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Traditional Houses in Materials Analysis; Konuralp, Düzce Example

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ABSTRACT

In this study, mortar and plaster samples taken from a traditional house (1799 parcel) located in the neighborhood Konuralp, Düzce Province, were subjected to acid loss, ignition loss, loss of aggregates sieve analysis after acid, protein, and fat tests, tests of salt, as well as Petrographic and SEM-EDX analyses. Brick samples underwent physical examinations microscopic analyses and mechanical in addition to SEM-EDX analyses. For wood samples, macroscopic and microscopic analyses were conducted to determine their types. Based on these analyses, recommendations have been made to contribute to the repair and reuse of the material properties of the selection processes of traditional structures.

Malzeme Analizinde Geleneksel Evler; Düzce, Konuralp Örneği

Anahtar Kelimeler: Geleneksel yapı, Prusias ad Hypium, Konuralp evleri, Malzeme analizi

ÖZ

Bu çalışmada, Düzce İli, Konuralp Mahallesi’nde bulunan geleneksel konuttan (1799 parsel) alınan harç ve sıva örneklerine; asit kaybı, kızdırma kaybı, asit kaybı sonrası agregalara elek analizi, protein yağ testleri, tuz testleri ile petrografik ve SEM-EDX analizleri yapılmıştır. Tuğla örneklerine; fiziksel ve mekanik analizlerin yanı sıra mikroskobik incelemeler ile SEM-EDX analizleri, ahşap örneklerine ise cinslerinin tayin edilebilmesi için makroskobik ve mikroskobik analizler yapılmıştır. Bu analizler doğrultusunda geleneksel yapıların onarım ve yeniden kullanım süreçlerinde seçilen malzeme özelliklerine katkı sağlamaya yönelik öneriler getirilmiştir.

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1. Introduction

Culture for centuries, by affecting the individual's worldview, values, lifestyle, the area, and the person who performs all the actions on this occasion has been one of the most basic elements of organizing. Through transfer from generation to generation, all the values we have today are the richness of the cultural heritage. Protecting this wealth and transferring it to the next generations in a healthy way are of importance for each individual [1]. The protection of traditional buildings is an area of practice that has been secured by many legal studies on the subject.

The research on this subject has enabled the conservation discipline to include both monuments and more modest structures and the textures formed from them. In this context, all kinds of buildings and building groups with features worth protecting are considered as architectural heritage, and multifaceted studies are conducted to transfer them to the future. Traditional houses which are among the leading structures are mostly considered as modest works and are taken under protection [2].

The establishment of the settlement known as Konuralp today dates back to B.C. This settlement of Düzce province in the western Black Sea region has a multilayered historical structure covering the Bithynia, Roman, Byzantine, and Ottoman periods. These historical buildings include cultural heritage elements such as ancient theatre, archaeological sites, aqueducts, and necropolises as well as traditional houses that are examples of civil architecture [3]. The historical texture of Konuralp, which has hosted many civilizations since the centuries before Christ until today (Üskübü) with the increasing acceleration of urbanization since the second half of the century, has faced a difficult situation in terms of rural life and its most important element, the traditional houses remaining in the city ensuring its cultural continuity. Such structures that have not lost their original qualities are frequently encountered in the Konuralp settlement.

In terms of building materials and systems, the construction observed in the Konuralp neighborhood is based on the wooden frame system. The rainy climate and presence of forests in the region have allowed wood to be frequently preferred as a building material. In this system called humish, the columns and beams that make up the skeleton are made of wood. In wood frame systems, a foundation of approximately one meter is dug and a stone foundation wall is built on top of it. The exterior walls in the upper parts of the building are plastered or the wall-filling can be left visible without plastering, as is the dominant character in Konuralp buildings [4]. The main building materials that make up the buildings consist of brick, wood, and stone.

In the study, physical, chemical, mechanical, and petrographic analyses of the materials taken from Konuralp traditional building, which have survived to the present day while preserving their original structural features, were carried out, and the data obtained in line with these analyses was aimed to contribute to the material properties selected in the repair and reuse processes of the building.

2. Materials and Method

2.1. Materials

2.1.1. Building with plot number 1799

The building with parcel number 1799, located in the Konuralp District of Düzce province, is located approximately 60 meters south of the ancient theater known as 40 Steps, dating from the Roman Period. It is located within the borders that have been declared as a 2nd-degree archaeological site by the decision of the Kocaeli Cultural Heritage Preservation Regional Board dated 13.03.2013 and numbered 889. The building was registered as a 2nd Group cultural asset by the same board's decision dated 30.09.2015 and numbered 2221. A general perspective and bird's eye view of the location of the parcel in question is shown in Figure 1.

Figure 1. Structure of electric vehicle types

2.1.1. Sampling and identification of samples

Before taking samples from the buildings, the building materials that determine the character of the building were identified and the bricks, mortar, plaster, and wood of the buildings were analyzed observationally. In order to proceed systematically during the sample collection and to record the locations of the samples taken, survey drawings of the building obtained from Düzce Municipality [5] were used. Figure 2 shows the ground, first-floor, and second-floor sampling sheets.

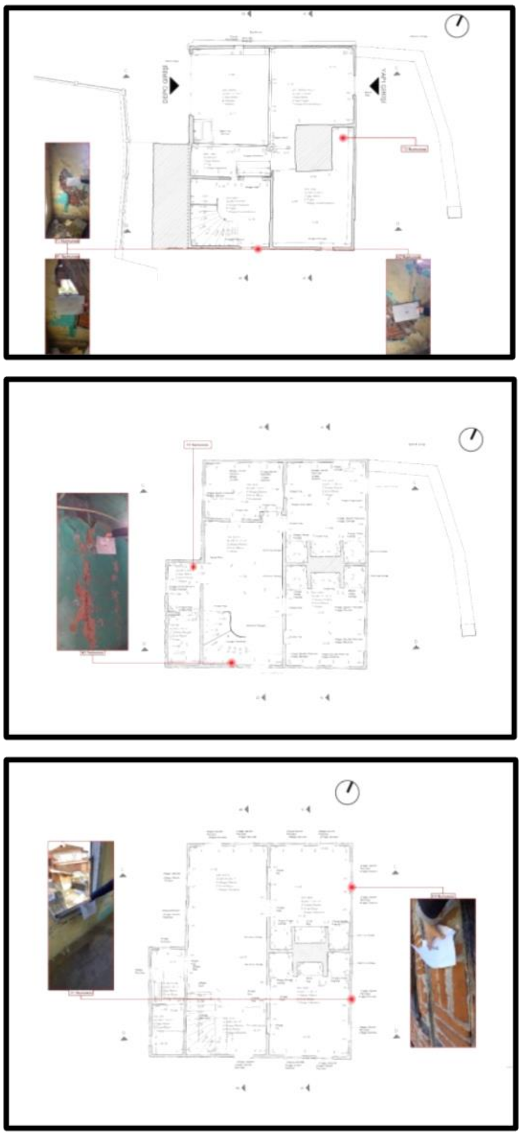


Figure 2. 1799 parcels numbered floor, first floor, and II. sampling sheet of a plan

Samples of definitions and coding system is shown in Table 1.

Table 1. Sample codes

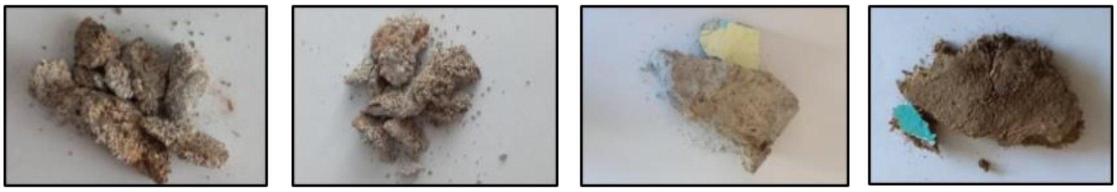
Sample Code	Type	Building it belongs to
T1	Brick	
T2	Brick	
T3	Brick	
H1	Masonry mortar	1799 Parcel
H2	Internal plaster	
H3	Internal plaster	
H4	Masonry mortar	
A1	Wooden window joinery	

For parcel number 1799; Brick samples were taken from different points of the building, which form the unique character of the building, are used as filling material between the wooden frames, and are thought to contribute to the structure of the building (Figure 3).

a b c

Figure 3. Brick samples from building number 1799 (a) T1-numbered sample (b) T2-numbered sample (c) T3 numbered sample

Mortar and plaster samples (Figure 4) were taken from different points in the interior of the building.



a b c d

Figure 4. 1799. the mesh structure of the mortar and plaster interior of the samples
(a) H1 masonry mortar (b) H4 masonry mortar (c) H2 interior plaster (d) H3 interior plaster

For type determination, a guillotine window joinery sample (Figure 5) was taken from the second floor of the building.

Figure 5. The structure of wood joinery number 1799 A1

2.2. Method

Within the scope of the analysis studies, a specific gravity test was carried out according to TS EN 1936 [6], a unit volume weight test according to TS EN 1936, total water absorption tests according to TS EN 13755 [7] and complexity and porosity tests were carried out according to TS EN 1936 standards in order to determine the physical properties of the brick material. To determine the mechanical properties, the compressive strength test was carried out on brick samples with a load increase of 2 kN/s, using a 500kN capacity Matest

test device according to TS EN 772-1+A1 [8] standard. Mortar and plaster samples; Sieve analysis (sieve analysis with 5000µ, 2500µ, 1000µ, 500µ, 250µ, 125µ, and 63µ sized sieves), protein-oil tests, and salt tests were performed on the aggregates remaining after acid loss, superheating loss, and acid loss; The definitions and textural properties of the aggregates and minerals were determined by petrographic analysis of the samples, thin and thick sections of which were prepared, using a stereo microscope and a polarizing microscope. Macroscopic and microscopic examinations of the materials for petrography analysis were carried out in accordance with TS EN 12407 [9] and TS EN 12440 [10] standards. Section preparation for petrographic examination of the samples was carried out with a METKON brand GEOFORM model section preparation device. Stereomicroscope imaging is performed with Nikon brand, SMZ 800 model and the camera integrated into the microscope, TOUPCAM brand, E3ISPM20000KPA model device; Polarizing microscope imaging was performed with a Nikon brand, Eclipse Ci-POL model, and a camera integrated into the microscope, Imaging Source brand, DFK NME33UX265 model device. In microscopic examinations and SEM-EDX analyses of brick samples and elemental oxide distributions, the Carl Zeiss brand EVO LS 10 model SEM device was used for imaging, and the Bruker brand and Quantax 200 model device was used for energy Dispersive X-ray spectrophotometry (EDX). Sample preparation for wood species determination was carried out with a LEICA brand SM 2400 model microtome, and cross-sectional examination was performed with the Zen/Zencore program using a Carl Zeiss brand, AxioscopeA1 model microscope and a Carl Zeiss Microimaging Axiocam HRC model camera integrated into the microscope.

In the study, chemical and petrographic analyses of mortar and plaster, SEM-EDS (EDX) analyses, and type determination analyses of wooden materials were carried out by the Restoration and Conservation Laboratory of the Istanbul Metropolitan Municipality Cultural Heritage Department, Directorate of Conservation Application and Inspection [11]. Physical experiments on brick samples were carried out at Düzce University Civil Engineering Materials Laboratory.

3. Results and Discussion

3.1. Physical analysis

Physical analyses of brick samples taken from the building belonging to parcel number 1799 were carried out. The results of the total water absorption rates, unit volume weight, specific gravity, compactness, and porosity values of the samples are given in Table 2.

Table 2. Physical properties of brick samples

Sample Code	Unit Weight (kg/m^3)	Specific Gravity (kg/m^3)	Total Water Absorption (%)	Open Porosity Porosity (%)	Composite
T11	1,763	2,655	12,45	22,12	77,88
T12	1,725	2,581	15,06	25,30	74,70
T13	1,708	2,552	15,51	27,19	72,81
T1average	1,732	2,596	14,34	24,87	75,13
T21	1,825	2,497	8,93	16,89	83,11
T22	1,813	2,461	9,96	18,15	81,85
T23	1,810	2,449	10,84	19,08	80,92
T2average	1,816	2,469	9,91	18,04	81,96
T3	Physical analysis could not be made due to the dissolution of samples.				

Brick samples from the physical analysis of the structure according to the results, the specific gravity of the brick T1 value 2,596 kg/m^3, while the value of the bricks T2 2,469 kg/m^3 was determined. 1,732 kg/m^3 bricks with specific weights in inverse proportion to T1 unit weights in kg/m^3 of bricks with a value of T2 1,816 kg/m^3 lower than the value that has been identified. The water absorption rate of the samples' porosity values correlated with the 24,87% porosity water absorption of bricks T1, which has the value 14,34%; 18,04% porosity water absorption of bricks with T2 value 9,91% that have been identified based on Çağlar (2018) [12]; threshing bricks the average of the value of the unit weight of 1.85 g/cm^3, specific gravity value 2,69 g/cm^3 and a porosity rate is 26.75%; 8% boron waste, the value of the average unit weight of bricks additive blending of 2 g/cm^3, the specific gravity of the value of 3.01 g/cm^3 porosity have been identified as 20,80%. Koç (2019) [13] scholarship in the study of Gölyazı traditional brick structures that is used in the average unit weights of the samples of 1,64-2,48 g/cm^3, specific gravity 1,72-2,64 g/cm^3, porosity of %has stated that a value is in the range 25%-37%. The values in the structure examined in the literature agree with that found it is seen.

3.2. Mechanical analysis

The values are given in Table 3 the results of the compressive strength of the bricks.

Table 3. Samples applied to brick compressive strength test results

Sample Code	Dimension (mm)	Breaking Load (N)	Compressive Strength (MPa)
T1a	40x40x40	12249	7,65
Diseases	40x40x40	5243	3,27
T1d	40x40x40	3903	2,56
T1Average		7131	4,49
T2W	40x40x40	8876	6,75
T2b	40x40x40	10238	7,79
T2d	40x40x40	8746	6,75
T2 Average		9286	7,09
T3 Average	Due to the dissolution of samples in the mechanical analysis could be made.		

From the structure according to the test results on samples retrieved brick compressive strength, the compressive strength of the brick T2 (7,09 MPa) and compressive strength of bricks by T1 (4,49 MPa) were high, it was determined that. The bricks of T1 4,49 MPA compressive strength value, and porosity seem to support each other with the fact that the value is high. Harman bricks in the relevant standards, the compressive strength of at least 4.00 N/ mm^2 and the average is 5.00 N/mm^2 was estimated to be. The average compressive strength of bricks is over the specified value of T2 when T1 is the value of the compressive strength of the bricks at the conclusion that the limit value is reached. Çağlar (2018); in the study, the average compressive strength of the bricks 2,98 MPa, 8% boron waste, the average compressive strength of bricks 5,94 MPa have been identified as [12]. Brick raw material sources resistance may vary according to differences in samples and production techniques. At the same time exposed to different heat treatments at different points in the kiln during the firing of the bricks, bricks can be shown among the reasons that affect the properties of threshing [14].

3.3. Chemical analysis

Loss on ignition, acid loss, post-acid loss sieve analysis, salt tests, and protein-oil tests were performed on the mortar and plaster samples taken from the building. Ignition loss and acid loss are given in Table 4 and Table 5, respectively, and sieve analysis results are given in Figure 6.

Table 4. The results of the analysis of mortars and plasters belonging to mass loss

	Mass Loss (%)		
Sample Code	Moisture At 105°C	Relative Humidity Water/Organic Additives 550°C	$CaCO_3$ 1050°C
H1 (masonry mortar)	1,00	3,39	22,92
H2 (Interior plaster)	0,94	2,21	21,18
H3 (Interior plaster)	2,51	4,32	7,00
H4 (masonry mortar)	0,75	2,18	16,78

When the ignition loss analysis results were examined, it was seen that the weight losses at 105 °C were between 0.94% and 2.51%. The results show that all samples contain small amounts of moisture. When the weight losses at 550 °C were examined, it was determined that the samples contained relative water and organic additives between 2.18% and 4.32%. According to the loss of ignition at 1050 °C, it was determined that the amount of $CaCO_3$ in the H1 and H2 samples was at the highest level because they were lime mortar.

Table 5. The results of the analysis belonging to acid loss mortars and plasters

Acid Loss (%)		
Sample Code	**Missing**	**Remaining**
H1 (masonry mortar)	21,14	78,86
H2 (Interior plaster)	21,79	78,21
H3 (Interior plaster)	10,62	89,38
H4 (masonry mortar)	21,83	78,17

When the acid loss and sieve analysis results were examined, the binder-aggregate ratios of the mortar and plasters belonging to H1, H2, and H4 samples were determined as 1:4, while the binder-aggregate ratio of the interior plaster sample numbered H3 of the same building was determined as 1:8-10. It is thought that the plaster number H3 was applied later for repair purposes.

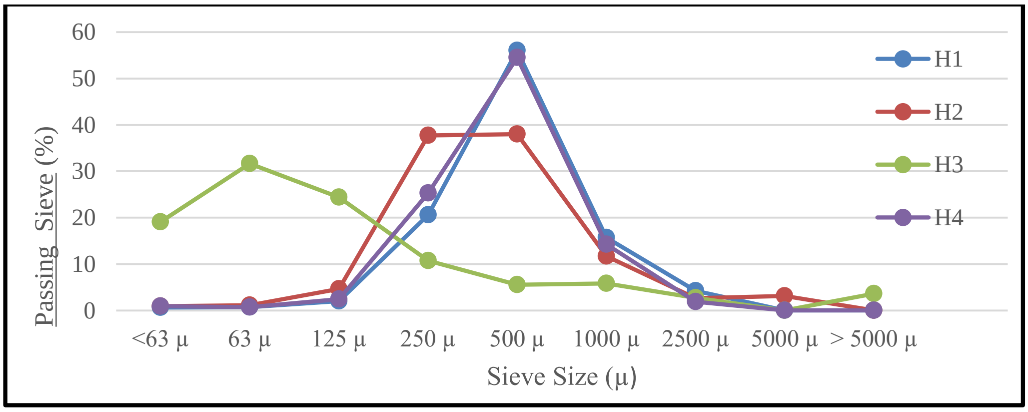


Figure 6. Particle size distributions of aggregates

Analysis results of water-soluble salts analysis and conductivity measurement values of mortars and plasters, as well as protein and oil test results, are given in Table 6. As a result of the salt tests carried out on mortars and plasters, no serious salinization problem was found, while a small amount of chlorine and nitrate was detected in the H2 sample, and a small amount of chlorine was detected in the H3 sample. The conductivity values of the samples were parallel to the salt tests. It was observed that the conductivity values of mortar and plaster varied between 150-241 µS and the detected salt amounts varied between 1.32-1.52%. When the protein and oil test results were examined, the presence of oil was not found in any of the mortar and plaster samples, while the presence of protein was detected in all samples. The presence of protein in the samples indicates the use of organic additives such as egg whites etc. to improve the properties of the mortar and strengthen its binding properties. Such additives reduce the brittle structure of the mortar and increase its plasticity [15].

Table 6. Table of mortar and plaster with water-soluble salts of analysis and conductivity measurement

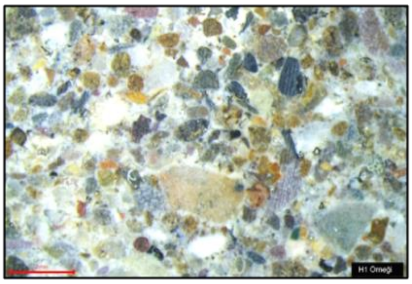
Salt Tests							Protein-Fat Test	
No	**Chlorine (Cl^-)**	**Sulfate (SO_4^{2-})**	**Carbonate (CO_3^{2-})**	**Nitrate (NO_3^-)**	**Conductivity (µS)**	**% Salt**	**Protein**	**Oil**
H1	-	-	-	-	154	-	+	-
H2	+	-	-	+	209	1,32	+	-
H3	+	-	-	-	241	1,52	+	-
H4	-	-	-	-	150	-	+	-

-: No; +: less: Var; +++: more; ++++: have too many

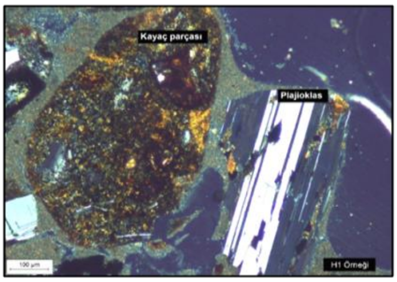
3.4. Petrographic analysis

3.4.1. Thick and thin-section analysis

The H1 sample was taken from the southwest wall of the ground floor of the building; It is a white-coloured, weak-structured knitting mortar sample containing sand aggregates and white masses, and its binder was determined to be slaked cream lime. A very small amount of the aggregates of the mortar, which has a binder ratio of 15-20% by area, contains brick fragments as contamination, while 2-3% contains limestone and marble fragments, etc. It was determined that the remaining aggregates of the sample, which contained a small amount of lime lumps and fossil shell fragments, were all black sand and consisted of mineral and rock fragments. Its minerals generally contain quartz, plagioclase, and small amounts of amphibole. Stereomicroscope and polarizing microscope images of the sample are given in Figure 7.



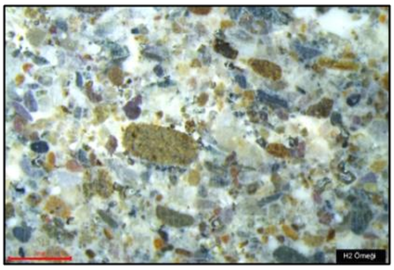
a



b

Figure 7. Sample of H1 (a) stereo microscope and (b) with a polarizing microscope image

The H2 sample was taken from the southwest wall of the ground floor of the building; It is a white-colored, weakly structured plaster mortar sample containing sand aggregates and white masses, and its binder was determined to be slaked cream lime. 3-5% of the aggregates of the mortar, whose area binder ratio is in the range of 15-20%, are carbonate rock particles and all of the aggregates are black sand. It is generally composed of volcanic rock types and contains quartz and feldspar minerals. Stereomicroscope and polarizing microscope images of the sample are given in Figure 8.



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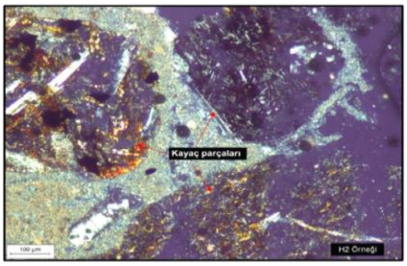
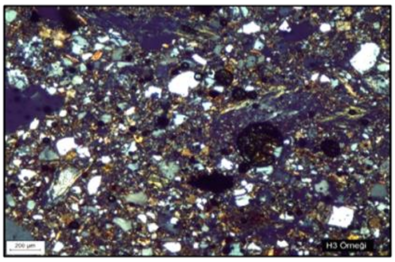


b

Figure 8. A sample of H2 (a) stereo microscope and (b)with a polarizing microscope image

The H3 sample was taken from the south wall of the ground floor of the building; It is a brown-coloured, weak-structured plaster mortar sample with plenty of tows in it, and its binder was determined to be 5-10% slaked cream lime reinforced soil. Approximately 3-5% of the sample aggregates are ash, and all the remaining aggregates are soil of terrestrial origin. The soil aggregate content contains 2-3% limestone fragments up to 1 mm in size, small amounts of quartzite and meta sandstones, and contains quartz, feldspar, and small amounts of mica minerals. Stereomicroscope and polarizing microscope images of the sample are given in Figure 9.

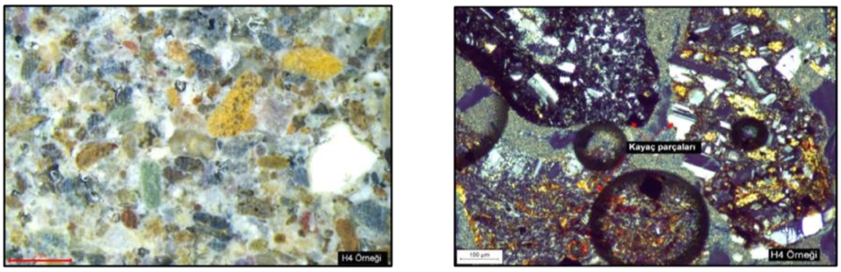
a



b

Figure 9. Sample of H2 (a) stereo microscope and (b) with a polarizing microscope image

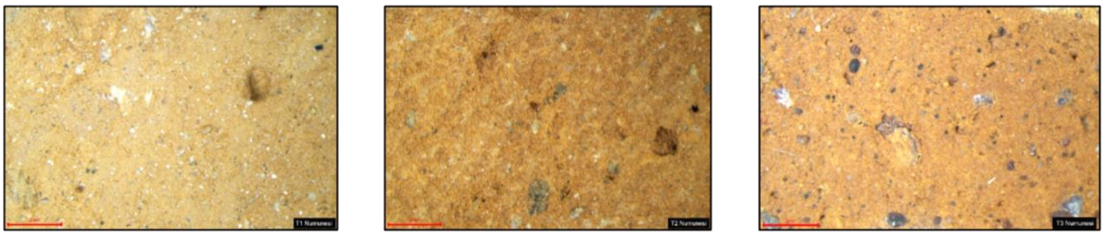
The H4 sample was taken from the 2nd-floor northeast wall of the building; It is a white-colored, weak-structured knitting mortar sample containing sand aggregates and white masses, and its binder was determined to be 15-20% slaked cream lime by area. It was determined that all sample aggregates were black sand. The mortar paste contains 1-2% carbonated lime lump particles, 1-2% fossil shells, and pollution tow particles. In addition, although the majority of its aggregates are volcanic rocks, there are small amounts of rocks such as meta sandstones and mica schist. It forms quartz, feldspar, and rarely pyroxene minerals. Stereomicroscope and polarizing microscope images of the sample are given in Figure 10.



a b

Figure 10. A sample of H4 (a) stereo microscope and (b) with a polarizing microscope image

According to the cross-sectional analysis of the T1 sample, the sample is a well-prepared and compressed blend brick sample with dimensions of approximately 4x4 mm, with voids of less than 5% and small diameter pores of less than 1 mm in the range of 5-10%. It was understood that approximately 10% of the sample area contained calcium carbonate (limestone particles) up to 0.5 mm in size, quartz (sand) particles in the same proportion, and the remaining part was soil with baked clay and a high content of iron oxide (Fe_2O_3). According to the cross-section analysis of the T2 sample, the sample is a better prepared, compressed, and fired blend brick sample than the T1 sample, with 1-2% of the pores smaller than 0.2 mm, except for the gap of approximately 5x8 mm. In the sample area, there is approximately 10% calcium carbonate (limestone particles) up to 0.25 mm in size, the proportion of quartz (sand) particles up to 1 mm in size is in the range of 15-20%, and the remaining part is baked clay and a high percentage of iron oxide (Fe_2O_3). It was understood that it was soil-containing according to the cross-sectional analysis of the T3 sample, it is a non-highly compressed blend brick sample with a medium amount of voids in the range of 1-5 mm and less than 5% porosity of approximately 0.5 mm. In the sample area, the proportion of calcium carbonate (limestone particles) and quartz (sand) particles up to 0.5 mm in size is approximately 10-15%, and the remaining part is soil containing baked clay and high amounts of iron oxide (Fe_2O_3). It turned out that it was. The production material of T3 brick is considered to be good but its preparation and firing are poor. The stereo microscope image of the samples is given in Figure 11.



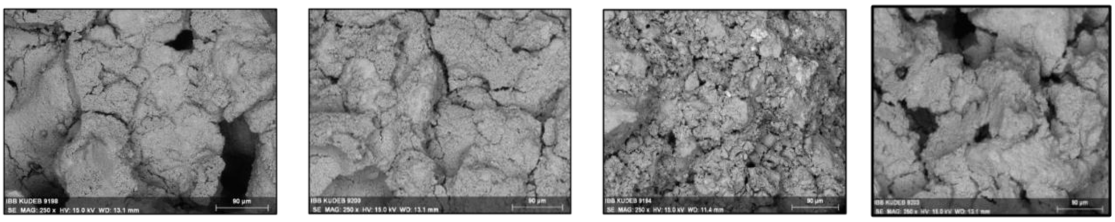
a b c

Figure 11. (a) T1, (b) T2, and (c) T3 samples from stereo microscope images

3.5. SEM-EDS (EDX) analysis

3.5.1. Mortar analysis

With SEM-EDX analyses, SEM images were taken from the binding parts of the mortar samples and EDX analyzes were performed on the marked areas on these images. SEM images and EDX analysis element and oxide ratios of H1, H2, H3, H4 samples are given in Figure 12.



(a) Spectrum

Element	norm. C [wt.%]	Atom. C [at.%]	Compound	norm. Comp. C [wt.%]
Oxygen	30.77	51.85		0.00
Magnesium	0.27	0.30	MgO	0.45
Aluminium	1.47	1.47	Al2O3	2.77
Silicon	3.51	3.37	SiO2	7.51
Calcium	62.26	41.88	CaO	87.11
Phosphorus	0.00	0.00	P2O5	0.00
Sulfur	0.00	0.00	SO3	0.00
Chlorine	0.00	0.00		0.00
Iron	0.61	0.30	FeO	0.79
Titanium	0.00	0.00	TiO2	0.00
Sodium	0.14	0.16	Na2O	0.19
Potassium	0.97	0.67	K2O	1.17
Total:	100.00	100.00		

(b) Spectrum

Element	norm. C [wt.%]	Atom. C [at.%]	Compound	norm. Comp. C [wt.%]
Oxygen	29.66	50.88		0.00
Magnesium	0.31	0.35	MgO	0.52
Aluminium	0.67	0.68	Al2O3	1.27
Silicon	1.94	1.90	SiO2	4.16
Chlorine	0.18	0.14		0.18
Calcium	65.84	45.09	CaO	92.12
Phosphorus	0.00	0.00	P2O5	0.00
Sulfur	0.00	0.00	SO3	0.00
Iron	0.51	0.25	FeO	0.65
Titanium	0.00	0.00	TiO2	0.00
Sodium	0.17	0.20	Na2O	0.23
Potassium	0.72	0.51	K2O	0.87
Total:	100.00	100.00		

(c) Spectrum

Element	norm. C [wt.%]	Atom. C [at.%]	Compound	norm. Comp. C [wt.%]
Oxygen	44.25	61.11		0.00
Sodium	1.36	1.31	Na2O	1.84
Magnesium	1.67	1.52	MgO	2.77
Aluminium	9.73	7.97	Al2O3	18.39
Silicon	24.68	19.42	SiO2	52.80
Sulfur	0.00	0.00	SO3	0.00
Chlorine	0.90	0.56		0.90
Potassium	2.47	1.39	K2O	2.97
Calcium	4.54	2.50	CaO	6.35
Titanium	1.55	0.72	TiO2	2.59
Iron	8.85	3.50	FeO	11.38
Phosphorus	0.00	0.00	P2O5	0.00
Manganese	0.00	0.00	MnO	0.00
Total:	100.00	100.00		

(d) Spectrum

Element	norm. C [wt.%]	Atom. C [at.%]	Compound	norm. Comp. C [wt.%]
Oxygen	29.89	51.11		0.00
Magnesium	0.38	0.42	MgO	0.62
Aluminium	0.93	0.94	Al2O3	1.75
Silicon	2.17	2.11	SiO2	4.64
Calcium	64.94	44.33	CaO	90.87
Phosphorus	0.00	0.00	P2O5	0.00
Sulfur	0.00	0.00	SO3	0.00
Chlorine	0.06	0.05		0.06
Iron	0.78	0.38	FeO	1.00
Titanium	0.00	0.00	TiO2	0.00
Sodium	0.13	0.15	Na2O	0.17
Potassium	0.73	0.51	K2O	0.88
Total:	100.00	100.00		

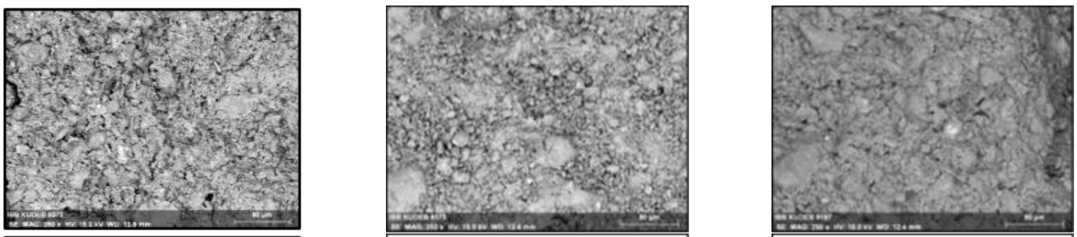
a b c d

Figure 12. (a) H1, (b) H2, (c) H3 and (d) H4 SEM image and EDX Elemental analysis and oxide ratios of samples

As shown in Figure 12, the binder of the H1 mesh mortar sample is lime-derived calcium carbonate, which contains clay formed by the decomposition of feldspars in the range of approximately 10-12%. While the sample contained 87.11% calcium originating from lime, it was determined that this element contained much smaller amounts of silicon, aluminum, potassium, iron, magnesium, and sodium. The binder of the H2 plaster mortar sample is lime-derived calcium carbonate, which contains clay formed by the decomposition of feldspars in the range of approximately 5-6%. It was determined that the sample contained 92.12% calcium, originating from lime, and much less of this element, silicon, aluminum, potassium, iron, magnesium, sodium, and chlorine. H3 plaster mortar sample; The binder is approximately 8-10% lime-derived calcium carbonate, and the remainder is clay formed by the decomposition of potassium and sodium-based feldspars. It was determined that the sample contained 52.80% silicon, originating from clay, and smaller amounts of this element, aluminum, iron, calcium, potassium, magnesium, titanium, sodium, and chlorine. The binder of the H4 mesh mortar sample is lime-derived calcium carbonate, which contains clay formed by the decomposition of feldspars in the range of approximately 10-12%. It was determined that the sample contained 90.87% calcium, originating from lime, and much less of this element, silicon, aluminum, iron, potassium, magnesium, sodium, and chlorine.

3.5.2. Brick analysis

SEM images and EDX analysis of element and oxide ratios of T1, T2 and T3 samples are given in Figure 13.



(a) Spectrum

Element	norm. C [wt.%]	Atom. C [at.%]	Compound	norm. Comp. C [wt.%]
Oxygen	45.62	62.21		0.00
Sodium	0.71	0.67	Na2O	0.95
Magnesium	1.47	1.32	MgO	2.44
Aluminium	10.40	8.41	Al2O3	19.65
Silicon	26.90	20.89	SiO2	57.54
Potassium	2.31	1.29	K2O	2.78
Calcium	1.58	0.86	CaO	2.22
Titanium	0.64	0.29	TiO2	1.07
Iron	10.36	4.05	FeO	13.33
Phosphorus	0.00	0.00	P2O5	0.00
Sulfur	0.00	0.00	SO3	0.00
Chlorine	0.00	0.00		0.00
Total:	100.00	100.00		

(b) Spectrum

Element	norm. C [wt.%]	Atom. C [at.%]	Compound	norm. Comp. C [wt.%]
Oxygen	43.32	60.49		0.00
Sodium	0.92	0.89	Na2O	1.24
Magnesium	1.15	1.05	MgO	1.90
Aluminium	9.17	7.59	Al2O3	17.33
Silicon	25.03	19.91	SiO2	53.54
Sulfur	0.09	0.06	SO3	0.22
Chlorine	2.74	1.73		2.74
Potassium	3.20	1.83	K2O	3.86
Calcium	4.20	2.34	CaO	5.88
Titanium	0.50	0.23	TiO2	0.83
Iron	9.68	3.87	FeO	12.46
Phosphorus	0.00	0.00	P2O5	0.00
Total:	100.00	100.00		

(c) Spectrum

Element	norm. C [wt.%]	Atom. C [at.%]	Compound	norm. Comp. C [wt.%]
Oxygen	44.48	61.71		0.00
Sodium	0.78	0.75	Na2O	1.05
Magnesium	1.20	1.09	MgO	1.99
Aluminium	9.91	8.16	Al2O3	18.73
Silicon	25.26	19.97	SiO2	54.05
Potassium	2.02	1.15	K2O	2.44
Calcium	3.95	2.19	CaO	5.53
Titanium	0.71	0.33	TiO2	1.18
Iron	11.53	4.58	FeO	14.83
Phosphorus	0.00	0.00	P2O5	0.00
Sulfur	0.00	0.00	SO3	0.00
Chlorine	0.00	0.00		0.00
Manganese	0.15	0.06	MnO	0.20
Total:	100.00	100.00		

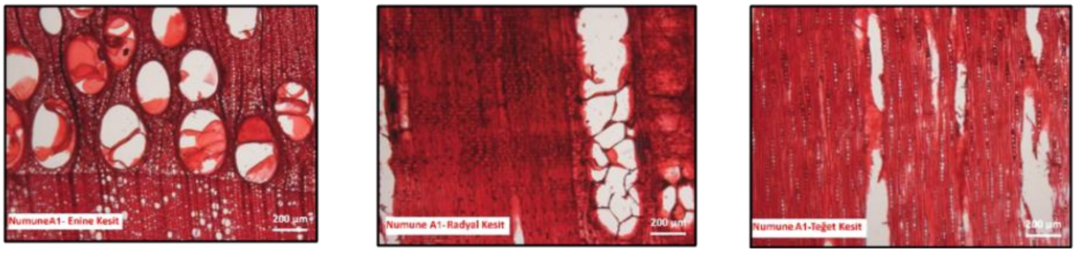
a b c

Figure 13. (a) T1, (b) T2 and (c) T3, SEM image and EDX Elemental analysis and oxide ratios of samples

Calcium carbonate was detected in the range of 2-3% in the content of the T1 brick sample, and it was observed that there were silt and clay-sized particles in the area determined as clay in the sample examination area. It was determined that the sample contained 57.54% silicon, and smaller amounts of this element, aluminum, iron, potassium, magnesium, calcium, titanium and sodium. Calcium carbonate was detected in the range of 5-6% in the T2 brick sample, and it was observed that there were silt and clay-sized particles in the area determined as clay in the sample examination area. It was determined that the sample contained 53.54% silicon, and smaller amounts of this element, aluminum, iron, calcium, potassium, chlorine, magnesium, sodium, titanium and sulfur. T3 brick sample; It was determined that the sample contained 54.05% silicon, and smaller amounts of this element, aluminum, iron, calcium, potassium, magnesium, titanium, sodium and manganese. The most suitable soils for brick making are clay soils. Generally, clays include illite, montmorillonite, kaolinite, quartz, limestone and iron minerals. When these minerals are fired between 800-1200 °C, they have the strength required for bricks. Illite and kaolinite clays are the most suitable for brick and tile making [16]. SiO_2/Al_2O_3 ratio of kaolin type minerals is 2/1; In montmorillonite, illite and chlorite type minerals, it is 3/1 [17]. Since these ratios are more than 3/1 in the brick samples taken from the building, it can be concluded that the bricks are not kaolinite in structure.

3.6. Analysis of The Type of Wood

The cross-sectional features of sample number A1, which was taken from the window joinery of the building and was a wood sample with a layer of white paint on it and was damaged by fungus and insects, were examined (Figure 14). In the examination, it was observed that it has a ringed tracheal structure, the summerwood trachea diameters are gradually decreasing, and it forms narrow radial or oblique, sometimes bifurcated rows. In radial section features, the core rays have a homogeneous structure, the perforation trays are of simple type, and sometimes ladder-like perforation trays are observed in the summerwood trachees. In the tangential section features, it was determined that the core rays were single cell wide and mostly 5-30 cells high. As a result of macroscopic and microscopic examinations, the type of sample A1 taken from the window joinery was determined as chestnut (Castanea sativa Mill.).



Cross-section Radial cross section Tangent to the cross section

Figure 14. Thin section images of sample A1

4. Conclusions

The results obtained by physical, chemical, mechanical, and petrographic analysis of the materials taken from the Konuralp traditional house (1799 parcel), which has survived to the present day while preserving its original structural features, are shared below.

According to the physical property results of the brick samples; unit volume weights are within the range of the specified standard values (1600-1800 kg/m^3); Although the specific gravity of T1 brick is high; It was found that T2 brick has lower water absorption rate and porosity. When its mechanical properties are examined, the compressive strength of blend brick is predicted to be at least 4.00 N/mm^2 and an average of 5.00 N/mm^2 in the relevant standards. It was concluded that while the average compressive strength of T2 brick was above the specified values, the compressive strength of T1 brick was at the limit value. In addition, it was determined that T1, T2, and T3 samples contained silicon at the rates of 57.54%, 53.54%, and 54.05%, respectively, and generally fewer amounts of this element: aluminum, iron, potassium, magnesium, calcium, titanium and sodium.

When we examined the mortar samples, according to the acid loss results of the mesh mortar samples numbered H1 and H4, the binder-aggregate ratio was 1:4, and according to the petrographic analysis results, it was determined that the binders were slaked cream lime. The aggregates of the masonry mortar samples showed similar properties, and the remaining aggregates consisted of black sand, except for brick fragments and carbonated lime lumps in terms of contamination. Only a very small amount of tow pieces (flax) were detected in the H4 mortar. When we examine the plaster samples from the same building, the binder ratio of plaster mortar numbered H2 is approximately 20% and the binder is slaked cream lime. The aggregates of the sample consist of small amounts of carbonate rock fragments, while the rest is entirely black sand. The H3 sample is a soil mortar reinforced with lime in the range of 5-10% and the binder-aggregate ratio is in the range of 1:8-10. The sample aggregates are a small amount of ash, and all the aggregates are soil of terrestrial origin. Although there are less than 1% black slag particles in the sample paste, 4-5 kg of straw tow was added per cubic meter. While sample H2 is a sample of the original plaster used in the building, sample H3 is thought to be an adobe mortar applied later for repair purposes.

According to the results of ignition loss applied to mortar and plaster; The relative water and organic contribution rates in the samples vary between 2.18% and 4.32%. According to the results of salt tests, while samples H2 and H3 contain a small amount of chlorine, sample H2 also contains a small amount of nitrate. Apart from this, no significant salinization problem was detected in either structure.

When the protein and oil test results were examined, the presence of oil was not found in any of the mortar and plaster samples, while the presence of a small amount of protein was detected in all samples. This indicates that organic additives are used in the creation of mortars and plasters.

According to the SEM-EDX results of the mortar samples, it is understood that the binder parts of the mortars numbered H1, H2, and H4 contain a very high amount of calcium originating from lime, while the amount of silica in the H3 mortar is quite high due to the high clay it contains. It was determined that the wood of the window frame taken from the second floor of building number 1799 was chestnut (Castanea sativa Mill.). It was envisaged that the same type of wood as the tree species specific to the region could be used during the repair phase.

Acknowledgment

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Conflict of Interest Statement

The authors declare that there is no conflict of interest.

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