Investigation of Clay Bound Exterior Plaster Properties on Mud-Walls in Diyarbakir Region

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Abstract: *This study is about the investigation of the physical and mechanical properties of the clay bound plasters applied on the surface of adobe used as wall element in one of traditional building type, adobe buildings. The protection of wall surfaces against outdoor conditions and the resistance against adverse effect in adobe buildings is important in respect to fulfill the protective function. It's possible to minimize the damage that can occur in clay-based exterior plasters covering the surface of mud-wall and protecting the building's wall against outdoor conditions, by determining properties of the plaster used. In the study made for this purpose, physical and mechanical properties of the material have been investigated by experimental methods by taking clay bound exterior plaster samples from an adobe building in Diyarbakir province, Bismil district, Yuvacik village. Performance of clay bound plasters against outdoor conditions in terms of protective function is evaluated through the experimental study.*

Keywords: *Traditional Architecture, adobe, earthen Plaster, clay soil*

Diyarbakır Bölgesindeki Kerpiç Duvarlarda Kil Bağlayıcılı Dış Sıva Özelliklerinin İncelenmesi

Özet: *Bu çalışma geleneksel yapı türü olan kerpiç yapılarda, duvar elemanı olarak kullanılan kerpicin yüzeyine uygulanan kil bağlayıcılı sıvaların fiziksel ve mekanik özelliklerinin incelenmesi üzerinedir. Kerpiç yapılarda duvar yüzeylerinin dış ortam koşullarından korunabilmesi ve olumsuz etkilere karşı direnç göstermesi, koruyuculuk işlevini yerine getirmesi bakımından önemlidir. Kerpiç duvar yüzeyini örten ve yapının duvarını dış çevresel etkenlere karşı koruyan kil esaslı dış sıvalarda oluşabilecek hasarların en az düzeye indirgenebilmesi, kullanılan sıvanın özelliklerinin belirlenmesi ile mümkün olabilmektedir. Bu amaçla yapılan çalışmada Diyarbakır ili, Bismil ilçesi, Yuvacık köyündeki kerpiç bir yapıdan kil bağlayıcılı dış sıva numuneleri alınarak, malzemenin fiziksel ve mekanik özellikleri deneysel yöntemlerle incelenmiştir. Yapılan deneysel inceleme ile kil bağlayıcılı sıvaların dış çevresel etmenlere karşı koruyuculuk işlevi açısından performansı değerlendirilmiştir.*

Anahtar Kelimeler: *Geleneksel Mimari, kerpiç,toprak Sıva, killi toprak*

1. INTRODUCTION

Earth material is one of the oldest building materials. Adobe material obtained by using earth material has been a building material as old as the existence of the human history. Because adobe is economic and easily available, it's possible to find a widespread usage pattern in rural architectural buildings, however, due to its performance increased by different additives included, it can be a preferred building material also in cities.

Outdoor conditions may cause some damage on the surface by affecting the building external shell. Increasing performance of the building wall against outdoor conditions will contribute to the increase of interior comfort of the building, decrease of repair needs by minimizing damages on the wall surface and decrease of energy loss. Therefore, it becomes important that wall surfaces of the building can be protected against outdoor conditions and resist the adverse effects.

Because adobe has no significant strength against water, it's softened and disintegrated by contact with water, it's not used in rainy regions. When used as a filler within the carcass system in rainy regions, it is protected by plaster and wide fringe systems [1]. Because earth material abounds, it's seen that adobe, which is more preferred in hot regions, is being used extensively in slope and plain settlements.

Plasters applied to outer surfaces of buildings play a major role in protecting the wall from environmental factors by ensuring that the wall is not directly exposed to the outdoor conditions. Plasters used to protect mud-wall surfaces also vary according to their structural characteristics. Plaster types obtained as a result of addition of some materials with different binding properties to the adobe mixture have different properties against environmental factors acting on the wall surface. Therefore, plasters, the final layer of the building shell are very important. Due to deformations in the plaster structure because of environmental factors, some damages such as blistering, cracking and shedding may occur. These damages, which can be seen on the surfaces plaster cause the protective function of plaster to be reduced, the wall surfaces are worn out, exposed to some environmentalfactors and the strength is adversely affected. For this purpose, it is important to increase the strength by determining the properties of the plaster well. Clay bound plaster application on the adobe used as a wall element is considered as a common usage type. Through the experimental study, material properties of clay bound plasters to be determined and contribution to the improvement studies to be made are aimed.

2. MUD-WALLS AND SURFACE CHARACTERISTICS

Adobe is a building material obtained by mixing clayed and suitable soil with straw or other additives and kneading with water, then pouring into molds and forming, finally, air seasoning. In different parts of Anatolia, wool, bristle, gypsum, lime, wood ash, salt, stalks, fibrous plant wastes, straw, etc. are included in the plaster [2].

The adobe masonry is similar to the brick masonry. However, lime is used instead of mortar and mud is used instead of cement. The wall is continued by laying adobe lines on each other by means of mud mortar. Adobe intersections along the wall are called horizontal joints, confused in vertical order cut joints are called vertical joints. Since the mud mortar is a late drying binder, when joints are excessively thickened, it causes the wall steepness not to be maintained and to be deteriorated due to the overload from the top [1].

The mud mortar used in mud-wall masonry is the same as that used for adobe production. But, it's paid attention that straw added in the mud mixture is fine fibrated and the soil is sieved. Common tools and materials are used in masonry works.

It's possible to divide the sizes of adobes into two parts. One of them is called the filler adobe. Its weight is as a normal brick and it's rather used as filler material in wooden carcass buildings. The other one is building adobe and used for laying massive walls in masonry buildings. Building adobes are cast as full and half in some regions. Full adobes are called mother, half adobes are called lamb [1]. Although they vary from region to region, the most used adobes commonly used in our country are adobe blocks with 30-35cm of length, 15-17cm of width, 10-12cm of height (Figure1) [3].

Adobe may be disintegrated after a while by affecting by humidity and water. Therefore, foundations, foundation and basement walls of masonry adobe buildings are made of a material resistant to water up to the sub-basement level. In the traditional construction, it’s rubble stone [4].

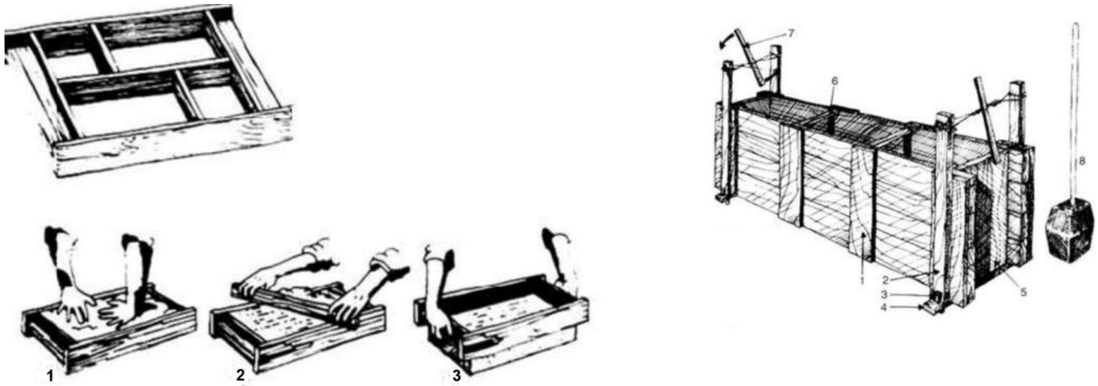

Figure 1. Adobe Mold Types

Characteristics and particle sizes of clay, which perform binding task of adobe, are important. Pressure strength, resistance to atmospheric effects, water solubility of adobe material to be used in the building is important to be determined. Sand and gravels in the soil, which are the main material of adobe, perform the skeleton task, clay performs the binding task. Type and availability of clay largely cause the characteristics of adobe to change [5]. Properties of wall surfaces made of adobe material are related to the characteristics of soil used in adobe making and other additives in the soil.

Wall surfaces made of adobe are affected by various environmental factors. Plaster is applied to the surfaces to minimize deformations and damages that may occur on wall surfaces due to the effect of environmental factors. The layer of plaster to be applied to the wall surface will prevent possible deformations on the surface by acting as protector. The plaster protecting wall surfaces should be suitable for the wall surface properties [5].

Adobe balances the moisture content of the indoor climate more than other building materials. It quickly absorbs the moisture in the air and can release the moisture in its body to the air quickly again. So, the indoor climate becomes neither too dry nor too humid. Temperature of the building is balanced in the use of adobe building [6]. Physical properties of some building materials are given in Table 1.

In water-related materials, water absorption and in materials with superficial contact with water, water permeability occurs. Material gap is an important factor in water absorption. Pressured or capillary water permeability occurs in materials with superficial contact with water [8].

Pressure permeability varies depending on water amount passing through the material, water pressure effective on a material with particular section and thickness and pressure water permeability coefficient of the material. Pressure water permeability of the material varies with the porosity of the material, and with grain structure and diameter in granular materials. Additionally, another effect of water entered the internal structure in materials is that creating changes similar to thermal deformations and to cause internal stresses [8].

Table 1. Physical Properties of Some Building Materials [7]

	Material	Unit weight (kg/m³) (ρ	Thermal conductivity (W/mk) (λ	Specific Heat (kJ/kgK) (C)	Vapor diffusion resistance μ)
[SIA]	Brick	1100	0.37	0.9	4.0-6.0
381/1	Lime, Sandstone	1600	0.80	0.9	10-25
	Aerated Concrete	400	0.18	1.1	3.0-5.0
	Wood (pine)	450-500	0.14	2.0-2.4	20-40
	Wood Fibreboard	350-500	0.09	1.6	2.0-5.0
CRA	Massive Adobe	2000	0.46-0.81	1.0	10.0-11.0
Terre	Cement Adobe (%8)			0.65-0.85	
	Light Adobe	1200	0.47	1.0	8.0-10.0
Al-ker	Gypsum Adobe	1600	0.40	-	13

Capillary water permeability is that water rises in material openings and capillary channels due to the superficial tension of water, when the material surface contacts with water. In this case, the amount of absorbed water varies depending on the material surface contacted with water, time for water pass through to the other side and the material's capillarity coefficient [8].

Durability and load carrying properties of building materials are determined by mechanical strength. The level of mechanical strengths of a material depends of its elasticity modulus. This value is preferred to be high in cases the carrier quality is high, and to be low in cases it's requested to be shock absorber against flexible and sudden loads. In order to determine the material's mechanical behavior, related states of the material such as pressure, tensile, shear, torsion, bending, buckling, fatigue, impact, hardness, etc. should be examined [8].

3. CLAY BINDED PLASTERS

Adobe material is a compound composed of elements with different properties. Sand plays the internal skeleton role and also plays a binding role due to the cohesion it created. More or less than necessary clay causes serious damage to adobe [5]. Soil has various proportions of clay depending on type. Adobe clays consist of various metal oxides and alkaline-earth such as calcite, gypsum, etc. and aluminum silicate systems. Another property of clays is that they take the desired shape when kneading with water and after water is discharged, shrinkage is formed in clay. Clay particles stop when they cannot move and plasticity of the clay is also lost [9]. Clay minerals are divided into 3 groups. They are as follows;

- Kaolinite group clay minerals: Kaolinite is the most known mineral of this group. Swelling amount in such minerals is very low and they have plastic properties.
- Montmorillonite group clay minerals: Because the bonds between the plates of clay minerals in this group are weak, water molecules easily penetrate between them, swell and blister.
- Illite group clay minerals: Apart from some chemical differences in terms of structure, they are similar to montmorillonite group clay minerals. Swelling feature is less, internal friction is more than montmorillonite. Water molecules cannot penetrate and stay between layers.

Volumes of clay particles in the soil increase depending on water absorbed into the body. Clay, which has a binding property in soil, should not crack due to swelling or shrinkage which may be caused by changes in volume. The mechanical properties of the adobe made of clay bound earth material should be performed to be synthesized in a sufficient amount of clay, additive and water mixture by providing granulometry in the structural structure of the material. Sludge prepared from clay-rich soil, cracks more during drying. In order to prevent this, additives can be added into soil [10].

Since the plaster material is clay and earth based, weak structure of the material, which is very susceptible to cracking, should be reinforced after mixed with water and applied. The most common method used for this purpose is to increase strength and binding property by adding fibers to the mixture. By adding straw, lax fiber, cotton stalk and similar plant wastes as organic fiber while the mixture is prepared, binding performance of the plaster will be increased by reducing cracks while the applied liquid is dried. In applications made in some regions, only straw and cotton waste or plasterer's hair are added to the mixture as binder in order to prevent plaster cracks and to obtain a single layer on the whole surface [11].

According to the researches on this matter [12]:

There should be a sufficient amount of clay such as cement to bind the small granules in the mixture of the soil and the sand amount should be at the level to facilitate the drying. Sandy clay or slime clay is suitable soil for adobe.

The soil to be used for the adobe is mixed with clay and sand. More clayed soils are oily, less clayed soils are weak soils. It is difficult to process oily soils as adobe. Shrinkage cracks easily occur. Weak soils are not suitable for shaping adobe. More clayed and oily soils should be weakened. Moderate oily soils are required to be used and their clay amounts should be between 15-25% and never exceed 25% for making adobe. It's known that shrinkage stress of more clayed soils is met by herbal materials such as straw, fern, moss, etc.

Some effects such as expansion, shrinkage, vapor pressure, etc. may occur in clay bound plasters depending on the structure of the plaster. In the expansion effect; conditions such as frost, varying wetness or dryness, etc. may lead to disintegration of the clay and thus to expansion on the inner surface of the plaster. If the plaster is very rigid, cracks are formed first and then dividing into small pieces is seen. Similarly, in heterogeneous walls (stone-soil mixed), the difference in the thermal expansion of the soil and the stone may cause some deformations. In the shrinkage effect; the plaster shrinks, when it dries first and makes the materials it contains stretched. If the structure of the wall is very rigid and smooth, relaxation occurs in the plaster. If the wall is rough, the plaster cracks. Depending on the binding property of the plaster, crack may occur more or less. Cracks on the outer surface of the plaster due to the exposure to sun light and wind, start from inside in dry walls with less water and continue to the outer surface. The most sensitive points are niche corners and corners on the ledge. In the vapor pressure effect; water vapor can increase the expansion on the internal structure of the wall. Swellings may be seen. It's more visible where internal vapor pressure is higher than the external pressure. This pressure difference directs the vapor movement in wall and plaster. Therefore, it’s waterproof and thick plasters should be avoided [13].

Clay bound plasters are affected by water. Disintegration may occur in parts exposed to water. It can be eliminated by renewing the plaster. Straw added into this plaster type prevents plaster cracking. Life of these plasters may be increased with the condition of whitewashing. In outdoor plasters, also lime plaster can be applied to the surface [5].

Plasters may vary depending on clay binding properties and other binder types entering the mixture. These binder types are; clay-cement, clay-gypsum, clay-lime, hybrid and straw fiber bound. These are as follows [14]:

3.1. Clay-Cement Bound Plasters

Clay - cement bound plasters have high strength and low elasticity. They are plasters sensitive to thermal and mechanical movements of the building and easy to crack. Therefore, they shouldn't be used as internal and external plaster in low strength wall material (wall material weight per volume less than 1000 kg/m^3) and in building sections with expected motion or moving building systems. Because of these properties, they are applied in building with limitation. They are preferred as external plaster of exterior walls of basements on or under ground level and as ceiling plaster of reinforced concrete floors open to outdoor conditions [14].

They are used as internal plaster in sections of the building with constantly high ambient humidity or in building elements with high wear resistance request. There is a need for moisture that mortar setting of such plaster is completed. It should not be used in thin plaster layers generally glazed with trowel because of the tendency to form capillary surface cracks due to drying. These mixtures can be used only in the final layer finished with wooden trowel [14].

In order to prevent the shrinkage occurred during the drying leads to the cracking of the thin plaster by reducing the adherence between the new applied layer and the substrate or the plastered surface, a new one should be avoided before the plaster layer is completely dried. Dry time of the plaster is closely related to openness, humidity and air breeze. By considering these factors, the possibility that salts that may lead to capillary cracks or efflorescence to leak to the surface, should be reduced. Weak mixtures with less cement ration in roughcast shouldn't be used together with a thin plaster prepared with strong mortar [14].

3.2. Clay-Gypsum Bound Plasters

In clay-gypsum bound plaster type, as the gypsum ration increases, the hardening o the plaster accelerates. A humid environment is not created after the plaster is set, so it prevents cracking. These plaster types have a flexible structure with low strength. They balance the ambient humidity by resisting to heat and moisture transmission. Because their water solubility and disintegration features are less than clay bound plasters, they are difficult to wear. Their surface properties are smooth and they don't produce dust [14].

3.3. Clay-Lime Bound Plasters

Strength of clay-lime bound plasters is low. It is very difficult to increase the strength of the plaster mixtures prepared in this way. They have good adhesion to the surface, where they are applied, and a flexible structure. These plasters are hardly affected by water and not affected by moisture. Because of their low strength and flexible structures, they are plasters, which can be applied on walls and ceilings of the building, interior surfaces of the building. Temperature does not exceed 1000°C on the inside surface and on the floor of the plaster until the crystal water was completely removed from the plaster mass. Because this temperature is insufficient for the ignition of the building elements, the fire resistance of the elements protected by such plasters greatly increases. They should be preferred on lightweight wall material with low strength and in parts of the building where motion is expected. It's a plaster with low wear resistance. Such plasters should be applied in two layers. Moderate sand should be used in the first layer roughcast and fine sand should be used in the second layer. Because hardening of such plasters takes a long time, a new plaster layer should not be applied before the plaster is completely hardened and wetted [14].

3.4. Hybrid Bound Plasters

Hybrid plaster is produced as gypsum and lime with cement mixtures. Gypsum and lime bound plasters are plasters, which were mixed with water a suitable period of time before applied to the lime mortar, contain gypsum, have low strength but flexible and well-bonded to the surface. Plasters, where cement and lime binders are used together, are plaster types, which have the characteristics of their binders in proportion and can be used on internal and external surfaces [11].

3.4. Straw Fiber Bound Plasters

Binding features of the material to be used as plaster are increased by adding straw and other suitable herbal fibers into the soil mixture prepared as plaster. Since the plaster material is clay and earth based, weak structure of the material, which is very susceptible to cracking, should be reinforced after mixed with water and applied. The most common method used for this purpose is to increase strength and binding property by adding fibers to the mixture. By adding straw, lax fibre, cotton stalk and similar plant wastes as organic fiber while the mixture is prepared, binding performance of the plaster will be increased by reducing cracks while the applied liquid is dried. In applications made in some regions, only straw and cotton waste or plasterer's hair are added to the mixture as binder in order to prevent plaster cracks and to obtain a single layer on the whole surface [11].

4. EXPERIMENTAL STUDY

Physical and mechanical properties of clay bound exterior plasters were examined in the study. In order to carry out the experiments, a single-floor building constructed in 1967 was selected from Diyarbakir province, Bismil district, Yuvacik village (Figure 2). Adobe blocks obtained by adding straw into the soil in the region were used in its construction. Inner and outer plasters of the building was made by using earth material.

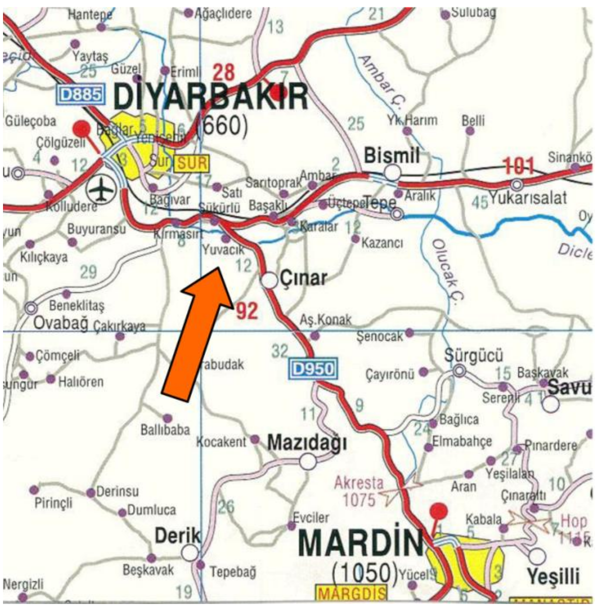

Figure 2. Diyarbakir Province Map

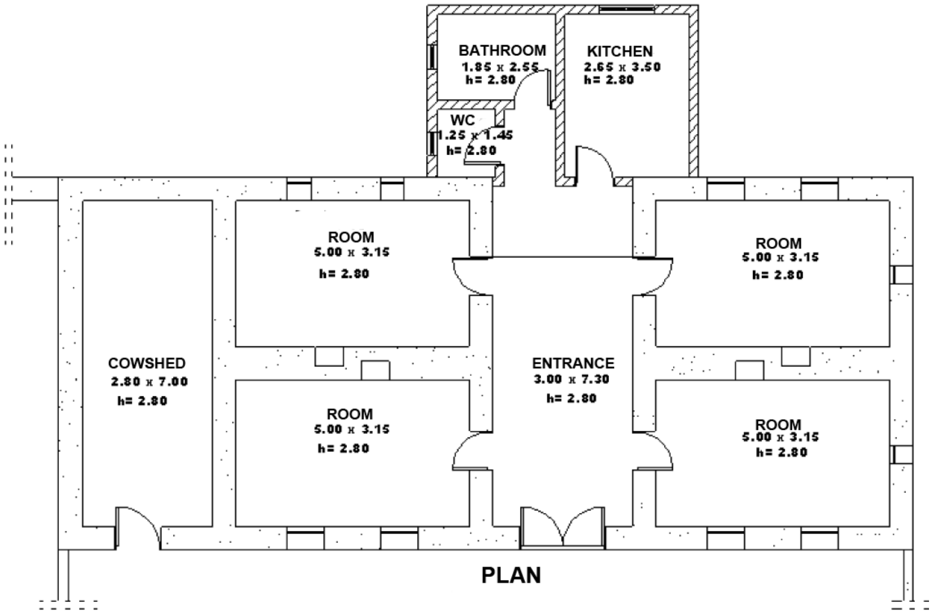

Figure 3. Layout of the Sample Taken Building

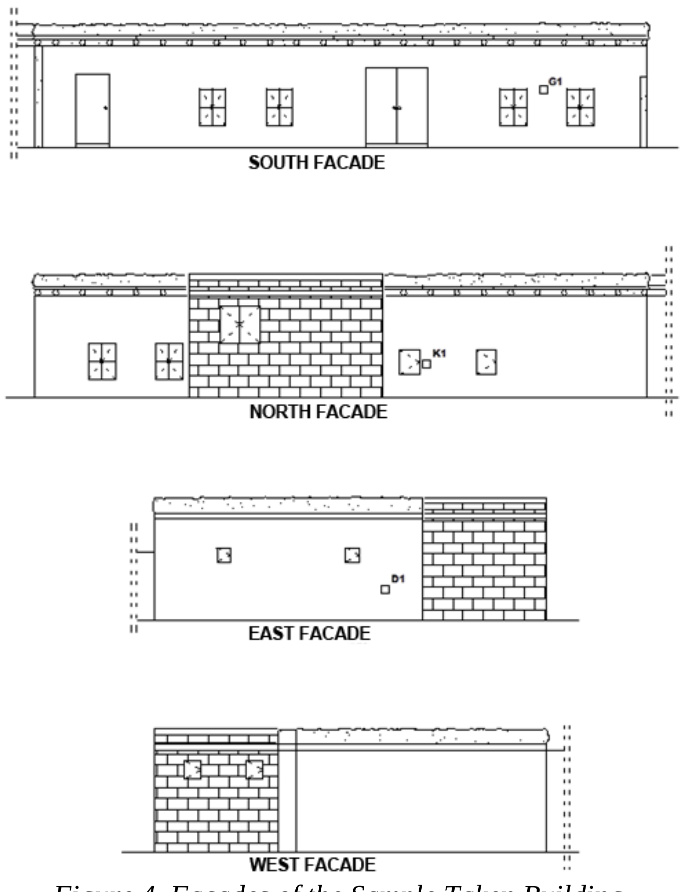

Figure 4. Facades of the Sample Taken Building

North, south and east facades of the building are open and the west facade is adjacent to the building next to it. Layout and windows of the building can be seen in (Figure 3-6). Samples are taken from outer plasters of north, south and east facades (Figure 7- 9.). The sample taken from the north facade is coded as sample K1, from the south facade as sample G1, from the east facade as sample D1.

In order to identify physical and mechanical properties of the plaster samples taken, experimental studies such as sieve analysis, mass per volume, composite-porosity, specific weight, water absorption by capillarity, time-dependent water absorption, vapor permeability were performed. In the test study, test methods suitable for Turkish Standards were used.

Figure 5.Facade of the Sample Taken Building

Figure 6. Facade of the Sample Taken Building

Figure 7. Sampling from the North Facade

Figure 8. Sampling from the South Facade

Figure 9. Sampling from the South Facade

4.1. Sieve Analysis

In order to determine the particle size of the material and physical properties of the used aggregate, sieve analysis was performed according to TS 130 standard (Figure 10) [15]. The sample was passed through 0.63mm, 0.125mm, 0.25mm, 0.5mm, 1mm, 2mm spaced sieves. Size of the sample in terms of particle size was identified. Weights of samples on the sieve and their percentage by weight to the total aggregate ratio were founded. Findings obtained according to the sieve analysis are indicated in Table 2 [16].

Table.2. Sieve Analysis Test Result

Sieve Opening (mm)	Weight on Sieve (gr)	Sample Percentage (%)
2	6,55	2,183
1	23,2	7,733
0,5	24,75	8,25
0,25	47,38	15,793
0,125	94,54	31,513
0,63	62,56	20,853
Collecting Vessel	41,02	13,673

Figure.10. Sieving the Sample

4.2. Mass Per Volume, Composite - Porosity, Specific Weight

The experiment was performed to find the material's mass per volume, composite-porosity, specific weight according to TS EN 1936 standard [17]. Weights per volume of the samples cut in appropriate sizes were calculated. Composite and porosity values of the samples were calculated by carrying out the specific weight experiment with samples. Findings obtained according to the experiments performed are indicated in Table 3[16]. As shown in the Table, porosity values of three samples are found higher than composite values.

Table 3. Mass Per Volume, Composite - Porosity, Specific Weight experiment results

Sample	Dimensions (cm)	Weight (gr)	Weight per Volume gr/cm^3	Composite %	Porosity %	Specific Weight gr/ cm^3
D1	1,53×2,23×2,91	9,98	1,01	41.06	58.94	2,46
G1	1,63×2,50×3,68	16,48	1,10	42.95	57.05	2,56
K1	1,28×1,28×3,32	6,24	1,15	44.75	55.25	2,57

4.3. Water Absorption By Capillarity

Water absorption of the samples, whose weights and dimensions are calculated by cutting in uniform sizes, by capillarity was measured according to TS EN 1925 standard [18] [16]. The experiment was carried out with G1, K1, D1 samples. G1 sample was completely wet at 25th minute and completely disintegrated at 169th minute. It was seen that K1 sample was completely wet at 81st minute and mostly disintegrated at 121st minute. Complete disintegration was not observed in the sample, which was mostly disintegrated. Although it was seen that D2 sample was completely wet at 154th minute, it was not disintegrated (Figure 11). Because D1 sample was not disintegrated, the experiment could be carried out to the end. The result of the experiment is shown in Figure 12 with the graphic method as indicated by the standard [18].

Figure 11. G1, K1, D1 Water Absorption of Samples by Capillarity

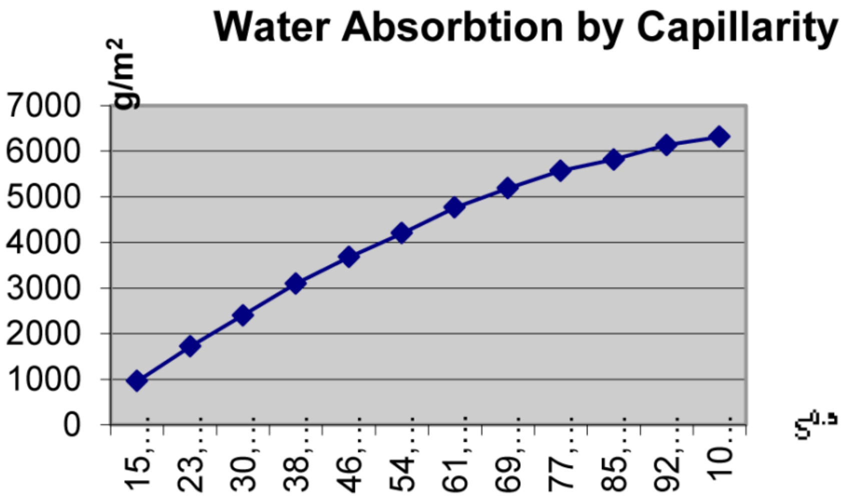

Figure 12.Water Absorption by Capillary Test Result Chart of the D1 Sample

4.4. Time-Dependent Water Absorption

In the time-dependent water absorption experiment separately carried out for G1, K1, D1 samples, it was carried out according to TS EN 1936 standard (Figure 13) [17][16]. In the time-dependent water absorption experiment, at the end of 90 minutes, the experiment period, the water amounts absorbed from the glass tube with a diameter of 1.4 mm are measured as follows; 3.6cm for D1 sample, 2.1cm for G3 sample, 4.4cm for K3 sample. The obtained data are indicated as graphs in Figure 14-16.

Figure 13.Time Dependent Water Absorption Test Absorption

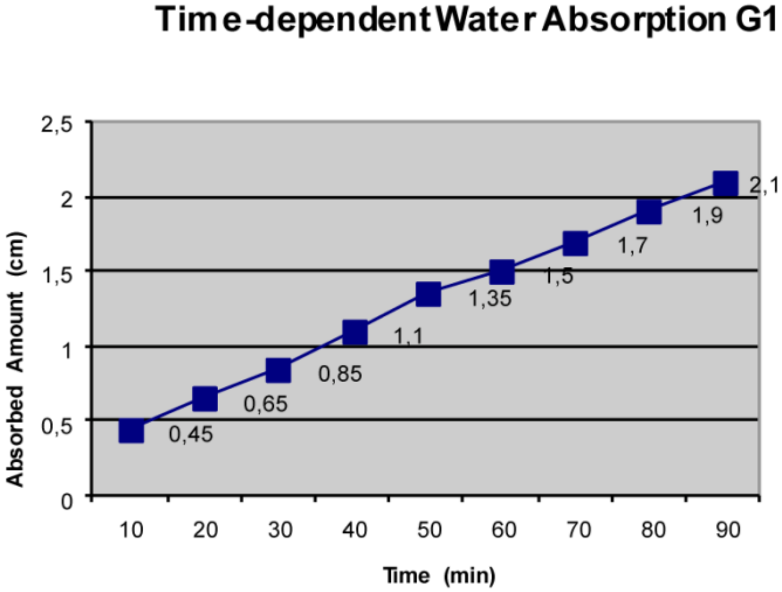

Figure 14. Time Dependent Water

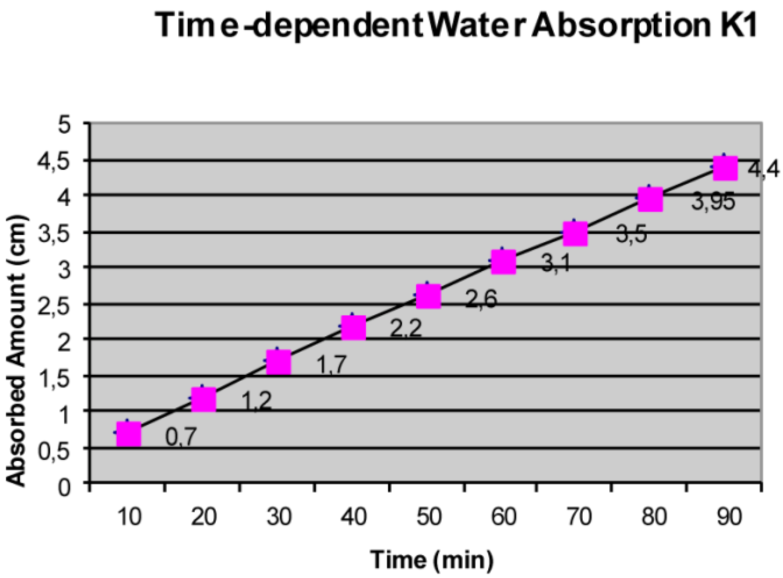

Figure 15. Time Dependent Water Absorption Chart of the K1 Sample

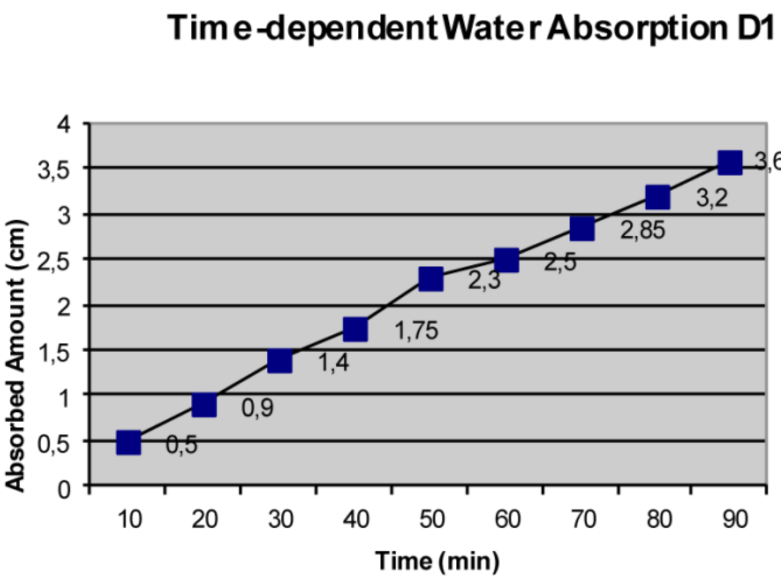

Figure 16. Time Dependent Water Absorption Chart of the D1 Sample

4.5. Vapor Permeability

The vapor permeability experiment was carried out for G1, K1, D1 samples according to TS 7847 standard [19][16]. According to the experiment result carried out, vapor permeability values of the samples were found as D1- 5,13m-1, G1- 4,89 m-1, K1- 5,33m-1. Data obtained from the experiment separately carried out for G1, K1, D1 samples are indicated in Table 4, (Figure 17).

Figure.17. Vapor Permeability Experiment

Table 4. Vapor Permeability Test Flow and Results

	Thickness d (m)	Diameter m	Area m^2		Time difference between two measurements (h)	Sample weight (kg)	Weight difference Δm	Amount of water vapor (G) (kg/h)	Steam diffusion resistance factor (μ)	1 / μ*d
				27.04.2004	0	0,10611535	0	0		
	d= 0.01137	0.06960	$3,80.10^{-3}$	28.04.2004	24	0,10669053	$5,75.10^{-4}$	$23,96.10^{-6}$		
				29.04.2004	24	0,10711226	$4,22.10^{-4}$	$17,58.10^{-6}$		
				30.04.2004	24	0,10741133	$2,99.10^{-4}$	$12,46.10^{-6}$		
				02.05.2004	48	0,10808952	$6,78.10^{-4}$	$14,13.10^{-6}$		
G1				03.05.2004	24	0,10847322	$3,84.10^{-4}$	$16,00.10^{-6}$	18	4,89
				04.05.2004	24	0,10886101	$3,88.10^{-4}$	$16,17.10^{-6}$		
				05.05.2004	24	0,10920959	$3,49.10^{-4}$	$14,54.10^{-6}$		
				06.05.2004	24	0,10962318	$4,14.10^{-4}$	$17,25.10^{-6}$		
				07.05.2004	24	0,10999859	$3,75.10^{-4}$	$15,63.10^{-6}$		
				10.05.2004	72	0,10999921	$10,00.10^{-4}$	$13,89.10^{-6}$		
				27.04.2004	0	0,10641432	0	0		
	d= 0.01218	0.07060	$3,91.10^{-3}$	28.04.2004	24	0,10692752	$5,13.10^{-4}$	$21,38.10^{-6}$		
				29.04.2004	24	0,10738312	$4,56.10^{-4}$	$19,00.10^{-6}$		
				30.04.2004	24	0,10771101	$3,28.10^{-4}$	$13,67.10^{-6}$		
				02.05.2004	48	0,10846637	$7,55.10^{-4}$	$15,73.10^{-6}$		
D1				03.05.2004	24	0,10889201	$4,26.10^{-4}$	$17,75.10^{-6}$		
				04.05.2004	24	0,10931364	$4,22.10^{-4}$	$17,58.10^{-6}$	16	5,13
				05.05.2004	24	0,10969011	$3,76.10^{-4}$	$15,67.10^{-6}$		
				06.05.2004	24	0,11013146	$4,41.10^{-4}$	$18,38.10^{-6}$		
				07.05.2004	24	0,11053827	$4,07.10^{-4}$	$16,96.10^{-6}$		
				10.05.2004	72	0,11162201	$10,84.10^{-4}$	$15,06.10^{-6}$		
				27.04.2004	0	0,10287144	0	0		
	d= 0.01043	0.07171	$4,04.10^{-3}$	28.04.2004	24	0,10340338	$5,32.10^{-4}$	$22,17.10^{-6}$		
				29.04.2004	24	0,10388227	$4,79.10^{-4}$	$19,96.10^{-6}$		
				30.04.2004	24	0,10422566	$3,43.10^{-4}$	$14,29.10^{-6}$		
				02.05.2004	48	0,10502938	$8,04.10^{-4}$	$16,75.10^{-6}$		
				03.05.2004	24	0,10547517	$4,46.10^{-4}$	$18,58.10^{-6}$		
				04.05.2004	24	0,10592834	$4,53.10^{-4}$	$18,88.10^{-6}$	18	5,33
K1				05.05.2004	24	0,10633344	$4,05.10^{-4}$	$16,88.10^{-6}$		
				06.05.2004	24	0,10680141	$4,68.10^{-4}$	$19,50.10^{-6}$		
				07.05.2004	24	0,10723465	$4,33.10^{-4}$	$18,04.10^{-6}$		
				10.05.2004	72	0,10838351	$11,49.10^{-4}$	$15,96.10^{-6}$		

4.6. Pressure Resistance

This experiment carried out to measure the pressure resistance of the sample was carried out according to TS 2514 standard (Figure 18) [16][20]. Pressure resistances of two samples of the D1 sample cut as quadrangular prism were calculated and averaged. According to the experiment result, pressure resistance of D1-1 sample is as 60.32 kgf/cm² , as 32.22 kgf/cm² for D1-2 sample and 46.27kgf/cm² as average of D1-1 and D1-2 samples (Table 5).

Table 5. Pressure Resistance Test Results

Sample	Dimensions (cm)	P_{max} Breaking load (kgf)	A Pressure applied area of the sample (cm^2)	σ_k Pressure resistance of the sample (kgf/cm^2)
D1-1	2.58*2.89*5.15	450	7.46	60,32
D1-2	2.23*3.62*5.76	260	8.07	32,22
D1-average				46,27

Figure 18. Pressure Test

5. CONCLUSION

Knowing characteristics of the material used in the building is important that the building is healthy and has a long life. Additionally, trying to develop these characteristics by well examining, affects health and comfort conditions of the people living in the building. For this purpose, in the current study, clay bound plaster samples applied to the mud-wall were examined by performing physical and mechanical experiments and the following results were obtained:

As unit weight and composite (fill ratio) increase in building materials, properties such as strength and thermal conductivity increase. As porosity (void ratio) increases, strength and thermal conductivity properties decrease. According to the results obtained from the experiment, the percentage of porosity of all three samples is more than the percentage of the composite. This shows that the material is porous.

When the water absorption of the materials by capillarity is measured, the sample should not be disintegrated before 45 minutes according to TS 2514. In the experiment carried out, these were observed that, G1 sample was disintegrated at 169th minute, K1 sample was disintegrated at 121st minute and D1 sample was not disintegrated within the Experiment period of 2 hours 49 minutes. The samples were not disintegrated before 45 minutes shows that disintegration depending on water absorption is less.

When the time-dependent water absorption of the materials is measured, the water amounts absorbed from the glass tube with a diameter of 1.4 mm were measured as follows; 3.6 cm for D1 sample, 2.1 cm for G3 sample, 4.4cm for K3 sample. It's seen that the sample taken from the south facade of the building absorbs less water compared to other samples taken from other facades.

According to TS 7847, the water vapor permeability value (1/µ.d) must be at least 0,5m-1. According to the experiment result carried out, because vapor permeability values of the samples are D1- 5,13 m- 1, G1-4,89 m-1, K1-5,33m-1, it was seen that it complies with the TS standard. It's important that the vapor permeability is at the proper value in terms of fulfilling the performance related to heat and moisture expected from the material.

When the sample is subjected to the pressure strength experiment according to TS 25142, the minimum pressure strength must be not less than 8 kgf/cm2 and the average of measurements must be not less than 10 kgf/cm² . According to the experiment result, pressure resistances were measured as follows; 60.32 kgf/cm²for D1-1 sample, 32.22 kgf/cm² for D1-2 sample and 46.27 kgf/cm² as average. The sample is at an appropriate pressure strength according to TS 2514. It's seen that the plaster material used on the building's wall can withstand the effects of incoming forces.

REFERENCES

[1] Özçelik, N., 1984. İnşaat Bilgisi, İstanbul, İ.Ü. Orman Fakültesi Yayınları.

[2] Koçu N., 2012. Sürdürülebilir Malzeme Bağlamında "Kerpiç" ve Çatı- Cephe Uygulamaları (Konya-Çavuş Kasabası Örneği), 6. Ulusal Çatı & Cephe Sempozyumu 12 – 13 Nisan 2012 Uludağ Üniversitesi Mühendislik ve Mimarlık Fakültesi - Görükle Kampüsü, Bursa.

[3] Gürdal, E. ve Acun, S., 2003. Yenilenebilir bir malzeme: Kerpiç ve Alçılı Kerpiç, Türkiye Mühendislik Haberleri, Sayı 427 – 2003/5.

[4] Türkçü, Ç., 2000. Yapım, İstanbul, Birsen Yayınevi.

[5] Kafesçioğlu, R.,1980. "Yapı Malzemesi Olarak Kerpiçin Alçı İle Stabilizasyonu", Türkiye Bilimsel ve Teknik Araştırma Kurumu Mühendislik Araştırma Gurubu Proje No: 505, İstanbul.

[6] Akman, A., 1995. "Kerpicin Araştırılması ve Niteliklerinin Geliştirilmesi Üzerine", Yapı Dergisi Sayı 169, Yapı Endüstri Merkezi.

[7] Işık, B., 1995. "Alçı Katkılı Kerpiç Yapı Malzemesine Uygun Mekanize İnşaat Teknolojisinin ve standartlarının Belirlenmesi", İNTAG TOKİ 622.

[8] Eriç, M.,1994. "Yapı Fiziği Ve Malzemesi", Literatür Yayıncılık, İstanbul.

[9] Gürdal, E., Koçu, N., 1993. "Kerpiç Ve Kerpiçte Eskime Ve Yenileme Sorunları Konya Alaaddin Köşkü Örneği",Yapı Dergisi Sayı 142, Yapı Endüstri Merkezi.

[10] Tanrıverdi,C., 1984. "Alçılı Kerpiçin Üretim Olanaklarının Araştırılması", Yüksek Lisans Tezi, İstanbul Teknik Üniversitesi.

[11] Ersoy, H.Y., 2001. "Kompozit Malzeme", Literatür Yayıncılık, İstanbul.

[12] Sönmez, N., 1955. "Zirai Yapı Malzemesi Olan Kerpiçin Özelikleri Üzerinde Araştırmalar", A.Ü. Ziraat Fakültesi Yayınları, No:71, Ankara

[13] Houben, H., Guillaud, H.,1994. "Eart Construction, A Comprehensive Guide", İntermediate Technology Publication.

[14] TS 1262, 1988. Sıva Yapım Kuralları- Bina İç yüzeylerinde Kullanılan, TSE, Ankara.

[15] TS 130, 1978. Agrega karışımlarının elek analizi deneyi için metot, TSE, Ankara.

[16] Ergin Oruç, Ş., 2004. "Kerpiç Duvarlara Uygulanan Kil Bağlayıcılı Dış Sıva Hasarlarının İrdelenmesi", Yüksek Lisans Tezi, Dicle Üniversitesi Fen Bilimleri Enstitüsü, Diyarbakır.

[17] TS EN 1936, 2001. Doğal Taşlar- Deney Metotları- Gerçek Yoğunluk, Görünür Yoğunluk, Toplam ve Açık Gözeneklilik Tayini, TSE, Ankara.

[18] TS EN 1925, 2000. Doğal Taşlar- Deney Metotları- Kılcal Etkiye Bağlı Su Emme Katsayısının Tayini, TSE, Ankara.

[19] TS 7847, 1990. Hazır Sıva – Dış Cepheler İçin, Sentetik Emülsiyon Esaslı, TSE, Ankara.

[20] TS 2514, 1977. Kerpiç Bloklar ve Yapım Kuralları , TSE, Ankara.
[21] Toydemir, N.,Gürdal, E., Tanaçan, L., 2000. "Yapı Elemanları Tasarımında Malzeme", Literatür Yayıncılık, İstanbul.
[22] Kömürcüoğlu, E.A.,1962. "Yapı Malzemesi Olarak Kerpiç Ve Kerpiç İnşaat Sistemleri", İstanbul Teknik Üniversitesi, Mimarlık Fakültesi.
[23] Kocataşkın, F., 2000. "Yapı Malzemesi Bilimi", Birsen Yayınevi, İstanbul.
[24] Eryıldız, D.I., Başkaya, A., 2000. "Saman Balyası ile yapılanma: Kırıkkale-Hasandere'de Bir Prototipin Yapımı",Gazi Üniversitesi Müh. - Mim. Fak. Dergisi, Cilt 15, No:2, 87-104, Gazi Üniversitesi.
[25] Kafesçioğlu, R., Gürdal, E.,1985. Çağdaş Yapı Malzemesi, Alker, İTÜ, ss. 40, İstanbul.
[26] Jinnai, H., Tanimizu, J., Eruzun, C. (Ed), 1990. Process Architecture 93 Turkey: Pilgrimage to cities, Tokyo.
[27] Damluji, S., 1999. A Yemen Reality- architecture sculptured in mud and stone, Garnet Publishing Limited, Reading, UK.
[28] Bardou, P., Arzoumanian, V., 1987. Archi de Terre, Parenthèses.

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