Examination of pressed adobe brick

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Abstract

The elimination of the disadvantageous features and characteristics of the adobe brick has been one of the aims of my research. My research is therefore directed towards the elimination and decrease, respectively of the construction disadvantages of the adobe bricks deriving from the „water sensitiveness", tiny tensile strength, sensitiveness for cracking, shrinkage and spreading sensitiveness as well as from the „water sensitiveness" of the execution, from the danger of the surface erosion and from the great variety of the different kinds of soils. Furthermore my aim is to make up for some lack in the literature in connection with the adobe construction as well as for setting up design and execution prescriptions in writing and to construe examination directives, guiding principles relating to adobe, respectively.

1 Introduction

During the research of the adobe „as building material" I have examined the different adobe construction technologies. A lot of procedures are well known in the literature however finally four main trends of them can be found

- monolithic: puddle wall and coursed wall
- pre-fabricated adobe bricks in blocks
- frame execution: wood, stone and brick frames
- adobe mortar execution

Load capacity and deformation/retentivity requirements can be set up only for the structures built by the first two technologies. As the first procedure will remain as a „home made" execution forever, it will be regulated and standardized with difficulties however the „normal production" of the adobe bricks has a real chance for that. Domestic regulation for adobe should be of course realized for that which can be set up from the DIN 18951-13957 [1] prescriptions, from the already accepted soil examination methods of the soil mechanics [2] and from some of the examination methods [3] having been already harmonized in the examination of the building materials.

2 The purpose of the experiment

In spite of its all advantages (is cheap, healthy, can be well formed, is a good insulation material, has a good heat storage capacity, is environment-friend) by the adobe possesses some grave disadvantages (water sensitiveness, great shrinkage, tiny solidity). The aim is to decrease these disadvantageous characteristics. The introduction of pressing was the first step in the modernization of the traditional adobe bricks. By examining the production circumstances and characteristics of the pressed adobe bricks such interventions are to be sought by which their disadvantageous can be diminished or eventually eliminated. For the time being I have not dealt with the thermal conductivity of the adobe bricks, we have uniformly put the same quantity of chaff into each brick so, that each adobe wall of 45 cm should meet the thermal technique prescriptions required by OTÉK [4].

3 Preliminaries

Pressed adobe bricks have been produced in the country in different places, by different people, e.g. ZELE-BAU of the town Hatvan, NATURBAU in Zalaegerszeg, and individual entrepreneurs, respectively in Újkígyós, in Székesfehérvár, in Debrecen . That was Mr. László Szlyuka an entrepreneur in Újkígyós, who put the pressed adobe brick at our disposal. He has been preparing pressed adobe bricks from straw and ,,soil" from his garden. By the influence of the orders of the people living nearby this activity has developed in to a small business. The preparation of pressed adobe bricks was realized in Újkígyós so ,,in the frame of a small plant". As the examination by sight of the bricks referred to a good quality it was worth to making the laboratory tests of the bricks based on accurate measurements. We received 16 pieces from the above bricks, one for establishing the grain distribution (by hydro metering), and 15 pieces for determining the changes of the mass, water content and measurement depending on time. Finally we executed bending, tractive and compressing strength tests on these 15 adobe bricks.

4 Description of the examined adobe bricks

Cledgy soils with nearly the same grain distribution can have different strengths and deformation capacities. The strength and deformation capability of these soils can be evaluated on the basis of the liquid limit and plastic index. According to Casagrande [2] the dry strength of the soil increases with about the same compressivity in case of a plastic index increasing by the same liquid limit, and the dry strength decreases and compressivity increases, respectively in case of an increasing liquid limit by the same plastic index. It can be shown that plasticity and bending-tractive strength increase almost linear with the clay mineral content, and at the same time the shrinkage increases, too, which is however disadvantageous. The grain distribution becomes of great importance in case of thin cledgy soils. As it is well known from the concrete and mortar technology, an even material with good grain distribution may increase the strength of the concrete and of the mortar, respectively. The adobe can be considered as a natural mortar, where coarse and fine sand are aggregates and clay is a binding material. As it can be seen in Figure 1, the material of the inspected adobe bricks is a very thin adobe, it can be considered rather as a clayey sand, consequently this is the grain distribution of the clay which is decisive. We have mixed 30 kg/m^3 straw chaff to the earth-moist material (clayey sand) used for producing bricks. It can be read from the grain distribution curve, that the composition of the used soil rounded in per cent is as follows:

- clay content: 5 %
- sludge content: 20 %
- sand flour content: 25 %
- sand content: 50 %

The examined adobe bricks were prepared with a nominal measurement of 10 x 14 x 29 cm. During control of the measurements we registered a maximum deviation of 5 mm. The brick heels and edges were undamaged. The mass of the adobe bricks changed between 7,38–7,90 kg.

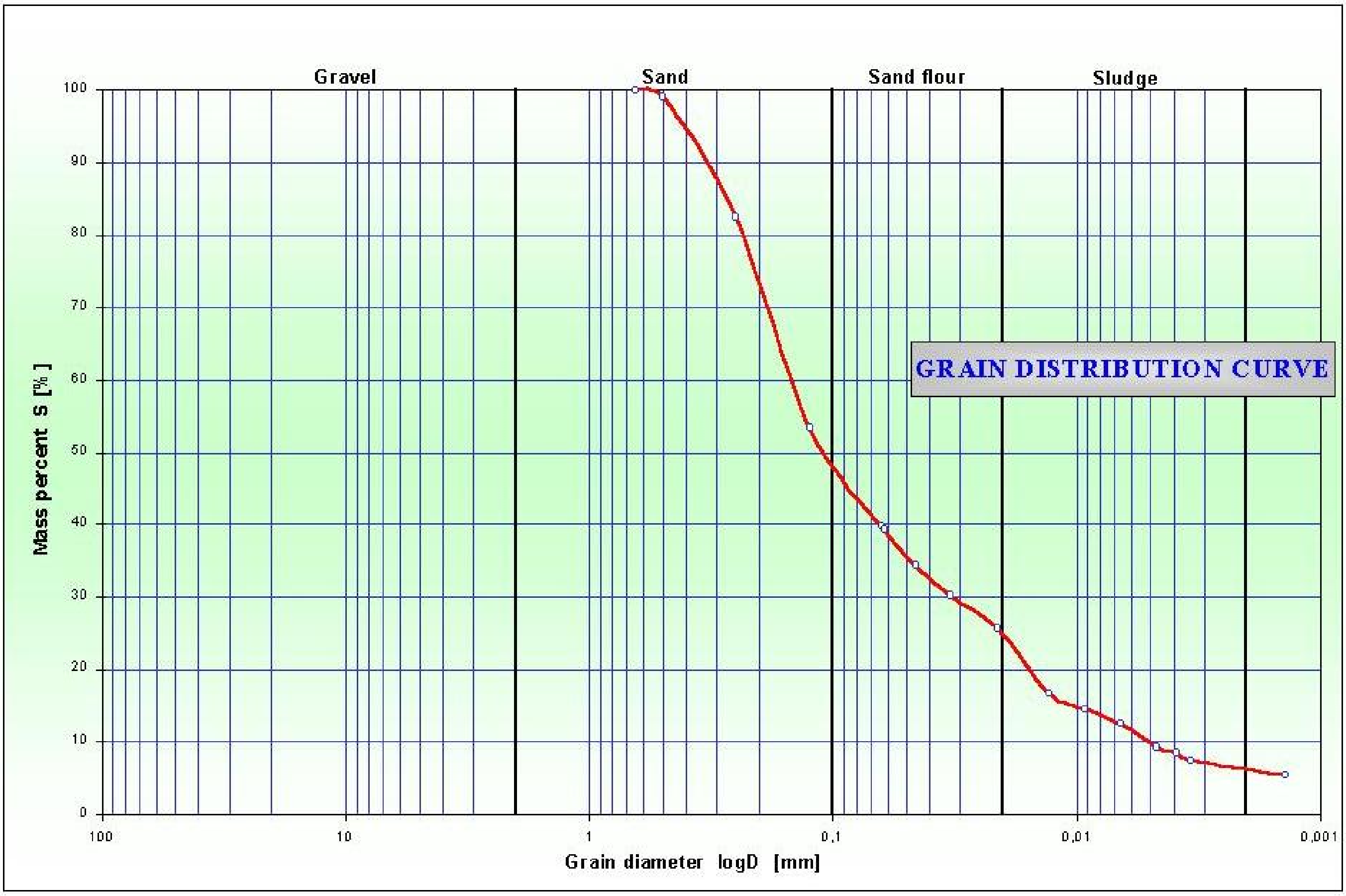
The examined adobe bricks were produced by a GEO-type motor- driven pressing machine. The pressing force is 16,25 t, that operates for 3 seconds. That means a compressing strength of about 4 N/mm^2. The ready-made bricks are put for conditioning for two-three weeks, depending on weather circumstances in order to insure that 98 percent of the shrinkage shall go on before installation. So the shrinkage after installation can be estimated to 1,0–2,0 percent.

5 Deformation test

The above described pressed adobe bricks were tested in the Széchenyi István Egyetem [SZE] Építőanyag és Szerkezetvizsgáló Laboratóriuma (Building Material And Structure Examination Laboratory of the Széchenyi István University, Győr, Hungary.

The test pieces were delivered to the laboratory under nylon cover. Extent of the shrinkage was followed both by length and by mass measurement. For determining the change in measurement the bricks were marked at three places in the middle of the direction towards the three dimensions. (h/2; sz/2, ill. v/2). (Later on that caused some storage problems.) The change of mass was measured by a Metripond type dial balance with an accuracy of 10 g, the change in measurement was measured by a slide gauge with an accuracy of 0,1 mm. The samples were drying in the laboratory for four weeks at 20 ^{o}C with a humidity of 12 percent. I executed measurements on the bricks every weekend. When I could not measure more changes than 0,1 mm and 10 g, respectively (at the fourth weekend) the adobe bricks were put into a cabinet drier and were dried out at 105 ^{o}C until mass stability. Diagrams show the results. The changes in time of the mass can be seen on Figure 2. , the ones of the humidity on Figure 3., and the ones of the deformation in Figure 4. All the three diagrams consist of–in harmony with each other–three different stages. In the first stage this is the capillary saturation, in the second this is the capillary aquosity and in the third this is the moisture diffusion that determines the extent of the changes of the mass, of the humidity and of the deformation, respectively. The practical benefit of the examinations is that all the three examinations unanimously prove that no more considerable (not bigger than about 1 percent) shrinkage can be expected after a natural drying up during 4 weeks.

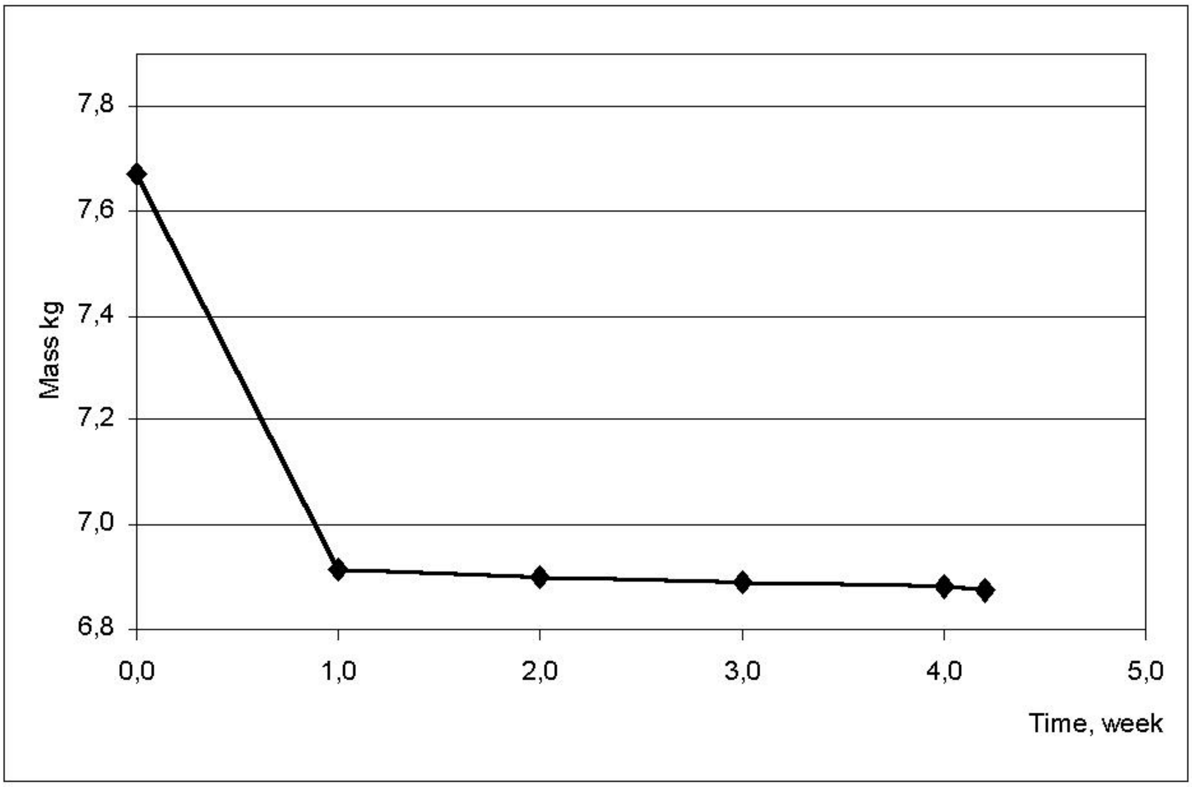
Figure 1: Grain distribution curve of the examined material



6 Examination of the slow deformation

After the drying process described above the examined adobe bricks were left standing in the laboratory and then the mass of the bricks were measured again. The result was, that the bricks practically re-gained their mass and water content, respectively before their artificial drying. Then the elements -based on the experiences of a former experiment– were loaded by 40 percent of the breaking force by 70 000 N for four weeks (σ = 1,7 N/mm^2). The measurements results were presented in diagrams. It can be seen in Figure 5that the significant part of the slow deformation change took place in four weeks. The experiments show that the slow deformation of the structures loaded in the flexible range goes according to a function within limits. Therefore a function within limits can be set up at the measurements points. The function $y = a - be^{-ct}$ is limited, on the basis of its limit the end value of the of the slow deformation is nearly 1 percent. After the extinction of the permanent load of four weeks the ,,return springing" of the slow deformation was approximately 50 percent that means a 0,5 percent real permanent slow deformation.

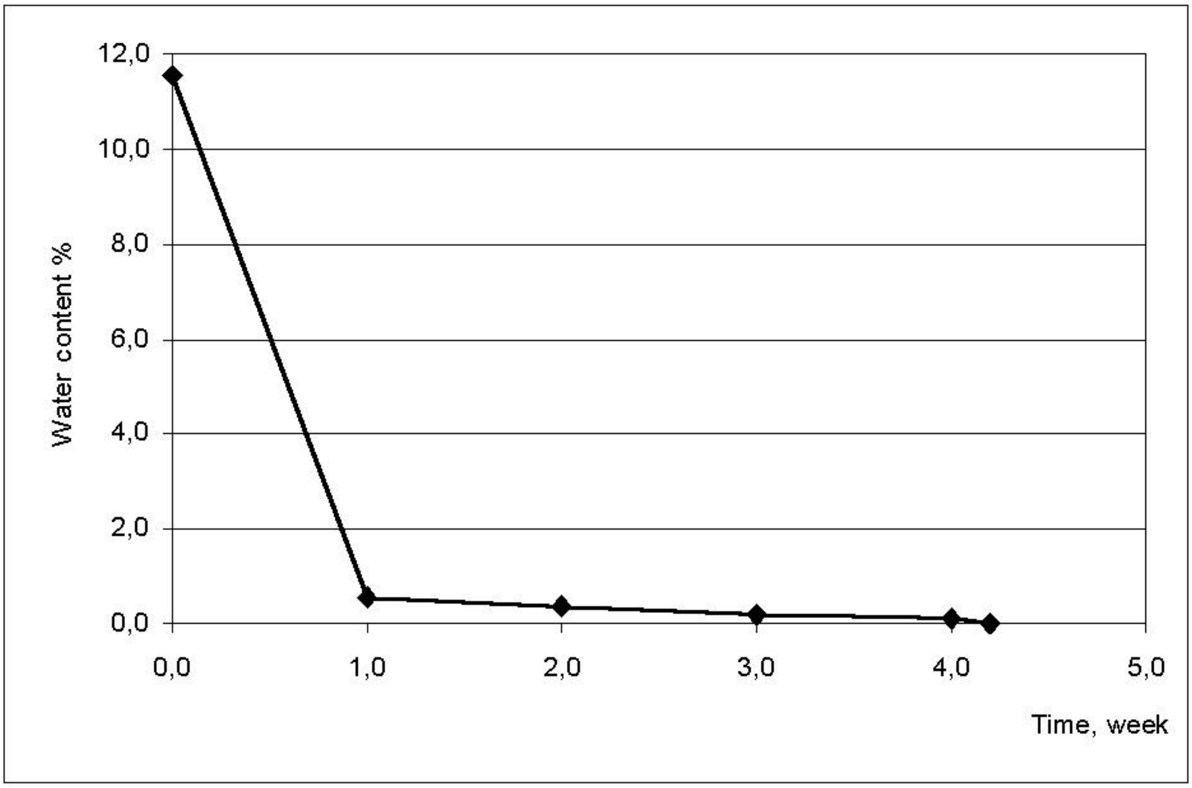
Figure 2: Changes in time of mass



7 Strength examinations

Considering that actually there is no standard in Hungary relating to adobe, the examinations were executed by taking into consideration the standard MSZ 551 ÉGETETT AGYAG FALAZÓELEMEK (HUNGARIAN STANDARD FOR BURNT CLAY BUILDING ELEMENTS) and its modified version, which has been much more adopted to adobe. Deviations

Figure 3: Changes in time of humidity



from the standard are as follows: Examinations were made on 15 and 30 pieces, respectively instead of 10 pieces determined in the standard, considering, that the standard deviation of the adobe bricks is possibly bigger than the standard deviation experienced with the burnt clay bricks.

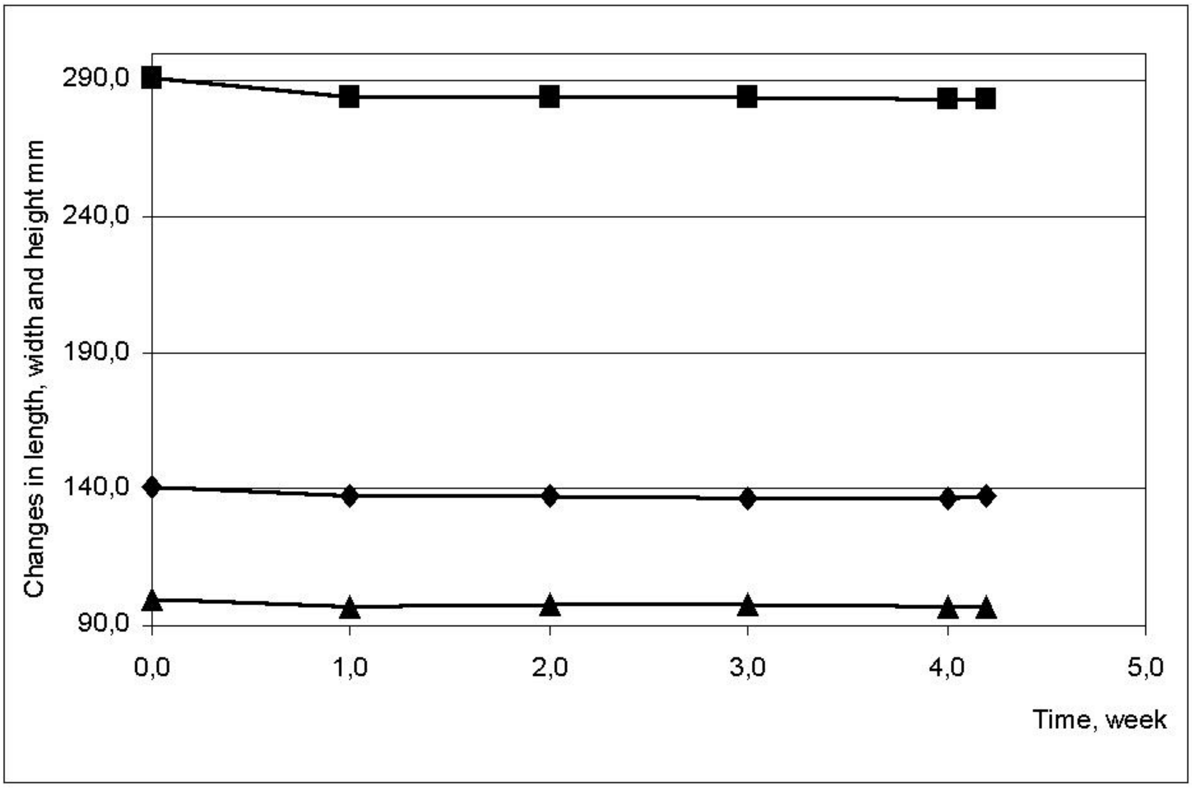
Instead of the point support (of 2-2 pieces 40 x 40 x 5 mm) used on the basis of the support standards for the bending- tractive examinations a full-width support (of 1-1 pc 140 x 40 x 5 mm) was applied. During the compressive strength examination instead of the fracture of the complete bricks mortared together according to the standard, the examinations were made on the half bricks gained from the bending-tractive examinations between100 x 140 mm pressing plates.

The bending-tractive examinations were made by RM 102 type, the compressive strength examinations were made by ZD 40 type breaking machines. During the bending-tractive examination the brick bodies were loaded by a concentrated force in the middle supported at a length of 1 = 250 mm. A compressive strength examination was made with the half bricks gained from the breaking of the bricks. The compression was made between 20 mm thick 100x140 mm (at the full width of the brick) pressing plates.

8 Examination results

Before the breaking examinations we controlled the measurements and mass of the adobe bricks. During examination we gained the following results:

Figure 4: Changes in time of deformation



- the mass of the pressed adobe bricks varies between 7,38- 7,89 kg, average is 7,67 kg, standard deviation is 0,151.

- The true measurement of the bricks after conditioning differs from the nominal measurement by max. 5 mm

- Density of the adobe bricks varies between σ = 1,82 - 1,94 g/cm^3 in average is 1,89 g/cm^3, standard deviation is 0,0359

- The bending-tractive strength of the bricks varies between 0,26 - 0,88 N/mm^2 in average is 0,64 N/mm^2, standard deviation is 0,1555

- The compressive strength of the bricks varies between 2,82 - 3,75 N/mm^2 in average is 3,25 N/mm^2, standard deviation is 0,2493, see chart 1.

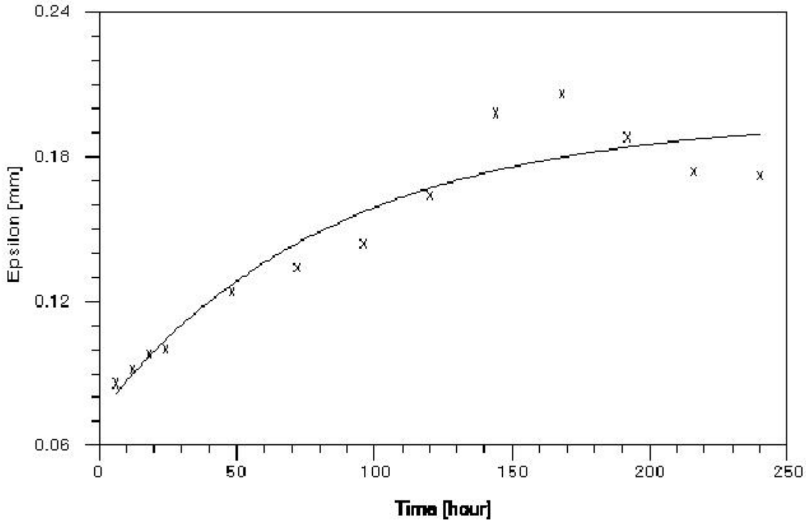
9 Summary of the evaluation of the examination results

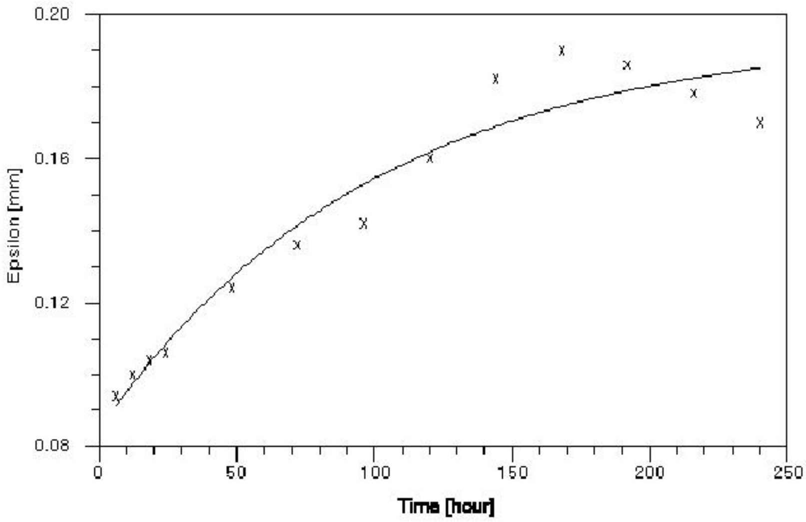
Comparing our examination results to the data in literature we get the following results: See chart 1:

On the basis of the above following statements can be made:

- Our measurement results agree well with the data in literature and with the data published in DIN 18951-18957, respectively

Figure 5: Slow deformation





Feature	Literature data	Measurements of my own	Difference Δ
density (σ) kg/m^3	1850 kg/m^3 lean clay [5]	1889 kg/m^3; σ=0,0359 standard deviation	~ 2 %
Humidity (%)	Air 43 %/adobe max. 2 % [6]	0,1 - 0,9 %	~ 1 %
shrinkage (%)	1 - 2,5 % [5]	~ 1 %	~ 1 %
Slow deformation (%)	-	~ 1 %	-
bending/tractive strength	1,2 - 2,7 N/mm^2 [7]	σ_{hh} = 0,64 N/m^2; $\sigma_{standard\ deviation}$=0,156	-
Compressive strength	1900 kg/m^3/3,0 N/mm^2 [1]	1889 kg/m^3 σ = 3,25 $\sigma_{standard\ deviation}$ = 0,15	~ 8 %

- On the basis of this the examined adobe bricks can be qualified to clayey sand bricks.
- In case of thin adobe after preparation insuring a conditioning for a month we can count with a 1 percent slow deformation
- The bending-tractive strength 0,64 N/mm^2 is highly backward from the 1,2 - 1,7 N/mm^2 value measured on the consciously fiber strengthened adobe specimen, the tractive strength of the adobe may be increased if necessary
- The compressive strength R = 3,25 N/mm^2 (σ = 0,15) surpassed the literature data by 8 percent, which also shows a good correspondence.

Consequently we can say that the examined features and characteristics of the examined adobe bricks agree well with the literature data.

So that the examined adobe bricks could become standardisable industrial products, their further physical and mechanical characteristics have to be determined, justified and, if required, improved. My tests for stabilising adobe (improvement of stability, reduction of water sensitiveness) are being carried out while in the future I am planning to determine thermal (thermal insulation, heat storage, vapour technique) and soundproof characteristics of pressed adobe bricks, respectively to improve them, if necessary.

Of course the execution of the domestic prescriptions (directives, standards) relating to adobe and adoption of the prescriptions of DIN 18951-18957 , respectively would facilitate and make more reliable the evaluation of the measurements.

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