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The Engineering Properties of Traditional and Fibre Reinforced Mud Brick

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ABSTRACT

In this study aim to investigate traditional mud brick has been used in South of Turkey. The population in the rural area of Turkey has been increased due to back to village project of Government. Most of the buildings in the area made out of limestone and adobe. But this material is not sufficient resistance for the earthquake. The research in the field of contraction at The University of Cukurova elaborates the mechanical properties and workability of raw materials. These are wheat the stem, basaltic pumice and clay. The production of this kind of bricks from mixes of waste from field of wheat and significant fraction of different ratios and clay mixed with fibber, gypsum and basaltic pumice.

In present study, mechanical properties of mud bricks, which were prepared by Seyhan, Almanpinari and Toprakkale (southern region of Turkey) clay with straw and plastic fibre were investigated. Compressive strength, tensile modulus of elasticity, water absorption capacity and weight loss of clay from three different regions were measured. Water absorption and weight loss properties should be taken into account if clay from these regions region is used as raw materials in brick production because they will affect drying time. Clay with higher tensile modulus of elasticity had higher workability when placing mud into moulds. Bricks made with plastic fibre and clay from Seyhan region had the highest compressive strength. The compressive strength of bricks with clay from all regions and with/without fibres had the compressive strength above the values given in standards. Polystyrene fibres led to higher compressive strength in all bricks from three regions compared to other types of fibre. The results of this study suggests that using these materials have many advantages, as little cost and improvements on the final properties of products.

Keywords: Head poses Traditional mud brick, fibre reinforced mud brick, clay

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INTRODUCTION

In the field of computer vision, facial feature detection is an essential step to implement face recognition system. Facial features detection methods are classified as geometric based, appearance based, statistic based, colour segmentation based and template match based methods. Most previous studies related to facial feature detection focus on eye detection as the first phase of extracting the detailed information that is needed [1-2]. The main advantages of templates match based methods over others are, it does not require negative training examples or facial feature points. Creating eye template from face images requires only cropping eye images and then calculating a correlation value between the eye template and all parts of face images. Templates match based methods are also well suited for both high and low-resolution face images [3].

Earth has been used in the construction of shelters for thousands of years, and approximately 30% of the world's present population still live in earth dwellings [1]. A large quantity of energy is consumed to manufacture fired bricks and cement for building industry. This generates a large quantity of greenhouse gas to the environment. Earth is a cheap, environmentally friendly and abundantly available building material. It has been used extensively for wall construction around the World, typically in developing countries. Mud structures are able to perform satisfactorily under some environmental conditions [2-3]. Home brick makers may need to experiment to find the right balance of ingredients. The consistency of the brick mixture should be optimal. With the utilisation of waste materials high ecological construction products can be manufactured due to the consequent saving in raw material (not opening of new mineral deposits) with an economic saving in production costs which give rise to some excellent properties according to European standards [4].

There is general exodus of rural population to the cities with the rapid industrialisation in developing countries. The infrastructure to support these cities, such as building for housing and industry, mass transit for moving people and goods, and facilities for handling water and sewage will require large amounts of construction materials. Enchanted construction activities, shortage of conventional building materials and abundantly available industrial wastes have promoted the development of new building materials [5].

Laterite and lateritic soils are commonly found in Cameroon, on nearly 67% of the national territory. They are used as building materials for the construction of roads and houses. For the construction of walls, mud and brick widely used according to economic factors. The climatic conditions cause damage to mud which is air dried and unsterilized. Brick are however, resistant materials. Their production needs considerable consumption of firewood which the manufactures use to raise the temperature in traditional furnaces during firing higher than 900^0C according to the standard of developed countries. 30% of the cost of production of these bricks is ascribed to energy, so final products are costly [6]. Many researchers have been dealing with the usability of waste in various industries, i.e., ceramic, cement and brick results have been promising [7-8].

Housing is great problem in today's World. In Turkey, many houses are built on one floor. The most basic building material for contraction of houses is the usual burnt clay brick. Continuous removal of topsoil, in producing conventional bricks, creates environmental problems. In Osmaniye-Adana, a huge quantity of wheat stem waste is produced every summer. These many times causes important problem. Because, farmers fired this material and got the ecological problems. Instead of firing this stuff it can be used in brick production. Background Soil is a common building material and people have been making use of it for a long time. Most bricks are made of clay. Concrete contains sand and pebbles and cement is mostly sand. Recently mud brick has become a popular and very attractive way of building houses.

In Osmaniye, Cukurova region of Turkey, traditional mud brick has been used in the construction of shelters. They have many advantages but generally concrete briquette has replaced the mud brick. However, the cost of the briquette structure is very high but they also don't have advantages in terms of heat and sound insulation. In spite of many earthquakes, from about 100 years these constructions still serve. However, on June 27, 1998 at 16.55 local time, a strong earthquake of magnitude mb=5,9 resp. Mw=6,3 shook southern Turkey. The epicentre was located between the cities of Adana and Ceyhan about 30 km north of the coast of the Mediterranean Sea. About 150 people were killed, 1500 were injured and many thousands were made homeless. Most of the observed damage occurred in traditional rural buildings, but many new multi-story residential buildings and industrial buildings also suffered heavy damage or even collapsed [9].

In this research, in the rural areas of Osmaniye production and construction techniques, used in the rural areas of Osmaniye, are investigated with this aim, many qualifications of these structures are examined carefully. In this study, clay from regions of Seyhan, Almanpınarı and Toprakkale were used to in mud brick productions. Mechanical properties of clay specimens with and without different kinds of fibres were determined. Then, mechanical properties of clay with and without fibres were compared.

MATERIAL AND METHODS

Materials

In this study, clay as main matrix; gypsum as stabilizers; straw and plastic fibres as fibrous materials and water were used as materials for fibre reinforced mud brick production. Clay is found in nature as coloured with metal oxides and organic materials. When it is pure, its colour is white. Impure clay colour can be yellow, pink, reddish, maroon, bluish, green and blackish. Clay used in this study was obtained from three regions, Seyhan, Almanpinari and Toprakkale, in province of Adana and Osmaniye, Turkey. Colour of Seyhan, Alamanpinari and Toprakkale clay was given as straw coloured, chartreuse and red, respectively. A chemical property of clay and gypsum was given in Table 1.

Table -1 The Chemical Contents of Materials Used

Materials	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_4	K_2O	SO_3	Crystal water	LI
Seyhan clay	52.40	25.12	7.95	1.42	2.45	0.64	4.27	-	-	3.6
Almanpınari clay	51.16	24.47	6.36	1.25	3.54	0.45	4.66	-	-	4.7
Toprakkale clay	49.44	24.82	7.23	1.14	3.78	0.79	4.74	-	-	3.8
Gypsum	5.2	-	0.7	12.6	1.3	-	-	42.8	19.4	16.1
Basaltic pumice	43.9	14.3	12.5	9.3	7.6	-	3.11	-	-	4.11

Mainly, reinforced earth is a composite material consisting of alternating layers of compacted backfill and man-made reinforcing material [10]. So, the primary purpose of reinforcing soil mass is to improve its stability, to increase its bearing capacity, and to reduce settlements and lateral deformation [11–14]. The materials used in this study for fibre reinforced mud brick production were clay as main matrix; basaltic pumice and gypsum as stabilisers; straw and plastic fibres as fibrous materials and water as lubricant. The particle size analysis of the basaltic pumice and clay was made

and the corresponding grading cure was obtained (see Fig. 1). The other materials mentioned in Table 2 were added to the mixture with the proportions given in Table 3, to obtain three different specimen groups, and mixed thoroughly in dry state. Water was added and the ingredients were further mixed thoroughly by kneading until the mass attained homogeny consistency.

Methods

Three groups of samples with clay from three regions with and without fibres were prepared to determine density, water absorption capacity, weight loss, compressive strength and tensile modulus of elasticity. Types of fibres were selected as straws and plastic fibres. Clays was dried at 120^{o}C for 24 hours. Then, clay was mixed with water and kept in 50% humid laboratory condition for 24 hours. Cubic specimens with dimensions of 15 cm x 15 cm x 15 cm for 30 days compressive strength tests and cylindrical specimens with dimensions of 4 cm x 10 cm for tensile strength tests were prepared. Clay with fibers was prepared by placing the fibers in three layers in steel moulds. A thin horizontal layer of straw, plastic fibres and polystyrene fabric was placed at 1/3 and 2/3 heights as shown in Fig. 2. After being filled in the foregoing manner, the moulds were properly compacted on a vibration table. The mud bricks were taken out from the moulds, covered with wet gunny bags and allowed to cure for a week. Then they were tested for compressive strength after 3 and 7 days of casting. Samples prepared with clay and gypsum was used as control specimens. Properties of clay with fibres were given in Table 2. Fibres used in this study and preparation of mud were shown in Fig. 3 and Fig. 4, respectively.

Table -2 The Properties of Mud Brick Mix

Mix type	Components (kg)				
	Clay	Gypsum	Fibre plastic	Straw	Water
Seyhan control	78	2	-	-	20
Seyhan plastic fiber	78	2	0.01	-	20
Seyhan straw	78	2	-	0.05	20
Almanpınarı control	78	2	-	-	20
Almanpınarı plastic fiber	78	2	0.01		20
Almanpınarı straw	78	2	-	0.05	20
Toprakkale control	78	2	-	-	20
Toprakkale plastic fiber	78	2	0.01	-	20
Toprakkale straw	78	2	-	0.05	20
Traditional mud brick	78	-	-	0.05	20

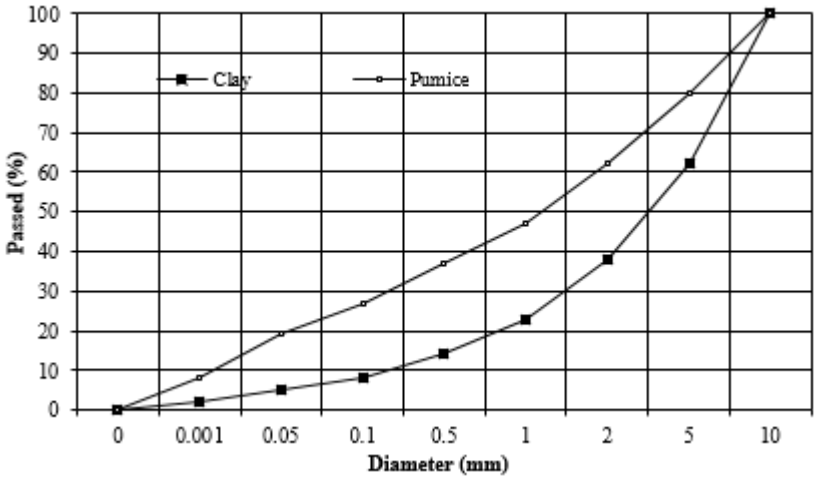


Fig. 1 Grading curves of clay and basaltic pumice used

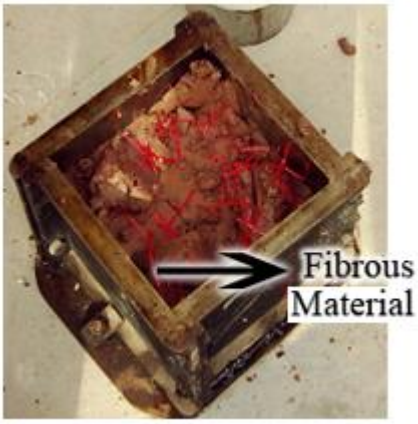


Fig. 2 The placing fibres used

Fig. 3The fibres used in mud brick production

Fig. 4 The knead of mud

RESULTS AND DISCUSSION

Mechanical Properties of Clay Specimens

Density, water absorption capacity, weight loss percentage and compressive strength of clay from three regions were given in Table -3.

Tensile Modulus of Elasticity of Clay Specimens

It was shown that clay should have adequate tensile modulus of elasticity in mud brick production. Clay with higher tensile modulus of elasticity had higher workability when placing mud into moulds. Tensile modules of elasticity of clay from three regions were determined by a pulling test. In this test, cylindrical clay specimens were placed between two cylindrical clamps as shown in Fig. 5 and then prepared specimen was pulled in test machine at a loading rate of 200gr/s as shown in Fig. 6. Load-deformation curve of specimens were determined at 2 days as shown in Fig. s 7, 8 [15]. As seen in Fig. 6, clay from Almanpinari and Toprakkale region had higher tensile modulus of elasticity with respect to clay from Seyhan region. However, clay from Almanpinari and Toprakkale region were ruptured at load of 4.4 and 4.6 kg, respectively, whereas clay from Seyhan region was ruptured at 4.8 kg.

Table -3 The Mechanical Properties of Clay Specimens [15]

Clay specimens	Density (kg/m^3)	Water absorption after 24 h (%)	Weight loss after 7 days (%)	Compressive strength (MPa)
Seyhan	1420	25	15	3.5
Almanpınarı	1480	28	20	2.8
Toprakkale	1450	25	21	2.4
Traditional mud bricks clay	1490	31	24	2.3

Fig. 5 Preparation of specimens for experiment

Fig. 6 Test setup for tensile modulus of elasticity of clay

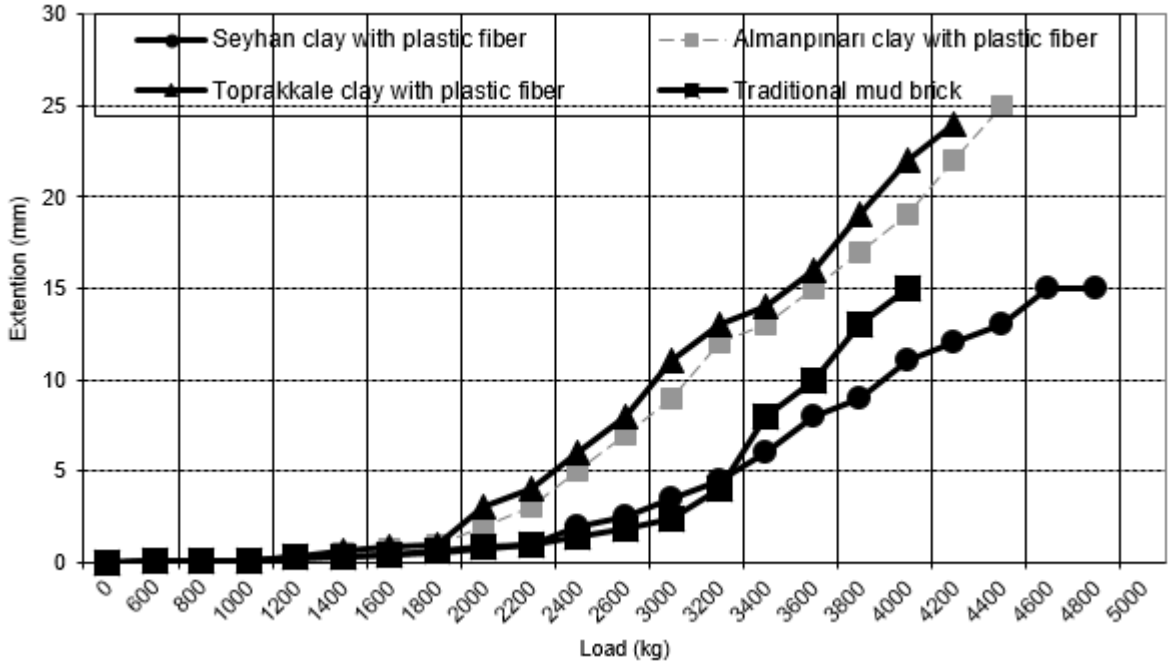


Fig. 7 The obtained results from extension test after two days (200 g/s definite load)

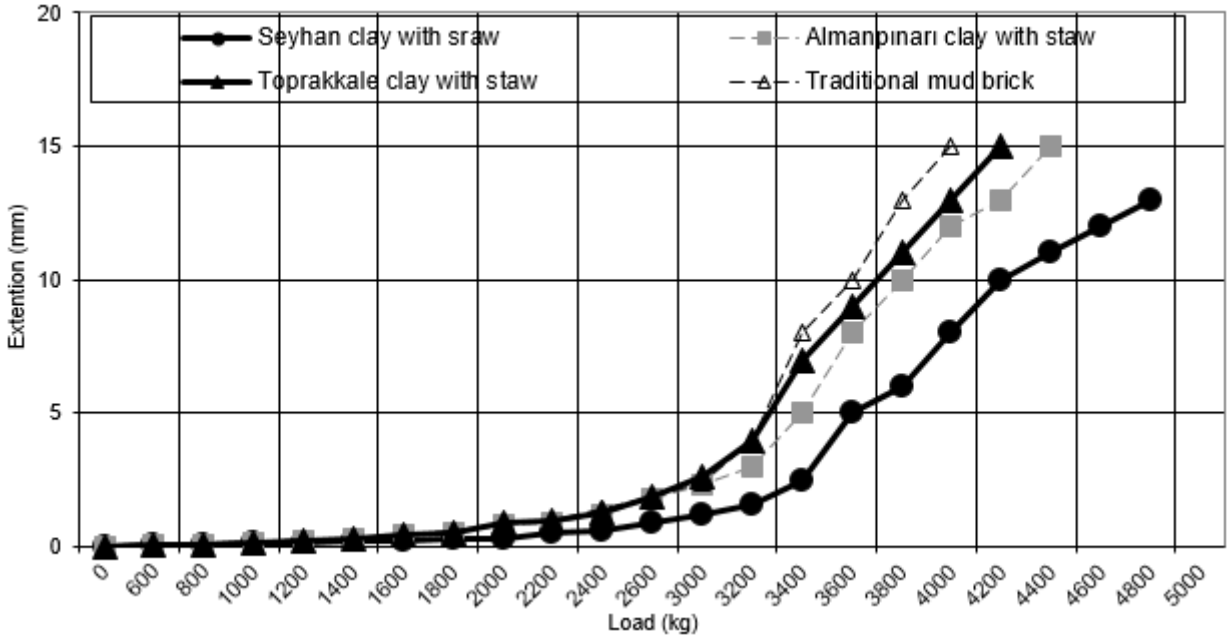


Fig. 8 The obtained results from extension test after two days (200 g/s definite load)

Table -4 The Mechanical Properties of Mud Bricks

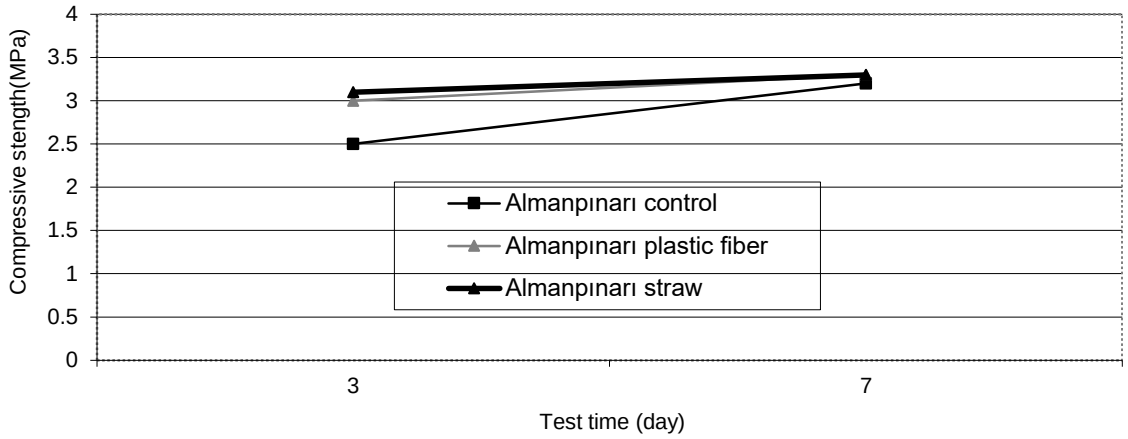
Mix type	Density (kg/m^3)	Water absorption (%)	After 7 days mass loss (%)
Seyhan control	1425	25	13
Seyhan plastic fiber	1415	23	11
Seyhan straw	1415	23	14
Almanpınarı control	1480	28	18
Almanpınarı plastic fiber	1473	25	19
Almanpınarı straw	1472	25	18
Toprakkale control	1455	30	12
Toprakkale plastic fiber	1452	29	20
Toprakkale straw	1452	30	19
Traditional mud bricks	1460	31	21

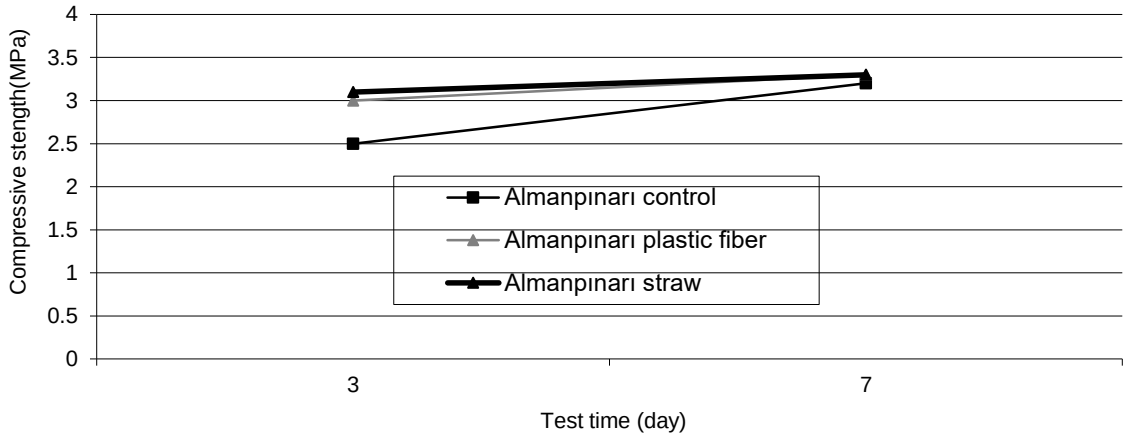
Mechanical Properties of Mud Bricks with Fibres

Mechanical properties and compressive strength of mud bricks with fibres were shown in Table 4 and in Fig. 9, respectively.

Compressive strength of mud brick was given as 0.5-1MPa in Turkish standard. In this study, compressive strength of mud bricks with fibres was determined as 2.2–3.7 MPa. This showed that fibres improved the mechanical properties of mud bricks and width of external walls could be reduced to 30 cm. Gypsum used in mud brick production led to shorter setting time. The shorter setting time also led to adequate strength of mud bricks when they were removed from mouldings. So, no workmanship, time and place for drying process were needed when gypsum was used in the mud production. Also, surface cracks and shape deformations due to non-uniform drying process were eliminated.

Fibres used in mud brick production also led to smooth surface and fixed brick dimensions. These also led to reduction in the thickness of plaster paste and good bonding between the bricks and plaster paste. Thus, spalling off the thick plaster on normal bricks due to light shaking was eliminated by use of fibres in mud brick production. Fibres in mud production were also led to an increase in the compressive strength and tensile modulus of elasticity of mud bricks. This will help to increase the resistance of masonry building to earthquake loadings [16]. Tensile strength of clay in mud bricks was low. Fibres were used to carry tensile stress in mud bricks. Fibres were located longitudinal and transverse directions in mud bricks. In this way, fibres can prevent the deformation and protect the brick structure. Tensile stresses were carried by the bond stresses between the clay and fibres. Fibres was also improved the compressive strength and flexibility of mud bricks because fibres led to high compressibility and decrease void ratio in mud bricks. Under compressive loading, outer layers of mud bricks with clay were spalled off when maximum strain was reached. However, inner layers were to try to expand due to Poisson's effects but fibres prevented this expansion. This led to increase in compressive strength and ductility of mud bricks [17].





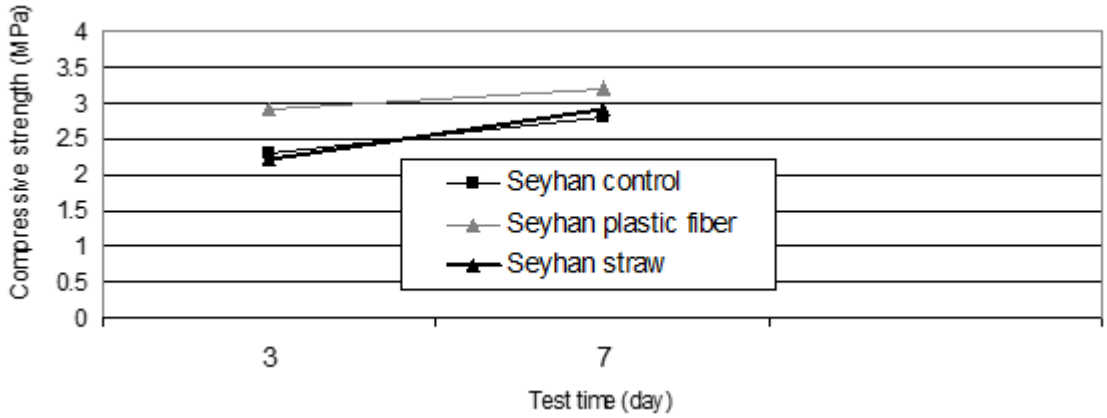


Fig. 9 The compressive strength of mud bricks

Fig. 10 Traditional mud brick house in Osmaniye

Advantages of Traditional Mud Bricks

The mud brick building (Fig.10) is told to be 100 years old and there isn't any deficiency in building. In spite of earthquakes in 1998 (Adana-Ceyhan) and in 2002 (Osmaniye). However, there are many briquette buildings suffering from damage in another village.

This research shows that the mud brick buildings are still alive in spite of many earthquakes and mud brick should be widespread in rural areas [11]. This helps both economical gain and sound thermal insulation. In the last few years briquette structures have been used widely in rural areas. Even though it is easy to use them, they don't provide good quality and they are expensive. It is very good to prevent the usage of briquette in terms of security in the earthquakes and in terms of economic gain. The use of earth construction is well-established in energy efficient housing [18]. There are many aspects to mud brick construction and despite the fact that most of the Osmaniye rural reign's buildings are made of earth and it is one of the oldest known building materials. This construction can be developed new technique and of course there is much about its properties and potential that remains poorly researched. There are many advantages of mud brick houses. The authors [19] reviews important aspects related to earth construction. It addressed economic advantages, non-renewable resource consumption, waste generation, energy consumption, carbon dioxide emissions, toxicity and indoor air quality. For less developed countries the cost-efficiency aspect remains of paramount importance. Zami and Lee [20] quotes several authors for whom ''earth construction is economically beneficial'', nevertheless one cannot take this as a guaranteed truth because the economics of earth construction depends on several aspects such as: construction technique, labour costs, stabilization process, durability, repair needs. Williams et al. [21] mentioned that the materials used in earth construction in UK have not a significant impact in the final cost. These authors state that production and construction costs represent the most important part because earth construction is labour intensive. However, this is not the case in less developed countries in which labour is available for a very low cost.

CONCLUSION

The results obtained in this study were given in the followings.

- Clay with higher tensile modulus of elasticity had higher workability.
- Clay with higher elasticity modulus had higher water absorption capacity and higher weight loss.
- Under tensile strength tests, Almanpinari and Toprakkale clay were ruptured at 4.4 kg whereas Seyhan clay was ruptured at 5 kg.
- Mud bricks with polystyrene fibres had higher compressive strength compared to the other types of fibres. Clay with polystyrene showed better composite action due to the fact that polystyrene fabrics had the smaller thickness compared to plastic fiber and straw, and the length of polystyrene fabric was larger compared to plastic fiber and straw.
- Mud bricks without fibres had the minimum compressive strength.
- Mud bricks produced with polystyrene fibres and clay Seyhan region had the highest compressive strength.

As a result, the results of this study show that the Seyhan, Almanpinari and Toprakkale clay can be used to improve the mechanical properties of mud bricks. Since clay is available in vast amounts in Turkey, it makes sense from the economic and environmental point of view to use these materials in the production of more durable mud bricks.

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