, the concept of time is lost when the experiences of the structures are erased [8].

In the city, which continues to grow nowadays, urban transformation studies and multi-storey buildings, the demolition or transformation of historical buildings, the direction of the city and the changing of the city axes, underground roads, make the city open to a rapid deterioration [8].

IV. MATERIAL AND METHOD

4.1. Material

Because of the effect of climate parameters (temperature, humidity, wind, rain, frost), the upper facades of the Kutahya Fortress, Upper Fortress, Inner Castle and Lower Fortress are the most worn facades.

4.1.1. Preparation of test samples used in the study

Scanning electron microscopy is a highresolution image taking technique in high magnifications. With this technique, morphological, structural and elemental information can be obtained from low magnifications to very high magnifications (x300,000 or more) [9]. Republic of Turkey Hitit University Scientific and Technical Research Center of any kind of application process for SEM sample preparation device is performed.

4.2. Method

Republic of Turkey Hitit University Scientific and Technical Research Center of application Laboratory Unit SEM Scanning Electron Microscope with great care under the supervision analysis (SEM) and EDS analysis were performed.

Figure 2:SEM-EDS analysis system

4.2.1. Experimental studies

In the experimental study, it is possible to perform 6-1000000x magnification with Quanta 450 FEG model Scanning Electron Microscope and high resolution imaging with 45° optical lens structure. Energy Distribution Spectrometry (EDS) analysis can also be performed on the sample [10]. Hitit University in the Republic of Turkey and the Department Scientific and Technical Research Center of SEM applications laboratory, accredited according to TS EN ISO IEC 17025 Standard. The experiments performed in this study were performed according to the relevant ASTM standards.

4.2.2. Kutahya province climate parameters and earthquake records

The average annual temperature in Kutahya is 10,8℃. The lowest average temperature value is 0.5℃ and the highest average temperature value is 21.0℃. Average temperature values generally do not fall below 0℃ during the year . 25℃ not much. The average rainfall in Kutahya is 547 mm. According to the seasonal distribution of precipitation, winters are rainy and summers are dry in the study area. Rainfall usually falls as rain. Snowfall is not important. Kutahya is moderately continental in terms of temperature. In terms of precipitation is not terrestrial. Although Kutahya is located in the Aegean region and in the Mediterranean climate in general, its climate shows a transition climate characteristic. The main reason for this situation is the geographical location and surface shapes of Kutahya. Outline of the character of climate in the study area; The parameters of temperature, precipitation and territoriality. Considering these parameters, Kutahya climate; Aegean, Mediterranean and Marmara climates as a mixture [11].

T. C. The statistical data of Kutahya province between 1929-2017 taken from the General Directorate of Meteorology of the Ministry of Forestry and Water Affairs are shown in Table 1 [12].

Table 1: Climate statistics data of Kutahyaprovince[12]

KUTAHYA	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	MeasurementPeriod(1929- 2018)												
AverageTemperature(°C)	0.3	1.7	5.0	10.0	14.5	18.2	20.8	20.7	16.7	11.8	6.8	2.4	10.7
AverageHighestTemperature(°C)	4.6	6.6	10.8	16.3	21.2	25.0	28.1	28.4	24.5	19.0	12.7	6.6	17.0
AverageLowestTemperature(°C)	-3.3	-2.4	-0.2	3.9	7.8	10.8	13.1	13.0	9.1	5.6	1.9	-1.2	4.8
AverageSunshine Time (hour)	2.4	3.4	4.6	6.2	7.6	9.4	10.4	9.7	7.7	5.2	3.6	2.2	72.4
AverageRainyDays	14.6	13.2	13.1	11.5	12.1	8.1	3.9	3.3	4.7	8.3	10.0	14.2	117.0
AverageMonthly Total Rainfall (mm)	71.8	59.2	57.5	50.5	56.2	38.4	18.6	16.1	23.0	40.8	49.5	78.2	559.8
	MeasurementPeriod(1929- 2018)												
HighestTemperature (°C)	17.1	24.2	27.0	30.2	33.8	36.2	39.5	38.8	36.1	31.6	25.4	21.7	39.5
LowestTemperature(°C)	-26.3	-27.4	-16.6	-7.8	-2.8	0.5	2.6	-0.2	-3.9	-6.9	-11.0	-28.1	-28.1
Daily Total HighestPrecipitationAmount					Daily FastestWind				Highest Profit				
18.12.2001			92.2 mm		05.02.2003		103.3 km/hour		26.01.2006			60.0 cm	

According to this information, the walls of the cultural historical structure are influenced by climate parameters such as temperature, wind, precipitation and frost. This situation causes freezing and dissolution resulting in surface spills. Also; wind, temperature difference and precipitation accelerate the rupture of the patina layer. At the same time, the earthquake zone where the city is located is also very effective on the resistance of the structures against time.

Sezer (2012) states that Kutahya province is one of the most important earthquake regions of Western Anatolia in the study named as seismicity of Kutahya region. He also mentioned that the energy discharge in this region, where there are many faults, is less likely to create a new long fault [13].

In the light of this information, the building materials and construction chemicals to be used in the restoration of the historical Kutahya Castle should be selected by considering the climate parameters and earthquake conditions of Kutahya.

V. FINDINGS AND DISCUSSIONS

5.1. Scanning Electron Microscopy Analysis (SEM) and EDS Findings

Morphological, structural and qualitative elemental analyzes were performed on the materials used by the high resolution images taken from scanning electron microscopy and the information obtained from the EDS analyses [9].

The results of SEM analysis are shown below[10].

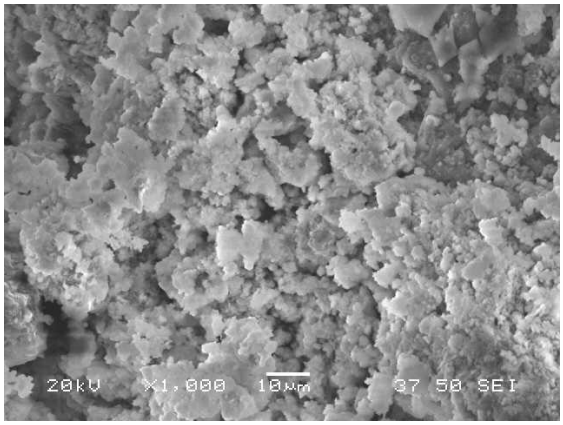

Figure 3:SEM analysis 10 micron meter of lower castle walls[10]

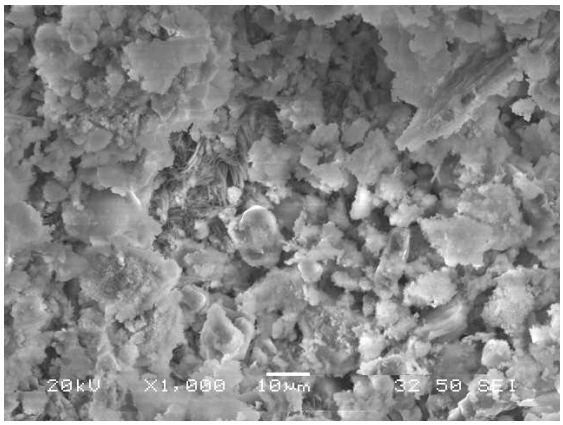

Figure 4:SEM analysis 10 micron meter of interior castle walls[10]

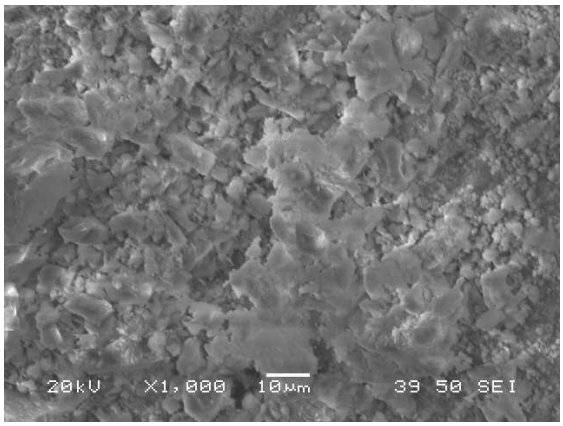

Figure 5:SEM analysis 10 micron meter of upper castle walls[10]

The samples were generally homogeneous in the SEM photographs, there was no excess space and very large particles, and it was observed that the samples were tight in oval circular shapes. In the EDS analysis of the stones on the south facade, the results obtained in the screening of a point region with a focus of 50 μm are given below.

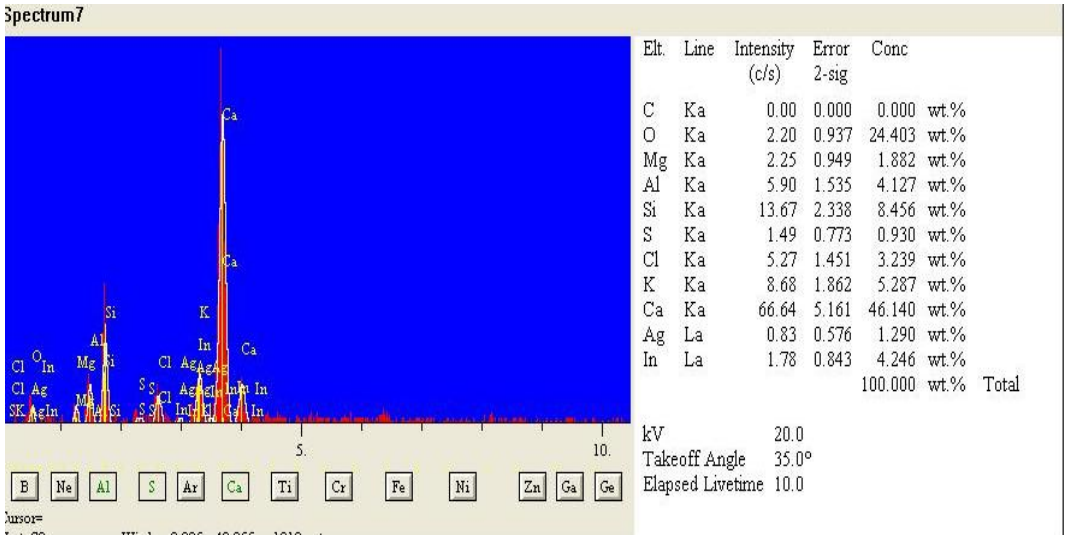

Figure 6: Lower castle south EDS[10]

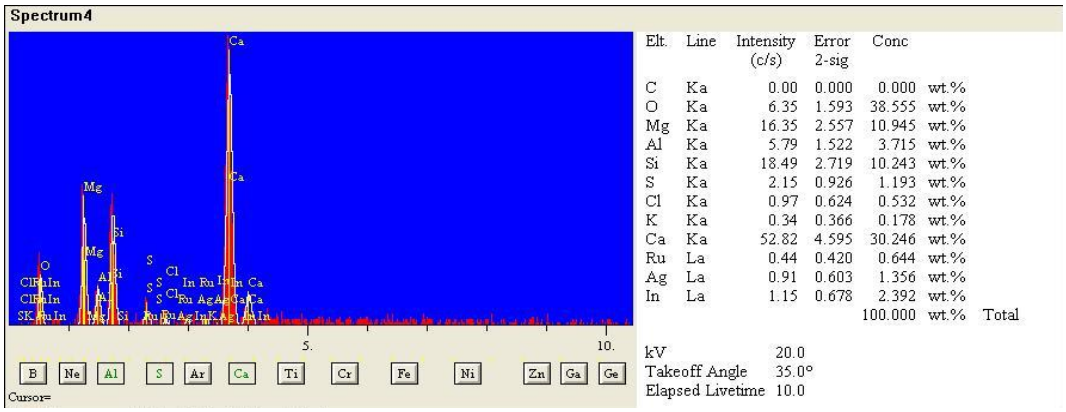

Figure 7: Interior castle south EDS[10]

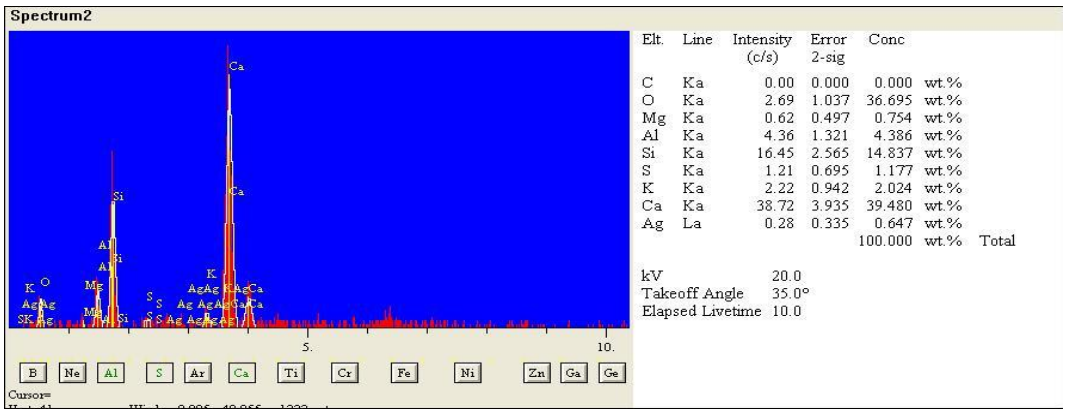

Figure 8: Upper castle south EDS[10]

The evaluations about the element percentages resulting from EDS analysis are as follows:
Fig. 6: Stone EDS analysis of Lower Fortress;
Lower Fort in the south of the Lower Fortress, the CaSiO3 (calcium silicon oxalate) compound has a higher concentration of calcium, silicon and oxygen.
Fig. 7: Stone EDS analysis of the Central Fortress;
Inner Fortress It is observed that CaSiMgO3 (calcium silicon magnesium oxalate) compound is more intense in the south side, where calcium, silicon, magnesium and oxygen percentages are higher.
Fig. 8: Upper EDS analysis of the Upper Fortress;
It was determined that CaSiAlO3 (calcium silicon aluminium oxalate) compound was more intense in the upper part of the Upper Fortress.

When the results of EDS analysis were examined, the southern facade of the fortress was overly worn; It was observed that the particles forming the structures of the samples taken from the southern facades were partially homogeneously distributed, and the elements containing Ca, Si, Mg, Al and O were predominant.

VI. CONCLUSIONS AND RECOMMENDATIONS

The area known as old Kutahya has become a center of tourism and commercial attraction and the consciousness of protection has started to develop over time. In this case, the most important fact is that the environment and every structure within it are taken under sustainable protection without losing their values with modern methods. The restoration of Kutahya Castle is clearly seen.

In order to determine the mechanical and physical properties of the materials used in the construction of the castle, analyzes were performed using spectroscopic methods. Granite stone materials were used throughout the fortress walls. In order to determine the damages caused by human or natural effects on the historical building which has not been restored for restoration or strengthening, visual inspection has been done in order to provide the structure to be more sheltered and serve for many years.

In this study, the characterization of the materials used in the construction of Kutahya Castle was carried out and important findings were obtained to shed light on the selection of materials that could be used in restoration works. The renovation works of Kutahya Castle should be evaluated by considering these data and suitable materials should be used.

REFERENCES

[1]. K. Guler,Kutahya through eyes of EvliyaCelebi,*EvliyaCelebi International Symposium*, Kutahya, Turkey, 2011, 309-318.

[2]. T. Koralay, B.Duman, Y. K.Kadıoglu, and A.Akyol, (2015). Investigation of historical mortar and plaster samples using multiple analytical methods:example of Tripolis (Yenice/Denizli). *31st The Meeting of Archaeometry Results*, Erzurum, Turkey,2015, 1-20.

[3]. S. A. Kahraman,*Intoday's Turkish EvliyaCelebitravel book:Kutahya – Manisa – Izmir – Antalya – Karaman – Adana – Aleppo – Damascus – Jerusalem – Mecca – Madinah*(Erzurum, Turkey:YapiKredi Publications, 2011*)*.

[4]. http://www.e-tarih.org/sayfam.php?m=teser&id=1101 (date of access: 21.03.2019).

[5]. Republic of Turkey Governship of Kutahya Provincial Directorate of Culture and Tourism,*Kutahya* (Kutahya, Turkey: Governship of Kutahya Provincial Directorate of Culture and Tourism, 2017).

[6]. S.Kurugol, C,Tekin,Evaluationof physical, chemical and mechanical characteristics of bricks used in castle structures of byzantine period, *Journal of the Faculty of Engineering and Architecture of Gazi University, 25(4),*2010, 767-777.

[7]. E.Zengin, *Investigation of physical and mechanical properties of Kutahyaresidential area's soils*, post graduate thesis, Dumlupınar University, Institute of Science and Technology , Kutahya, Turkey, 2013.

[8]. O.Ozbudak, *Analysis of Kutahyain the context of urban image*, post graduate thesis, Yıldız Technical University, Graduate School of Science and Engineering, Istanbul, Turkey, 2018.

[9]. General Directorate of Mineral Research and Exploration Mineral Research and Exploration Unit, Ankara, 2019

[10]. Hitit University Scientific Technical Application and Research Center SEM Laboratory, Corum, Turkey (2017)

[11]. I.Karbuz, Climatic properties of the province of Kutahya,*The Journal of Academic Social Science, 3(17),*2015, 417-428.

[12]. Republic of Turkey Ministry of Agriculture and Forestry General Directorate of Meteorology, Ankara, 2018

[13]. L. I. Sezer, Seismicity in the Kutahya Seismotectonic Region,*Aegean Geographical Journal, 19(2),* 36-52, 2012.

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