Combining cooled soil and natural night ventilation to achieve moderate tempered houses in Andalusia, Spain

O. Pankratz
designAID, Austria

L.M. Avila
Avila architectos, Spain

C. Buxbaum, A. Seiler
Carinthia University of Applied Sciences, Austria

ABSTRACT

In summer 2007 a housing project will be build, reachable within 20 minutes by car from Granada. It contains 33 single family houses , 21 apartements and 40 dwelling units social housing. The goal of this project is to achieve moderate temperatures without electric equipement during most of the time. Energy use achieves so called "Passivhouse Standard". For this project we have to adapt "cooled soil" in weight and thickness. Hygrothermal simulations showed the possibility to evaporate under the roof insulation 200 g Water per day and sqm in this climate. The cooling caused by evaporation is estimated the same value as Givoni found in his investigations. This paper deals with the hygrothermal behavior of the "light weight cooled soil" on the very first flat roof. We will monitor and investigate the heat flux, the in- and outdoor climate and evaporated masses of water. The second part of the paper shows the thermal simulations referring to the both strategies.

1. CLIMATE CONSIDERATIONS

Andalusia is the very most sunny area in Europe. The site is 450 m above sea-level. The artificial lake is near the planned buildings and there is always wind from north west or south east. Furthermore the night and day temperatures range around 18K in summer. For example in Heraklion, Greece, in July the range is 7.5 K.
The humidity in Beznar is average 50% in summer. Early morning temperatures in summer are always below 20° Celsius, except two or three days a year. Ancient dwellings in Granada show that comfortable housing without mechanical cooling is possible. Very first simulations with local building standards did not meet the energy use and comfort we want to achieve.

2. DETACHED SINGLE DWELLINGS FIRST DESIGN

We increased thermal insulation, used coated glass panes and improved air tightness. The shadings are outside Venetian blinds. Transverse ventilation supports the natural night cooling. Modern art of living with transparent openings and view in the landscape causes unwanted solar gains. Even well shaded dwellings gain diffuse sky radiation which causes cooling demand. Also there is a demand of heating during the winter. We tried different strategies to reach passive house standard. The thermal behaviour was significantly better but there are still 1000 hours during a typical year above 26° C inside.

2.1 Improving the Comfort with cooled soil.

The next step to a natural cooled house was the adaptation of the cooled soil, published by Givoni (95). Obviously the lack of cooling demand was few. Evaporation of 1 kg water causes 670 Wh cooling. Evaporation of 200 g Water/m²d evoke 114 Wh heat energy inside the roof during the hot daytime.

3. BASIC SIMULATIONS WITH A HYGROTHERMAL MODEL

Investigation of 3 variants of the computed flat roof from outside to inside.

3.1 Mineral Wool+200 g water per day and m² into the felt.

1^{st} layer vapor open but waterproof foil, Vapor resistance equivalent 0.02 m air.
2^{nd} layer 180 mm mineral wool with conductivity 0.04 W/(mK).Vapor resistance is equivalent 0.234 m air. Density 60 kg/m³. Specific heat 850 kJ/kgK. 3^{rd} layer 6 mm felt to storage and evaporate water. Felt with conductivity 0.038 W/(mK).Vapor resistance is equivalent 0.009 m air. Density 38 kg/m³. Specific heat 1600 kJ/kgK. 4^{th} layer foil as vapor barrier, vapor resistance

is equivalent 100000 m air. 5th layer 200 mm concrete reinforced with conductivity 1.6 W/(mK).Vapor resistance is equivalent 49.6 m air. Density 2220 kg/m³. Specific heat 850 kJ/kgK.

3.2 Combusted Clay Balls +200 g water per day and m² into the felt.

1st layer vapor open but waterproof foil, Vapor resistance equivalent 0.02 m air.

2nd layer 250 mm combusted clay balls with conductivity 0.09 W/(mK).Vapor resistance is equivalent 0.625 m air. Density 700 kg/m³. Specific heat 850 kJ/kgK. 3rd to 5th layer. Data like first Variant.

3.3 Combusted Clay Balls with dry felt.

Data like second variant no water added.

3.4 Boundary Conditions

Outside climate created with Meteonorm, compared and validated with measured data from 2000 to 2006. Shortwave absorption coefficient of the roof 0.4. Long wave emissivity 0.9. Radiation balance enabled. Inside Climate simplified 25 ° C constant and 60 % relative humidity. Time 10 days from 22. July to 1. August.

Heat resistance outside 0.0526 m²K/W. Heat resistance inside 0.125 m²K/W. Computing time step 0.001 hour.

3.5 Results of the simulations

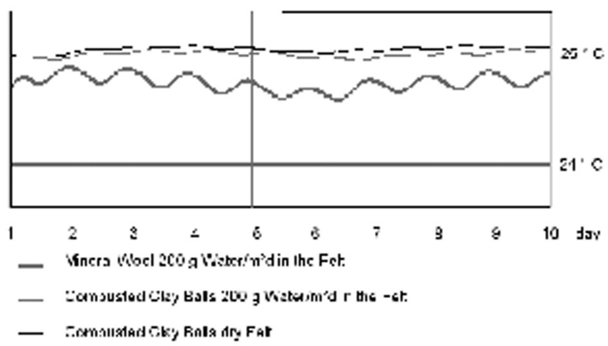

Figure 1: Comparing the roof surface temperatures inside Casa A during 10 days at the end of July. Inside temperature 25 °C constant.

3.5.1

The 1st variant with mineral wool and the daily watered felt performs excellent, the 2nd with the clay balls poor. The cooling effect at the watered flat roof with the MW is visible. Probably in reality the difference between MW and Clay Balls will be not so big, For comparing the simulations it was necessary to avoid increasing or diminishing water content in the 5th and in the 2nd layer. More about this assumption we know after the monitoring.

3.6 The evaporate cooling effect

Heat flow through the inside surface. According the difference between indoor air temperature and inside surface temperature and heat resistance is the amount of heat flow. MW + watered felt count in this 10 days 1,49 MJ per m² from inside to outside. The combusted clay balls with watered felt shows 0,32 MJ per m² with direction from outside to inside. The case for controlling mounts 1.06 MJ/m² from outside to indoor.

Be aware that the surface temperature on the flat roof reach 50°C.

Water content in the felt

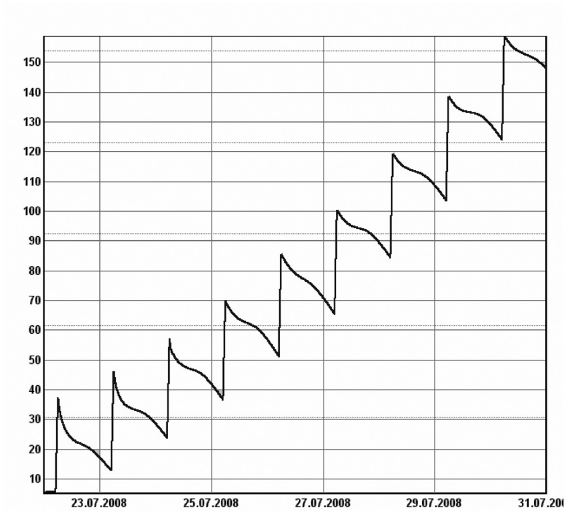

Figure 2: Felt in the MW variant. X..... time from 22. July till 1. August. Y shows the water content in kg/m³.

MW Water content in the felt. Every day at 6 a. m in the morning 200 g water per m² are irrigated in the felt. The accumulation is obvious. The watering of the roof is necessary just 2 to 3 months and the saturation of the felt is limited at 950 kg/m³. There is no risk to destroy the system.

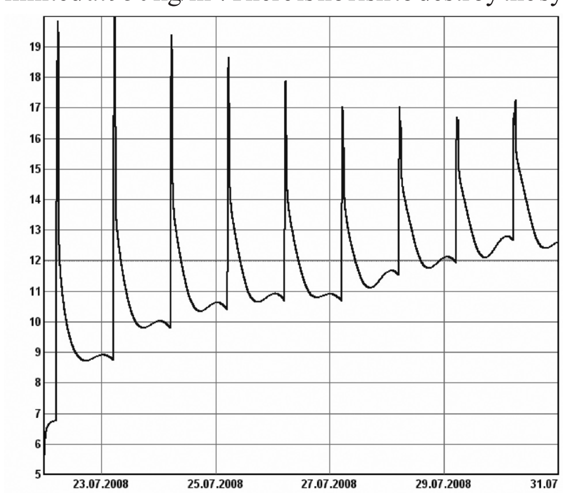

Figure 3: x time from 22. July til 1. August. Y shows the Water-content in kg/m³.

Combusted Clay with watered felt. There is no accumulation. Probably the use of more water as 200 g per day possible. WUFI is not able in this constellation to deal with liquid water in the felt. This is a question for the outdoor attempt.

Flat roof temperature

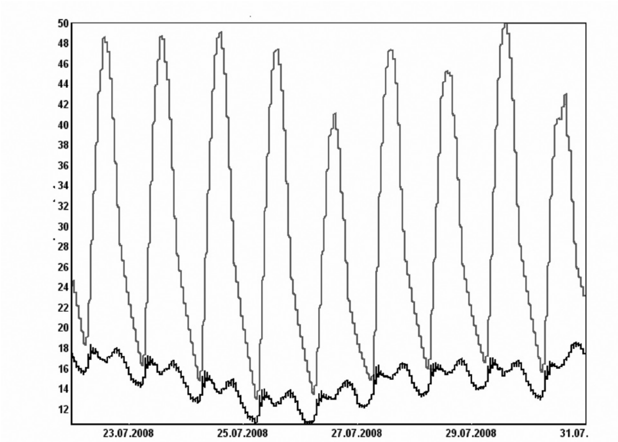

Figure 4: Temperatures on the mineral wool flat roof. x time from 22. July to 1. August. Y Surface temperatures up to 50°C and dew point temperatures below 20°C on the roof. Short wave absorption 0.4.

Remarkable is not only the big range between day and night, almost every night the surface temperature meets the dew point temperature.

Inside the construction

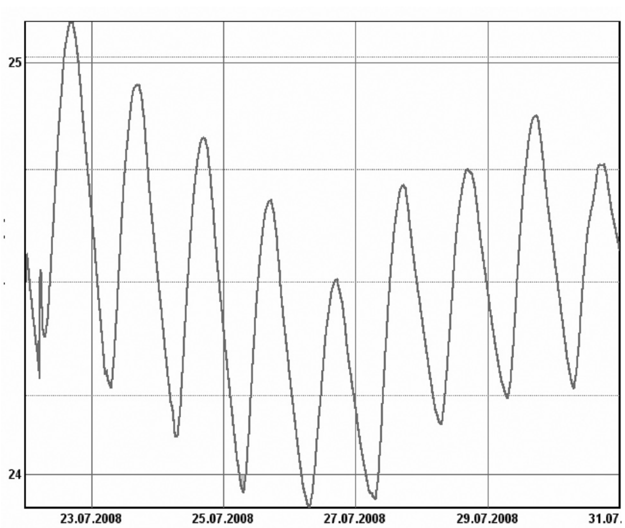

Figure 5: Temperature in the lower edge of the mineral wool next to the felt. It is clear below the indoor temperature and shows the effect of evaporation.

4. DISCUSSION

Modern buildings with a considerable amount of glass in the thermal envelope can not be cooled by naturally strategies in southern Europe. Even well done outside shadings are not able to avoid complete overheating caused by solar gains through the big windows. Here might be the cooled soil a useful solution. If the cooling power of the roof is too little, the support of the mechanical cooling should diminish the electric demand for cooling. The combination of shading, natural night ventilation, thermal mass and cooled soil may sufficient meet thermal comfort and low energy use of a passive house. The consumption of 200 g water per m² and day is not very much. In wintertime the cool effect must be avoided. We think a slight slope and a hydrophobic surface on the roof may be sufficient.

FORECAST

Unfortunately the building permission takes more time as we thought. It was not possible to carry out this experiment. We can not compare measured with computed data now. Soon as possible we will repair this mistake.

USED SIMULATION SOFTWARE

WUFI - Fraunhofer Institut für Bauphysik
ENERGY 10 – National Renewable Energy Laboratory

REFERENCES

Givoni, B. (1995). C*limate Considerations in Building and Urban Design, Hoboken,* John Wiley and Sons