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PASSIVE COOLING POTENTIAL OF EARTH WALLS - working hypothesis

Introduction

There is a usual proverb in Hungary:

"The earthhouses are cool in summer and warm in winter"

As a PhD-student of the Technical University of Budapest, Department of Building Construction, I am working on my thesis in the topic "The possibilities of optimum use of the earthhouses in Hungary" since September 1995.

The above mentioned wisdom, after the beginning of my research, seemed quite surprising, because the U-value of the traditional earthwall, with a density of 1800 kg/m3, is about 1.3 W/m2K, which is unfourable value, regarding the up-to-date heat transmittion requirement.

To prove the adobe mentioned wisdom I found the following statements in the past three years:

1, "The firewood demand of my claystrawhouse's heating is less as in my previous brickhouse, in spite of the fact that the U-value of claystraw is higher as the brick"
Balázs Nagy, Architect, 1995, Pomáz.

2, Comparison the inside and outside air temperature in two testbuilding, build from adobe and from concrete. Figure 1.
Hassan Faty, Architect, 1986, Egypt.

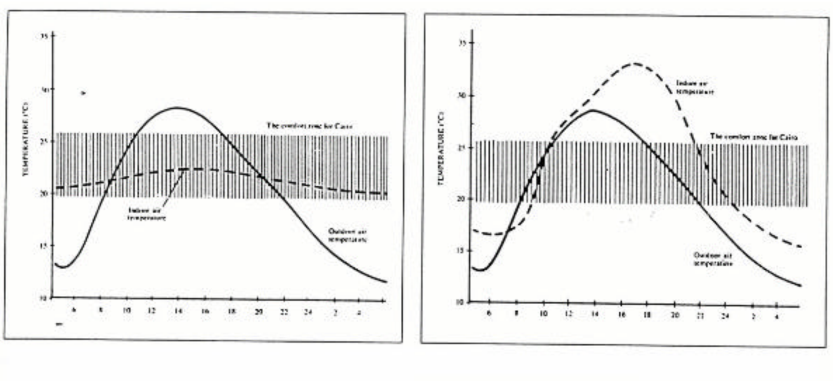

Figure 1.
Comparison the inside and outside air temperature in two testbuilding,

build from adobe (left) and from concrete (right). [4]

3, "The reason, that I work, since decades, with the earth as a building material is that the earth provide better inside air humidity as the other, common building materials." Prof. Gernot Minke, Kassel (videofilm: Der wiederentdeckte Erdbaustoff)

Hypothesis

After the above mentioned statements I devised the following working hypothesis:

" The earthwalls, because of it's special heat storage capacity, in the summer period have more less dynamination of the indoor temperature range as the other usual wall constructions."

Theoretical support

The heat transmission from outside to inside, because of the dynamic change of the air temperature is negligible. According to my working hypothesis, the passive cooling potential, the heat storage capacity of the building constructions are the function of it's heat absorption and moisture absorption capacity. Figure 2.

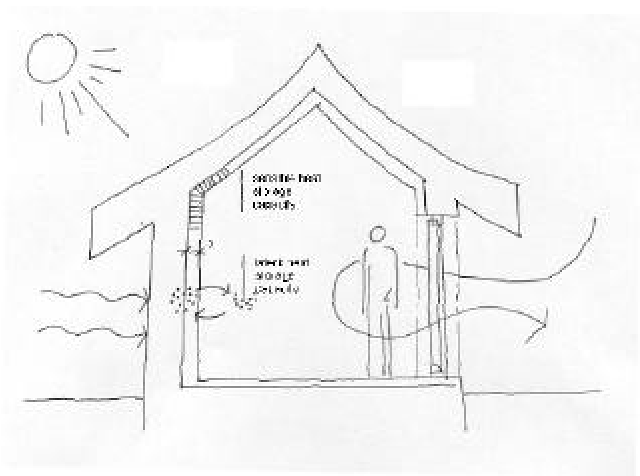

Figure 2.
Working hypothesis - sensible and latent heat storage capacity.

According to this hypothesis, the heat storage capacity is calculable using this form:

(1) $\mathbf{Q = (m_{material} * c_{material} + m_{moisture\ content} * c_{water}) * Dt + m_{moisture\ absor.} * R}$ (kWs)

Definition of the lettering in the formula (1)

(2) $\mathbf{m_{material}}$ = (1 m2) * $\mathbf{x_{effective\ active\ layer\ thickness}}$ * $\mathbf{r_{material}}$ (kg)

(3) **$c_{material}$** = specific heat of the material (kWs/kgK)

(4) **$m_{moisture\ content}$** = $m_{material}$ * **M%** (kg)

(5) **c_{water}** = specific heat of water (kWs/kgK)

The product of theorem (4) and (5) can be important because of the huge specific heat of water.

(6) **Dt** = inside air temperature variation (°C)

(7) **$m_{moisture\ absor.}$** = the mass of water which is absorbable and evaporable from the material in a determined material moisture content and air moisture content (g)

(8) **R** = the latent heat of water (g/m2)

Definition of the lettering in the formula (2)

(9) **$x_{effective\ active\ layer\ thickness}$** = the lower value from **x_1** or **x_2** (m)

(10) **$r_{material}$** = density of material(kg/m^3)

Definition of the lettering in the formula (9)

(11) **x_1** = **u** * **$l_{material}$** calculable using the usual counting method of bibliography number [1] (m)

(12) **x_2** = usual effective construction thickness (m)

Definition of the lettering in the formula (11)

(13) **u** = empirical formula, which value depends on period of examined heat storage capacity (Km2/W)

(14) **$l_{material}$** = thermal conductivity of material

The earthwalls have different special characters from the usual constructions

1. In connection with the formula (3) we have to emphasize, that the specific heat value of earth (adobe) walls are higher as the usual silicate wall constructions because of the fibrous material content of adobe. Figure 3.

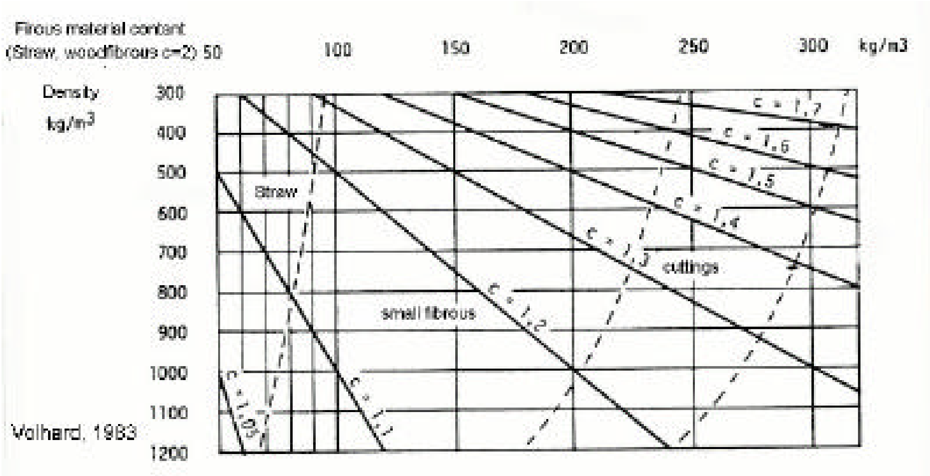

Figure 3.
Fibrous material content of earth (adobe) walls. [5]

2. In connection with the formula (7) we have to emphasize, that the absorption capacity of earthwalls is significant better as the usual (brick or concrete) constructions. Figure 4.

In the following calculation, because of the lack of data, I will use the approximation that the absorption-time diagrams can use as evaporation-time diagram.

Figure 4.
Sorbtion curve of an inside wall in the thickness of 11.5 cm, when the air-humidity increased from 50% to 80% in 21 °C. [4]

3. In connection with the formula (8) there is a large heat storage capacity because of the latent heat of water. Figure 5.

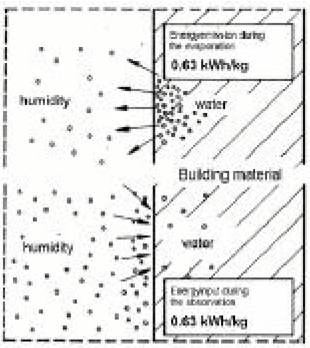

Figure 5.
During the absorption and evaporation of water
there is a huge interchange of energy. [2]

Verification of the working hypothesis with calculations

The thermal load and the heat storage capacity are quite difficult to calculate, because of the continuous change of inside and outside air temperature and humidity, is

In the following I will examine the calculable temperature variation of a concrete, brick and different earth walls, with the usual thickness, comparing against the data of a brickbuilding, measured in the TUB Department of Building Energetics in the framework of PASCOOL PROGRAM.

The thermal load and possible heat storage capacity of constructions is worth to analyse in two period. Figure 6.

a, possible heat storage capacity in a one-day period
b, possible heat storage capacity in a five-days period

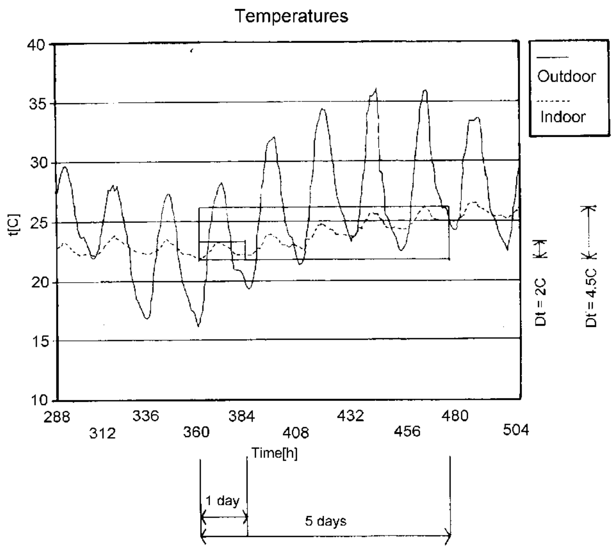

Figure 6.
Inside and outside air temperature diagram of a brickbuilding in Diósjenõ, measured in the framework of PASCOOL PROGRAM. [7]

<u>Calculable temperature variation, according to my working hypothesis - one day period</u>

Possible stored heat - thermal load - using the usual counting method [1]

(1/a) $\mathbf{Q = m_{material} * c_{material} * Dt = 86.6\ kWs}$

From my point of view this totality consist of 4 parts:

(i.) $\mathbf{Q_1 = m_{material} * c_{material} * Dt}$
(ii.) $\mathbf{Q_2 = m_{aggregate} * c_{aggregate} * Dt}$
(iii.) $\mathbf{Q_3 = m_{moisture\ content} * c_{water} * Dt}$
(iv.) $\mathbf{Q_4 = m_{moisture\ absor.} * R}$

		Concrete (2400 kg/m3)	**Brick** (800 kg/m3)	**Adobe** (1800 kg/m3)	**Claystrow** (1400 kg/m3)	**Claystrov** (700 kg/m3
(iv)	**Evaporative cooling effect** (kWs)	**6,13**	**5,23**	**36,75**	**28,88**	**28,88**
(15)	**Evaporative cooling effect** Q_4 / Q (%)	**7,07**	**6,06**	**42,44**	**33,35**	**33,35**
(16)	$\mathbf{(Q_1+Q_2) / Dt}$ (kWs/K)	**302,4**	**43,3**	**245,7**	**136,29**	**27,56**
(17)	$\mathbf{Q_3 / Dt}$	**17,28**	**0,73**	**21,62**	**8,92**	**1,59**

	(kWs/K)					
(18)	**Calculated temperature variation Dt = ((1/a) - (iv)) / ((16) + (17))** (°C)	**0,25**	**1,84**	**0,19**	**0,4**	**1,94**

Table 1.
The calculated values of "Evaporative cooling effect" and "Temperature variation", in one day period

Calculable hõingadozás, according to my working hypothesis - five days period

Possible stored heat - thermal load - using the usual counting method [1]

(1/b) $\mathbf{Q = m_{material} * c_{material} * Dt =}$ **1203,84 kWs**

From my point of view this totality consist of 4 parts:

(i.) $\mathbf{Q_1 = m_{material} * c_{material} * Dt}$
(ii.) $\mathbf{Q_2 = m_{aggregate} * c_{aggregate} * Dt}$
(iii.) $\mathbf{Q_3 = m_{moisture\ content} * c_{water} * Dt}$
(iv.) $\mathbf{Q_4 = m_{moisture\ absor.} * R}$

		Concrete (2400 kg/m3)	**Brick** (800 kg/m3)	**Adobe** (1800 kg/m3)	**Claystrow** (1400 kg/m3)	**Claystrov** (700 kg/m3
(iv)	**Evaporative cooling effect** (kWs)	**8,75**	**7,00**	**87,50**	**66,50**	**63,88**
(19)	**Evaporative cooling effect** Q_4 / Q (%)	**0,73**	**0,58**	**7,27**	**5,52**	**5,31**
(20)	$\mathbf{(Q_1+Q_2) / Dt}$ (kWs/K)	**302,4**	**267,52**	**900,00**	**770,00**	**262,50**
(21)	$\mathbf{Q_3 / Dt}$ (kWs/K)	**17,28**	**4,50**	**79,20**	**50,40**	**15,12**
(22)	**Calculated temperature variation Dt = ((1/b) - (iv)) /**	**4,74**	**4,40**	**1,14**	**1,38**	**4,08**

	((20) + (21)) (°C)					

Table 2.
The calculated values of "Evaporative cooling effect" and "Temperature variation", in five days period

Inference

1. The passive cooling potential of earthwalls is higher as the usual build brick and concrete constructions.

2. Probably in the heat storage capacity of earthwalls, especially in one day period, there is a significant role of latent heat storage capacity.

3. My calculated results must have modified according to the heat storage capacity of floor covering, the effective absorbable humidity, the covering of the wall construction and the use of the house.

4. The calculated results must be proved with different measuring

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