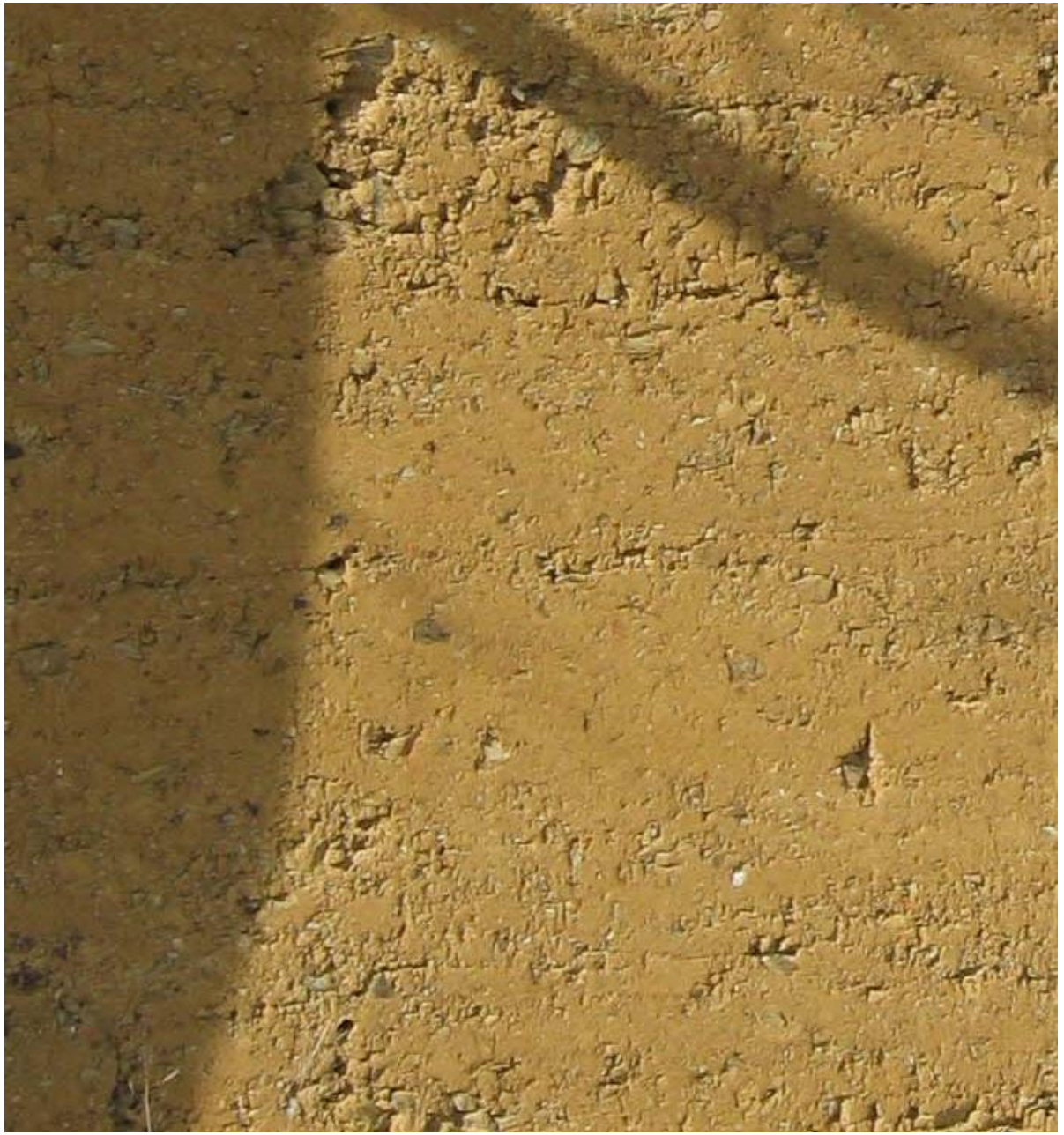
Earthen Buildings and ALKER



Architect Murat Kafescioglu
Architect Phd Figen Kafescioglu

ON BEHALF OF EARTHEN BUILDINGS GROUP

Introduction to Earthen Buildings

Although the technological developments of our time and social changes such as migration to cities have ceized the relationship between man and the land, experts in various fields emphasize the importance of soil for the physical and mental health of human beings.

Earth buildings meet all current needs of the societies from the poorest to the wealthiest at the highest level by using less energy, and without polluting the environment.

Why Earthen Buildings ;

- Provide living comfort at its best with its ability of thermal insulation
- Provide sufficient strength and reliability,
- It is a building material that can be produced in any size of construction site without requiring the establishment of a facility,
- Provide the opportunity to build his own house,
- As the largest and heaviest element of the structure, the naturally dried soil walls provide significant fuel savings during production, construction and use of the structure.
- Provide the opportunity to develop the traditional building tecniques and using the local labor in rural areas.
- Developed ready soil mixtures can be produced in masses and sold in bags in the market and carried to construction sites. This provides a great discount in building cost

1. EARTHEN BUILDINGS FROM PAST TO PRESENT TIMES

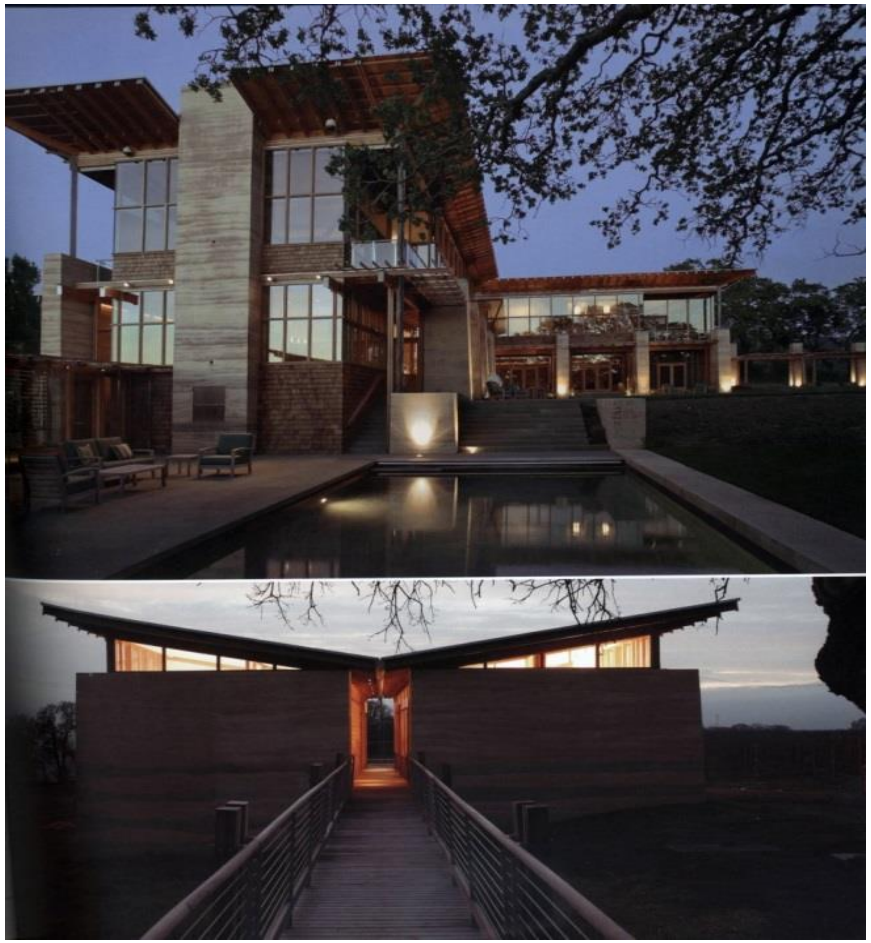
Adobe block walls, Çatalhöyük, 7500 BC

Castle of Hattuşaş *(1800-2OOO BC)*

Earth architecture in Yemen

Housing in Fijian Area-China

House in Scottsdale, Arizona, Jones Studio , Rael R. “EARTH ARCHITECTURE” p. 29, 1997



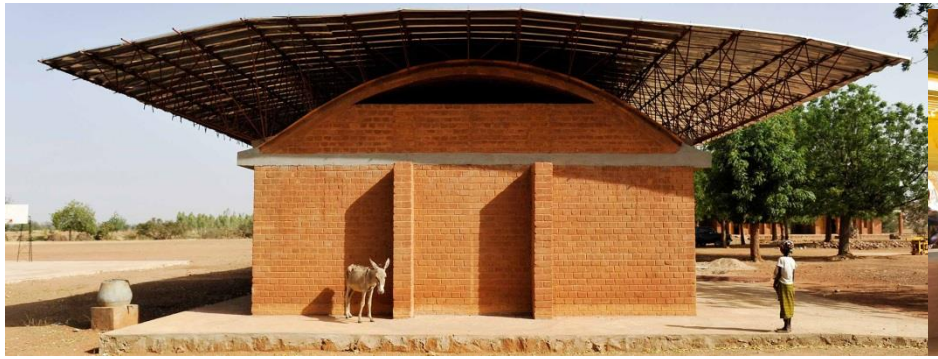
House in Napa Valley, California, 2003, Cuttler Architecture, Rael R. “EARTH ARCHITECTURE”, p. 29, 1997

Horse Farm, Cengiz Bektaş, Polonezköy, İstanbul, 1995

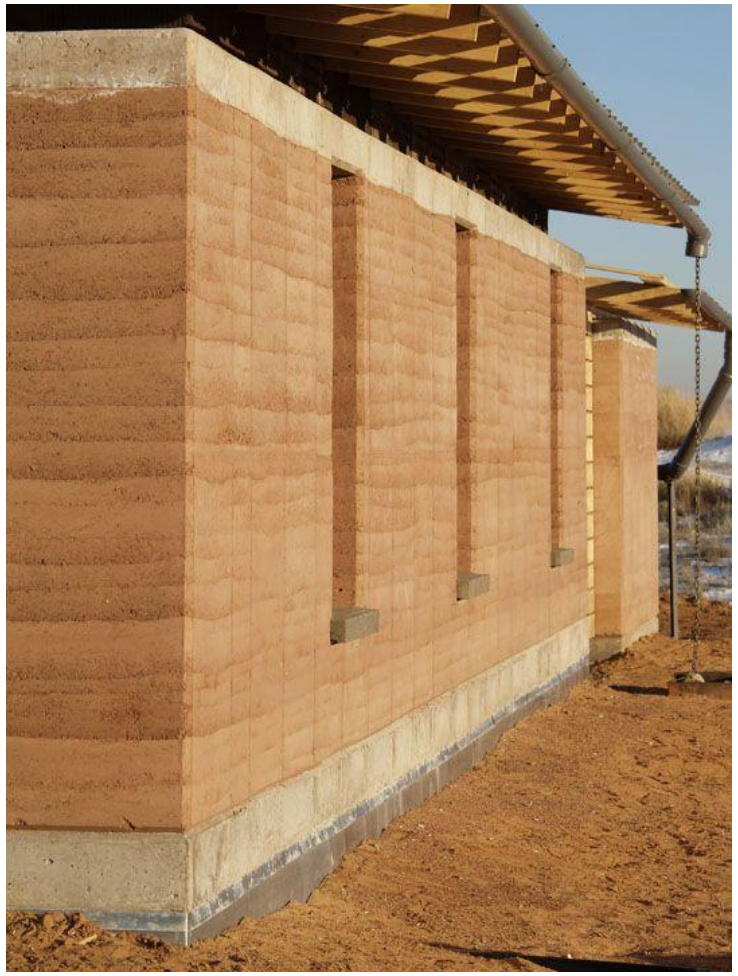
Güre Summer School, Cengiz Bektaş, Balıkesir

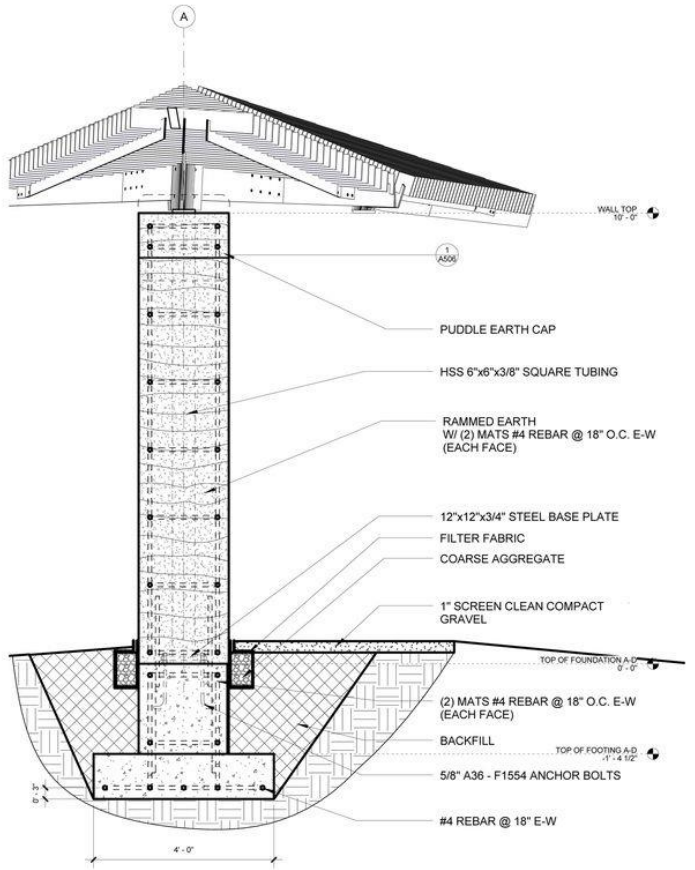
Residential House built with Alker, Prof. Bilge Işık, Altınoluk, Balıkesir, 1999

Rammed earth house, Arizona, USA



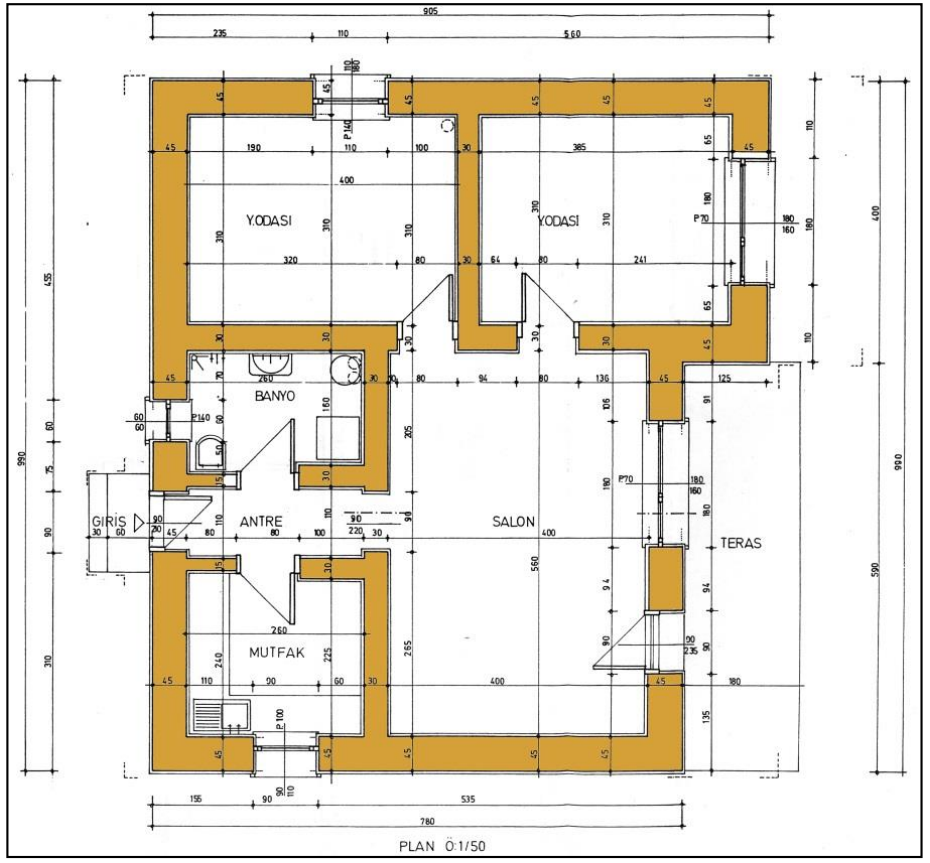
Gando primary school, Francis Kéré, Gando, Burkino Faso





Earthen building wall examples protected from atmospheric effects by eaves or socles.

1st Alker House, a kindergarten, Ayazaga Campus, ITU, 1983



plan

2nd Alker House, ITU, Ayazaga Campus,1995

Photo of the 2nd Alker House after removing the molds, Photo: Bilge Işık

Alker walls

A group of people with low income have realized a community of 20 houses with the organisation of a journalist, traveler with the participation of the local municipality in Viranşehir,Urfa, 2011

The mixture is prepared in the ground and placed in the mold by shovel

Plywood and planks were used as the molds

2. SOIL, ITS FORMATION AND PROPERTIES

- Earth is the top and loose layer of the earth's crust. In the earliest geological periods, the rocks which were shattered by various tectonic events crumbled over time and formed pebbles, sands and soils.
- Afterwards, they were crumbled and mixed with each other, sediments collected in the pits being carried by floods formed sedimentary masses. with various effects such as marble masses. Some of them, such as marble masses have survived and some have been re-broken, and combined with shredded natural cements, forming agglomerates and conglomerates. Some of them crumbled into sands and fine sands, and more crumbled ones turned into silts. In the later periods some of the silts underwent chemical decomposition to form clays.

Clays and Clay Soils

At the end of the development process under various conditions and natural conditions in geological periods, clays of different qualities were formed even from those of the same origin. Therefore, instead of clay types, clay groups are mentioned in the literature. Pebbles and sands in the soil are defined as coarse grains, silt and clays are defined as fine grains. Clays are the smallest of the grains contained in the soil, they are smaller than 2 microns (0.002 mm). A small mass of clay contains a very large number of clay particles. They form a very specific surface area.

Clay Particles attract water particles in humid environment, their surfaces are covered with water film and they gain **cohesion** quality. Clay particles attract and adhere to each other.

The resulting clay mass **adheres** to solid objects, gravel and sand and integrates the mass.

The soil which has 15-20% or more clay in its structure gains the characteristic of clay soil. The amount of water in the body increases, the volume grows. This is called the ratio of water content in the soil.

The integrated soil mass having a certain amount of clay gains the ability of **plasticity** and forming. The desired shape can easily be given to the mass, and the mass remains that way.

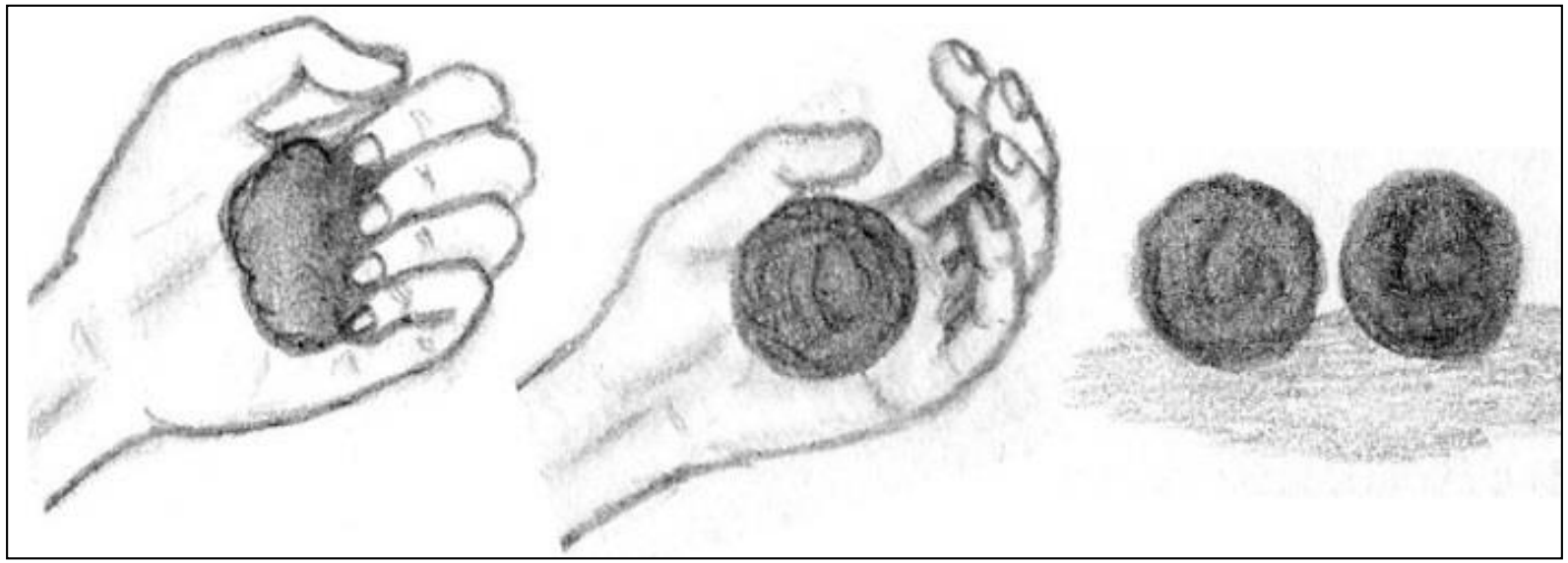
Plasticity (Forming ability):

Soil/ water mixture containing a lot of water loses water during drying process and its volume decreases, and depending on the type and amount of the clay it contains, it turns into soft dough at a certain water content and gains shaping ability. The current water content ratio is defined as the *plastic limit*. As the drying process continues, the volume becomes smaller, the dough solidifies, and it is necessary to use force to shape it. When the water content ratio decreases to a certain level, the grains come into contact with each other and the volume shrinks, the dough becomes semi-solid and loses its shaping ability. The current water content ratio is defined as the *shrinkage limit*. The status between *plastic* and *shrinkage* limits is the *plastic consistency interval* and soil can be shaped in the water content ratios between these two limits.

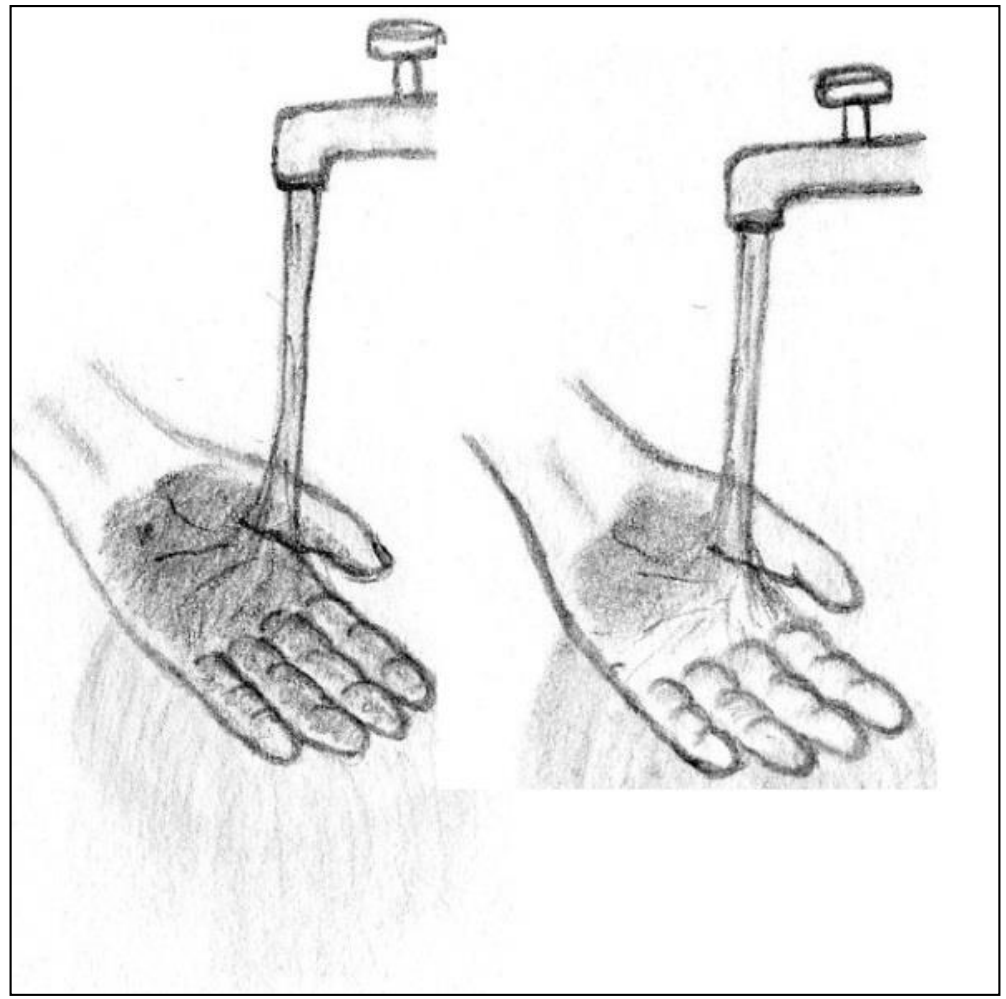
Visual Testes Used to Determine Soils With Cohesion Quality

Among the soil samples separated as ‘building soil’ with **plasticity** and **cohesion** abilities behave positively to the preliminary visual experiments explained below.

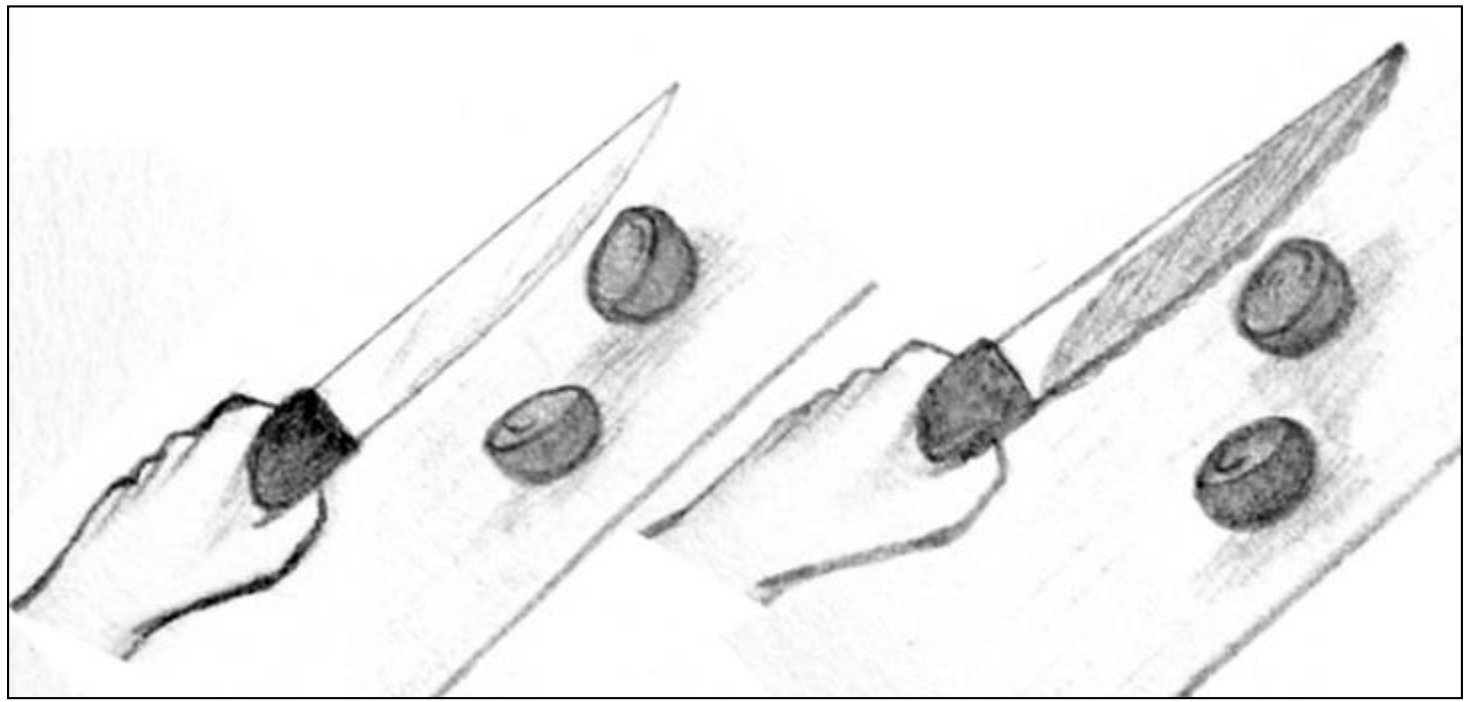
Soil samples are sieved through a 6 mm sieve, the pebbles are separated and the soft dough is kneaded until it becomes consistently smooth. A piece of the prepared sludge is kneaded in the palm and a few balls of 5-6 cm diameter are made and samples are formed for the experiments listed below.



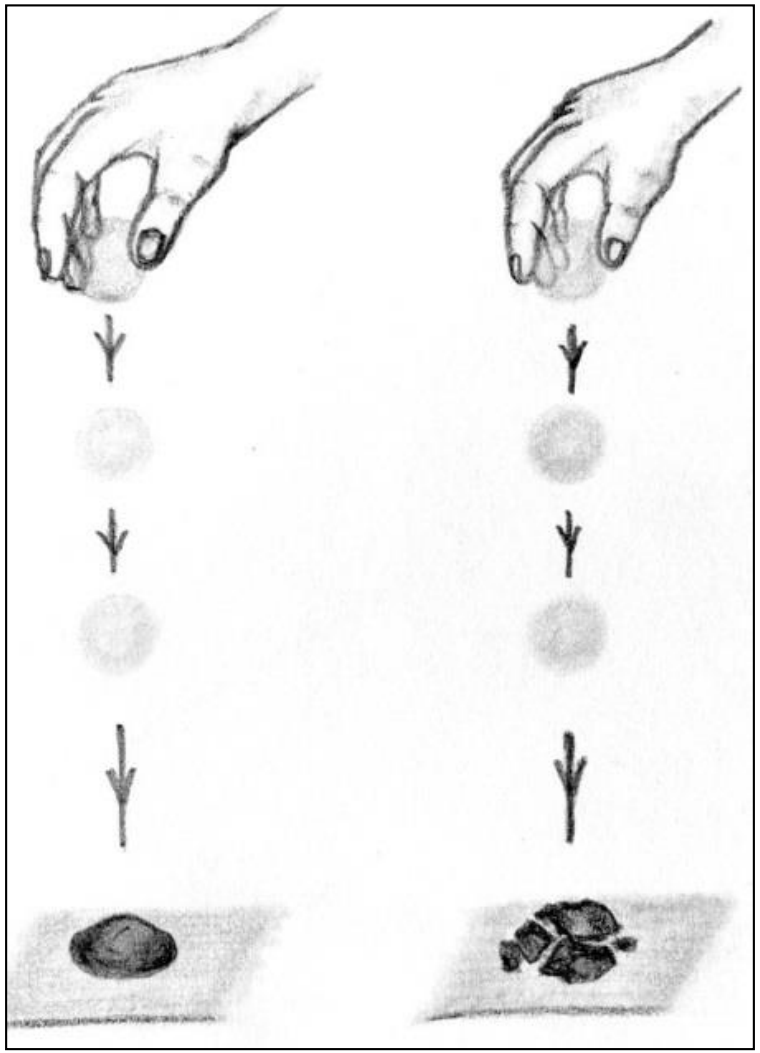
The clay soil easily rolls and the balls remain intact where they are placed.



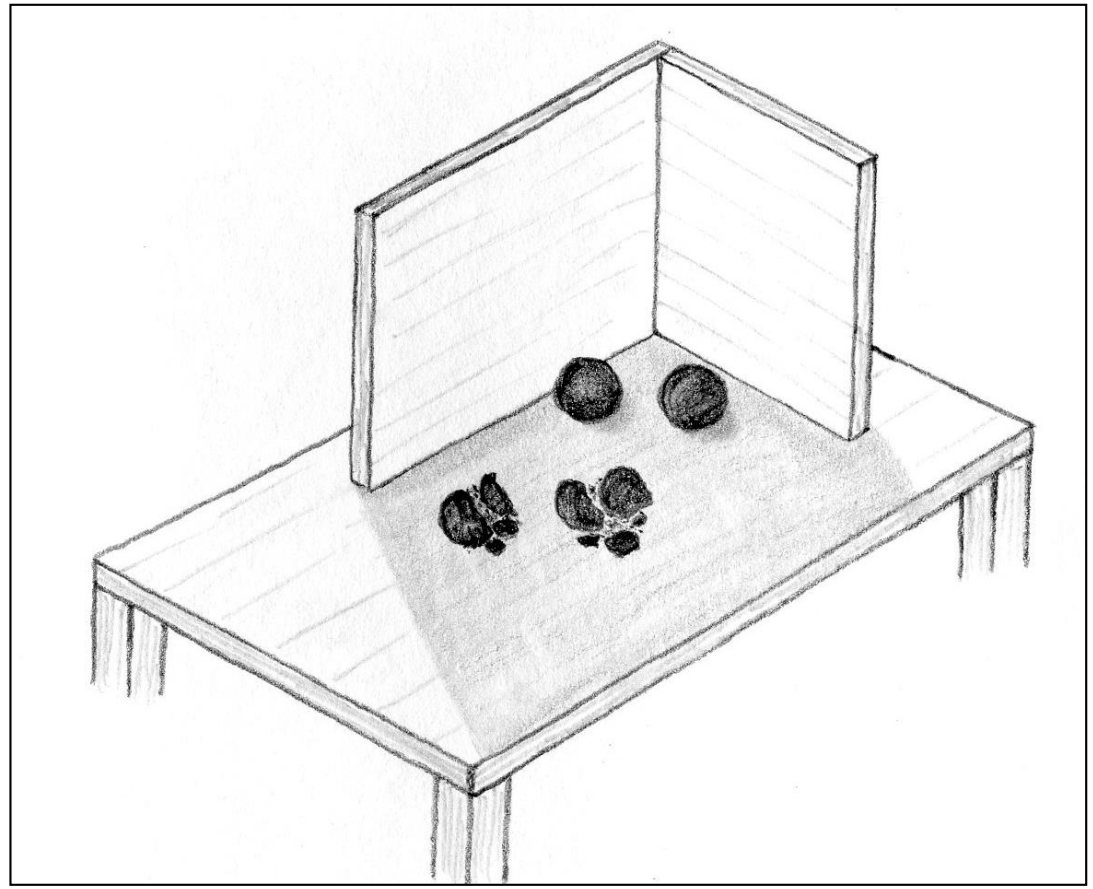
Clay soil contaminated hand is not easily cleaned



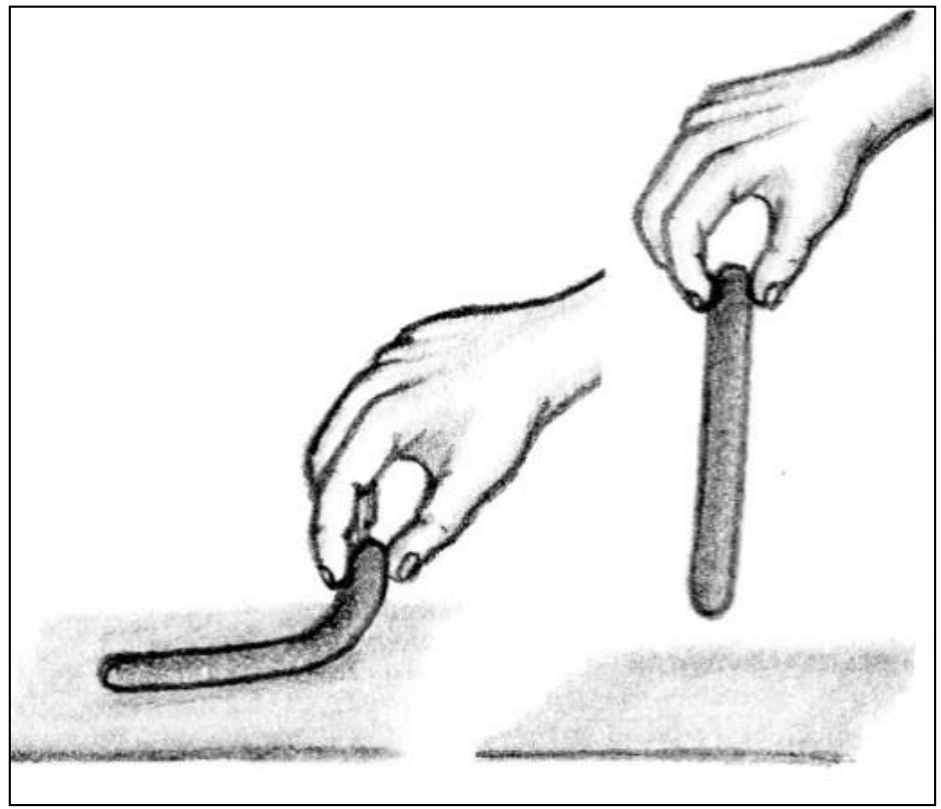
Clay soils the knife while cutting



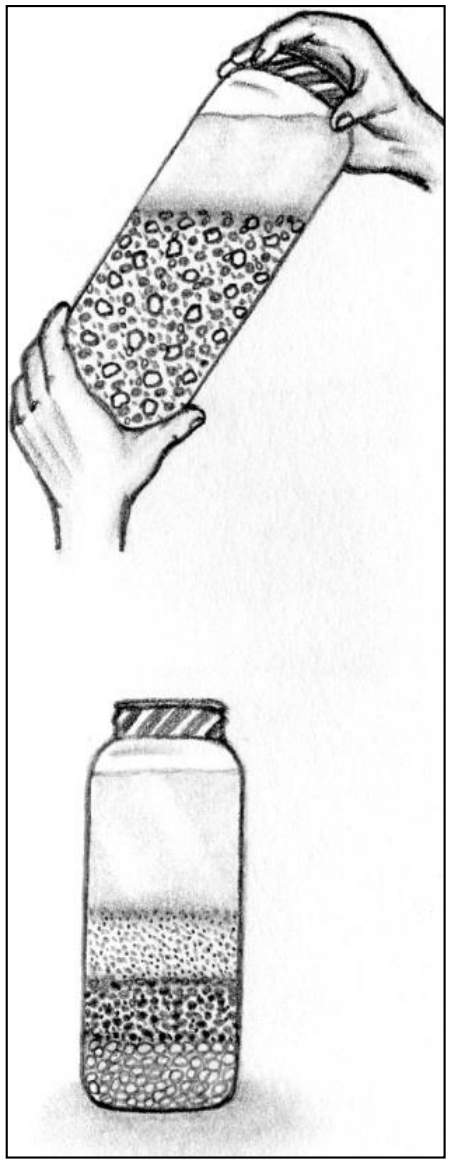
Balls made of clay soil spread to the ground without falling apart and stick to the ground



Balls made of clay soil remain monolith when left to dry in the shade.



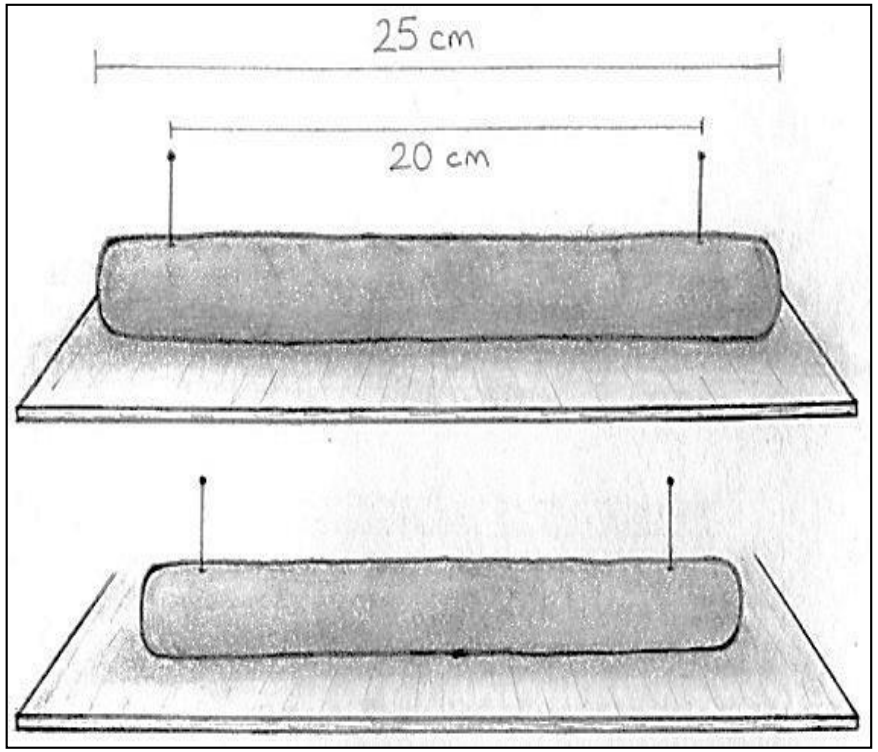
The cylinder made of clay soil can stay as a whole when held



Sedimentation Test

The soil intended to be used is passed through a 20 mm sieve. Half a jar of soil put in a jar and filled with water, shaked well and left still for 1 hour. Gravel, sand and total fine grains (silt + clay) in the soil precipitate to form distinct layers. The ratio of the thickness of the layers to the total of the sediment determines the distribution rates of the elements in the soil. In this experiment, some sand may remain between the gravel and the sand - gravel separation line may not be clear. For a better result, a certain amount of soil is sieved through a 6 mm hole diameter sieve and the pebbles are separated.

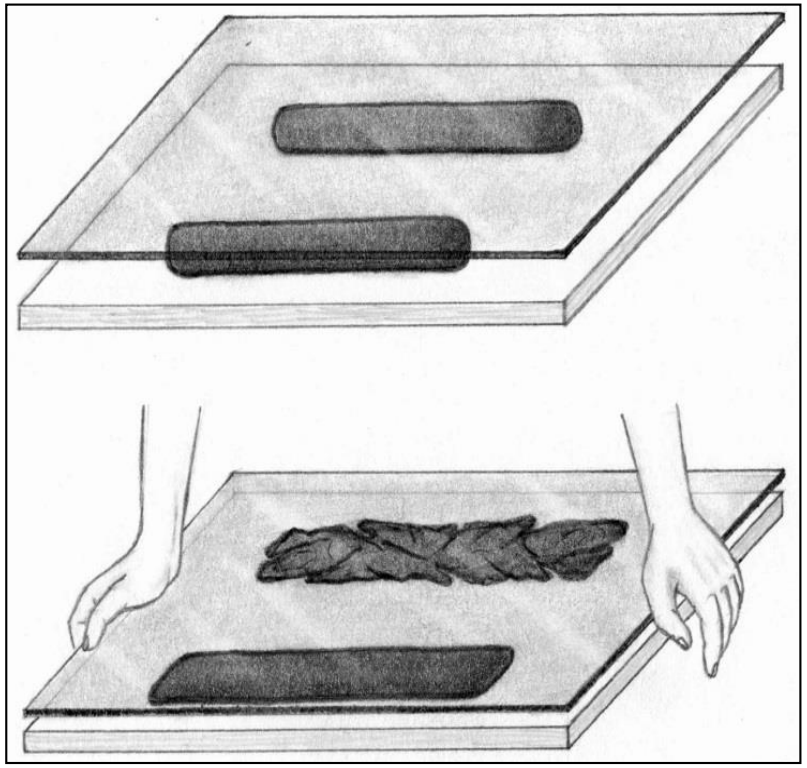
Sand and total fine grain layers remain in the sediment in the jar. The values obtained should be checked against the results of the Wash-Weigh test.
If the observation of the precipitate can be continued for 4 to 5 days, the layers become clearer. The color and contamination of the water above the jar indicates that the soil contains water-soluble organic substances and minerals.



Shrinkage Test

The soil is sieved in a 6 mm sieve and then kneaded into a soft dough consistency. A cylinder of about 3 cm in diameter and 25 cm in length is prepared. Two needles are immersed in 20 cm intervals. The sample is dried in a shady place. The sample must remain intact during drying. It is understood that the amount of clay is less than necessary in the soil where the fragmented samples are taken. After the sample has dried, the needles are measured.

The ratio of the shrinkage to the previous measure gives the linear shrink as a percentage. This ratio should not exceed 10% in suitable soils. If the shrinkage rate is large, it is understood that the amount of clay in the soil is more than necessary. By comparing shrinkage quantities, information on clay content in soils can be obtained.



Plasticity Test

The soil, which is sieved through a 6 mm sieve diameter, is kneaded to a soft dough consistency. Rollers with a diameter of about 3 cm and a length of 20-25 cm are made. It is placed on a hard and smooth table (eg on a glass). It is pressed with a hard plate on the same side until the thickness is 5-6 mm.

Examples which can remain in the form of a whole strip without disintegration are soils having a formable level of plasticity, containing sufficient or more fine grains. Specimens that do not contain enough clay cannot maintain their integrity and disintegrate.

3. ALKER

WHAT IS ALKER ?

Alker is an ecological, soil, building material that provides ease of use in various fields, production, application and technology in order to improve the poor quality, non-earthquake-resistant building stock in the rural area, to ensure the harmony of human beings with nature. It is a physically and mechanically developed naturally dried soil based material which is produced by adding; gypsum, lime to stabilize, water and sometimes a retarding agent to the clayed soil. The ratios of the components vary according to the the type of soil and aim of the building.

The first test for the ability of the soil to be used can be determined by basic try-outs on site as explained above. The soil in an area which is traditionaly used for adobe blocks (kerpiç)* is generally suitable for Alker.

ALKER was developed by Professor Ruhi Kafescioğlu in 1980 in İstanbul Technical University (ITU) as a research project supported by TUBITAK.

* *kerpiç* (Turkish) is the specific name of the building block naturally dried mixture of soil and straw.
adobe (English) is used to explain both *kerpiç* and a general name for earth buildings

Components of ALKER

Soil

The soil used in the preparation of Alker mixture has to be clay soil. . The clay in the soil provides the integrity of the mass by combining the soil grains with its cohesion and adhesion qualities. The grain distribution has to be corrected as needed in most of the other soil based building materials.

Gypsum

The gypsum added to the structure, forms a network of crystal needles that are strong enough to prevent the shrinkage of the clay. The homogenous mixture of gypsum to the mixture is very important. The setting time of natural gypsum begins in 8-10 minutes but it increases to 20 minutes when mixed with soil. The plaster gypsum with 60 minutes of initial setting can be found in the market. Preparation,
transportation, placing into the mold and compaction of soil mixture has to be finished during this time interval.

Slaked lime

When lime combines with clay minerals, it undergoes a structural change and transforms into an insoluble, permanent new structure in time.

Water

City water supplies and streams in nature, which are used in our daily lives without any pollution, can be used in Alker mixture. The dry clay soil with water becomes cohesive by first adhering the clay particles to each other, and then adhering the clay grains to the sand and gravels within the structure, providing the integrity of the mass. Using more water than necessary amount adversely effects the consistency of the structure.

Physical Properties of ALKER

Unit Volume Weight and Specific Gravity

The changes in the grain distribution ratios of the soil are effective in changing the unit volume weight.

unit volume weight

fine grain (clay + silt) ratio in the mixture

As the fine grain (clay + silt) ratio in the soil increases, the unit volume weight also increases for the fine grains fill the gaps between gravel and sand grains.

clay ratio in the mixture
Shrinkage

As the amount of clay in the soil increases, it is seen that unit volume weight and shrinkage increase.

unit volume weight and shrinkage

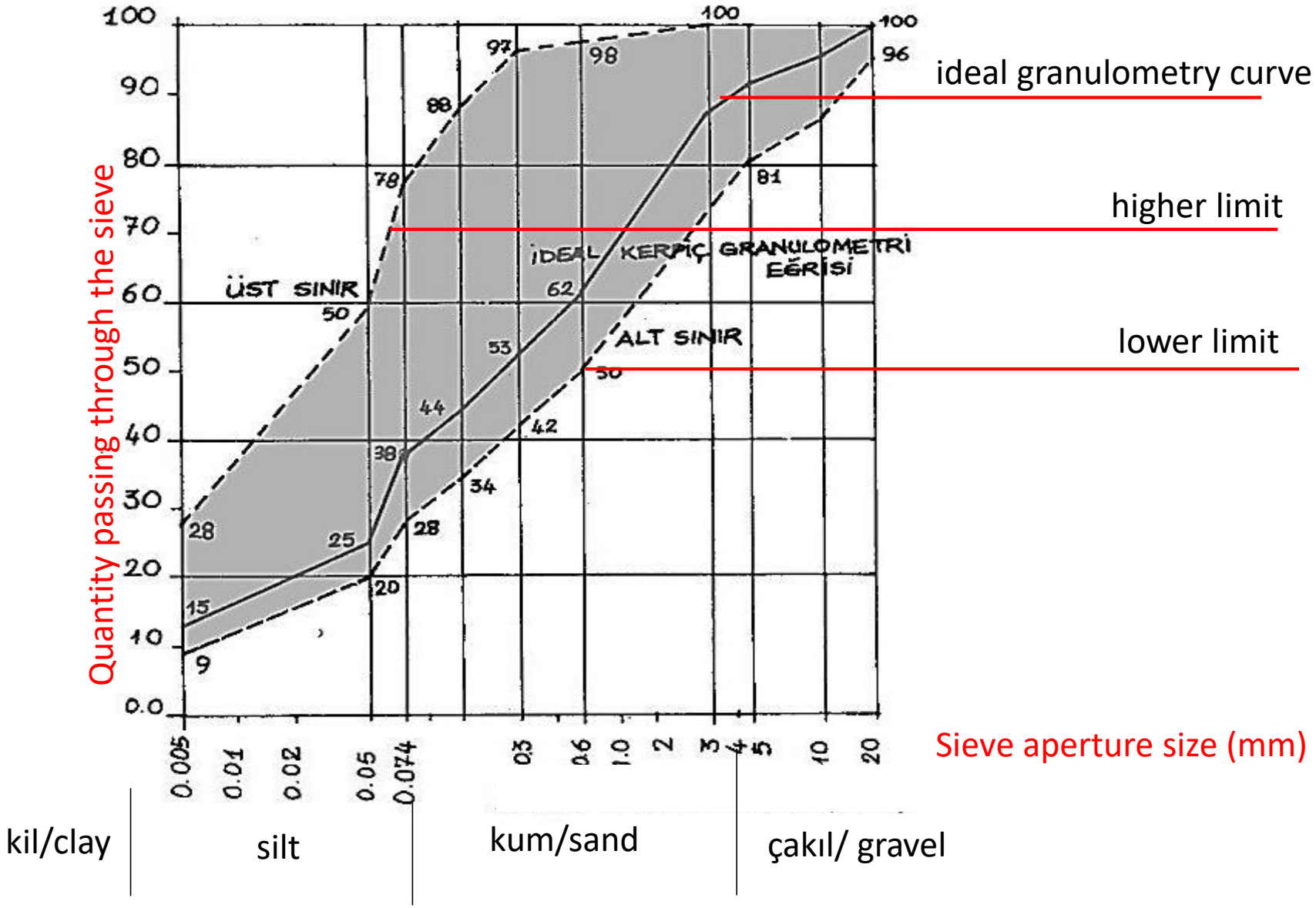
gypsum and lime ratio in the mixture

As the gypsum and lime ratio in the soil increases, the unit volume and shrinkage weight decreases.

Determination of Grain Distribution Ratios in the Laboratory Environment

During the preparation of Alker mixture the first stage must be the determination of the existing grain distribution ratios of the soil to be used by laboratory analysis, sieve analysis and hydrometry tests. It is checked whether the grain distribution ratio of the soil remains within the limits shown in **Scheme 1**. The soil remaining within these limits has approached the **ideal granulometry curve** giving the best **compressive strength.** The mixture is now called **structural soil.**

The limits of the soil with **ideal granulometry curve** where maximum compressive strength is obtained.



H.C. Schwalen, «Effect of Soil Texture Upon th Physical Characteristics of Adobe Bricks», Technical Bulletin, n. 58, Univ.of Arizona Agriculture Experiment Station, 1935,p.275

Tests for the Measurement of the Physical Properties of Alker

SHRINKAGE AND MEASUREMENT OF SHRINKAGE

Shrinkage is generally defined as the contracting of a hardened mixture due to the loss of capillary water. This **shrinkage** causes an increase in tensile stress, which may lead to cracking, internal warping, and external deflection, before the mixture is subjected to any kind of loading.

Samples with different ratios of additives must be tested during the preparations for producing Alker according to the soil used.
The amount of shrinkage is determined by experimenting with shrinkage device. The aim is to get the mixture with lowest shrinkage

CAPILLARY WATER ABSORPTION

In the Alker mixtures produced by adding 8-10 % gypsum and 2.5 - 5% lime to the soil water-resistant channels are formed within the structures in which no loss occurs although the body is filled with water.

Samples of water absorption experiment

Water rise in capillary water absorption test samples

Samples without additives and with different ratios are seen on the photograph.
On top: The sample without additive
The second from top with only gypsum added,
The third from top 10% gypsum, 2.5% lime,
At the bottom 10% gypsum, 5% lime samples in the capillary water absorption test as seen on the photograph.

EROSION RESISTANCE - SPRINKLER TEST

The soil containing a certain amount of clay is very sensitive to water. Swelling and disintegration occurs with the effect of water. It is seen that dispersion is minimized in Alker mixture and almost disappears when the lime ratio is increased.

While the samples with no additives are completely devastated, the wear on the samples produced with Alker mixture is very low as seen in the figure.

Before the sprinkler test

After the sprinkler test

- While samples produced from plain soil are completely dispersed and disappeared, losses in samples produced with Alker mixture are very small and can be reduced to zero if desired.
- While the rate of wear is 100% and 62% in plain samples, it decreases to 2.57% and 2.24% in the samples prepared with Alker mixture, and we see that the abrasion in the sample prepared by adding 10% gypsum and 5% lime to the higher clay content is increased to 8.50%.
- Excess amount of clay in the structure, as well as other physical and mechanical properties, adversely effect, decreases erosion resistance.
- During the formation process of Alker, the clay remains in its natural state without any structural changes and shows its natural behavior in every direction.

Mechanical Properties of ALKER

The mechanical properties of the soil block samples produced with Alker mixture are improved significantly compared to soil blocks without additives by adding gypsum and lime and using soil of which the grain distribution is corrected.
The product does not become brittle like other products, it gains ductility. They become products which are not affected by water and have sufficient mechanical qualities. In addition to compressive strength, the modulus of elasticity is reduced and the material becomes ductile. On the other hand, the shear resistance and stiffness modulus increase and gain important qualities for earthquake resistance.

The compressive strength of soils taken from nature is very low. In soils whose grain distribution ratio is corrected, these values are generally around 10kgf / cm2 and gain this strength after a long drying period.

This product gains sufficient stiffness for its setting process is completed in a short time because of the gypsum in the mixture prepared by the soils with corrected grain distribution. If block production is made, the product can be put into the stack immediately without the need for curing and drying process like in other products. The pressure increases to 25-30 kgf / cm2 after 7 days and the material continues to strengthen over time.

In the compressive strength test, it is seen that pure samples are completely dispersed and Alker blended samples are broken in pyramid shape

If Alker is evaluated by its technical aspects due to the test results:

- Unit volume weight of Alker is less than the plain soil material,
- Shrinkage and swelling rates are very small,
- It has a continuous capillary channel which is not affected by too much water,
- Compressive and shear strengths and elastic and stiffness modules at the required values for the structure,
- erosion resistant,
- It does not require curing and drying processes in production.

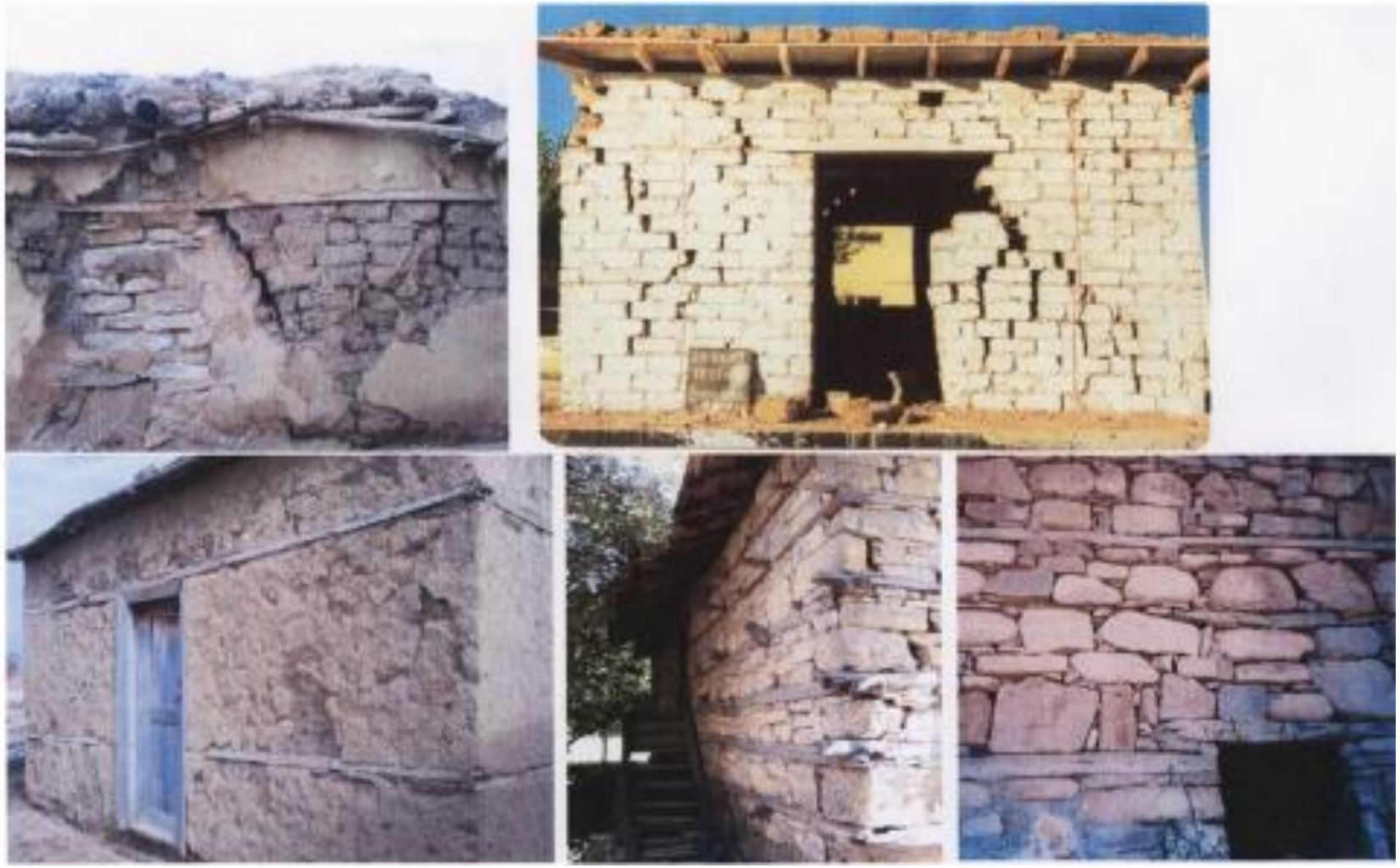
4. Earthen Buildings and Earthquake

According to our observations we made after many earthquakes in our country the traditional mudbrick structures **with beams** produced according to the building rules were not destroyed and did not cause any loss of life. This fact is also found in almost all of the experts' damage reports in earthquake zones after the earthquake.

Therefore, the idea that adobe structures are not resistant to earthquakes and causing death is not consistent with the facts and needs to be corrected.

The behavior of Alker blocks with improved quality and ductile structure with 2-3 times greater compressive and shear strength than conventional mudbrick structures will be much better against the earthquake. The images on the following pages haave photos supporting this phenomena. Most of the collapsed structures were built with round stones, not adobe.

Wooden girders provide earthquake safety in traditional buildings



Earthquake impact on walls with girder

Shaking Table Test

A test was carried out to see the behaviour of Alker against earthquake by using shotcrete method for filling the molds. Alker mixture is repelled in 2.40 m high and 40 cm wide in 5/5 dimensions molds.
The compressive strength in the samples were 0.3MPa while it is 3.5 Mpa in rammed earth applications. For the shotcrete is not a proper method for Alker production the application resulted as a weak building.

Shaking table test-Repelling Alker in the molds by shotcrete method.

The building before the test

A plastic mesh texture was placed on the wall blocks on every 50-60 cm height as girders. A concrete slab was built as a ceiling. After 3 months of drying, the shaking test was carried out according to the current procedures. After the experiment, the building remained intact except for some cracks. The mesh horizontally laid to serve as a beam creating a horizontal sliding surface and provided the building to survive although the building was a weak one.

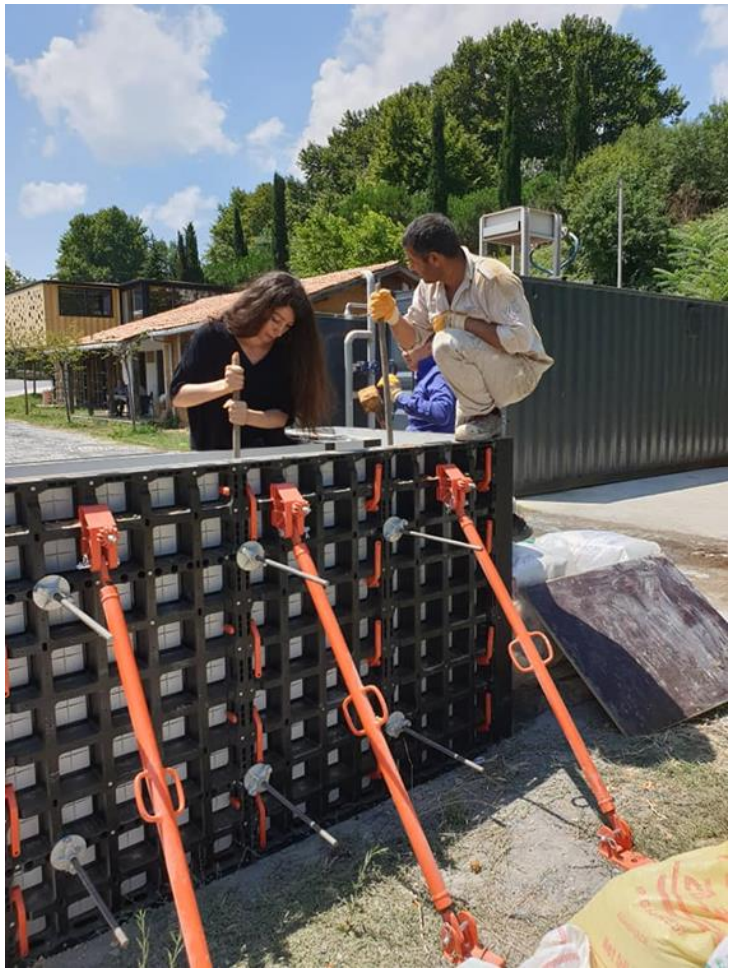
Sarsma tablası üzerine Alker karışımıyla yapılan deneme yapısının deneyden sonraki durumu (Foto: Bilge Işık)

5. ALKER WALL TRIAL JUNE 2019

Samples of Alker prepared with different ratios of additives

Alker wall trial-preparation for the mixture and pouring in the mold.

Since a homogeneous mixture of gypsum and lime is desired, it is preferred to make a dry mixture before adding water.



Ramming stage of the ALKER mixture in the mold

FINAL STAGE

ALKER wall after the mold was removed after an hour the casting

Members of **TYG** (**T**OPRAK **Y**APILAR **G**RUBU) Earthen Buildings Group (2013)

Architect/Civil Engineer
Prof. Ruhi KAFESCİOĞLU
1920-Kayseri, 1943-ITU

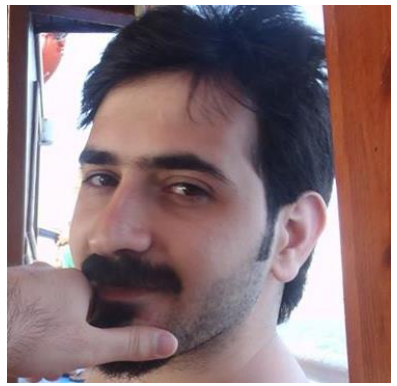
Architect
Alp AKMAN
1937-İstanbul,1957-ITU

Civil Engineer
Mete AKALIN
1944-İstanbul,1967-ITU

Architect
Murat KAFESCİOĞLU
1961-İstanbul,1981-MSGSU

Civil Engineer
Niyazi PARLAR
1960-İstanbul, YTU 1984

Architect **Hazal Zerife Ulaş**
1992, YTU-2017



Architecture student
Barış Kılınç,
1988, YTU