ADOBE
MOISTURE ABSORPTION
and
TEMPERATURE CONTROL

Logged Data for a Humid Heat Wave
6-11 AUGUST 2004
Del Rio, Texas

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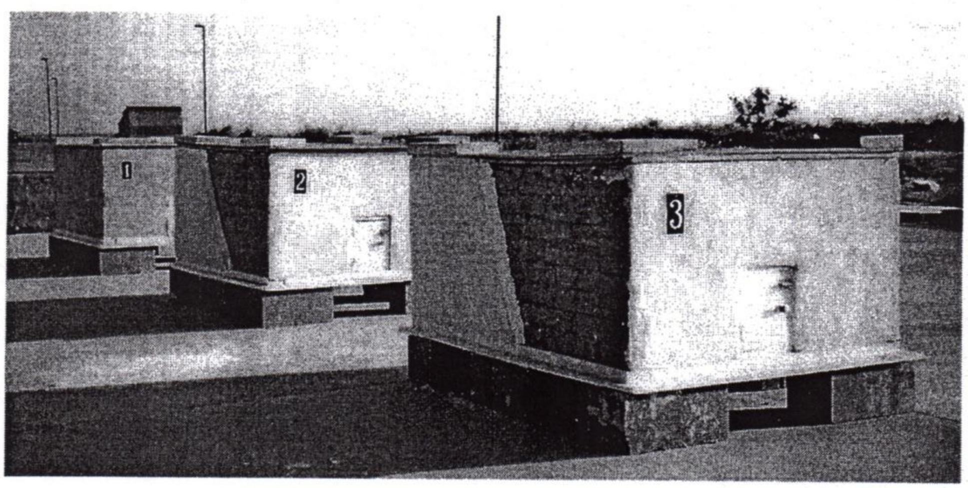

Three modules. All face due North: #1 cinder block with cement stucco; #2 traditional adobe; #3 compressed earth block. Modules #1 and #3 used in the study. Partial exposures of render face East allowing measurements to be taken of moisture movements and to illustrate a two-coated lime render. Modules rest on 8-inch cinder (concrete) blocks.

2005

Abstract

Logged data of temperature and humidity were collected inside two modules, one of compressed earth blocks (CEB) and one of cinder blocks; each is some 20 ft^3 with identical roofs and floors. With an ambient temperature of 106°F the cinderblock module was 110°F and the CEB was 101°F or 9°F cooler. When the ambient relative humidity (RH) was high the inside humidity of the cinderblock approached 100%, but in the CEB, the RH did not exceed the mid-60% mark. The lower RH is explained by the moisture being absorbed by the earthen walls. This suggests the possible use of evaporative coolers in buildings constructed of an earthen fabric in regions where evaporative coolers tend to build up too much humidity for human comfort.

Introduction

A previous study (Morony, 2005) revealed that adobe, and other unmodified earthen material, undergoes latent heat flux in response to differing states of relative humidity within and without an adobe building. In such instances, adobe walls may be absorbing and passing moisture vapor on either side of an adobe fabric provided the walls remain free of vapor barrier covering. This study presents specific evidence that such phenomenon does indeed occur.

A series of on-going studies is being conducted in Del Rio, Texas of indoor vs. ambient temperature of earthen building fabrics and concrete (cinder) blocks Modules of similar dimensions are used in conjunction with data loggers to record temperature and humidity. The principle focus of such studies concerns the response of varied building fabrics to prolonged summer heat characteristic of south Texas. It is summer heat and not the winter cold that intrudes into the human comfort zone and it does so to the point that air conditioning is required. Refrigerated air is used every month of the year every hour of the day for some months running. Air conditioning is currently the only effective, but very expensive means, to significantly lower the indoor temperature to the comfort zone (temperatures below 80°F). Air conditioning is often the most costly item on the monthly energy bill for a significant part of the year.

Procedures

Three modules, numbered on the north facing wall as #1 to #3, are illustrated in the frontispiece. They were built in 2004 on property adjacent to the Southwest Texas Junior College campus in Del Rio, Texas. All have six inch thick walls (not including stucco) and inside dimensions of approximately 34" x 42" x 25.5" resulting in an internal volume of *ca.* 20 ft^3. All face north and have a single opening on the north side with a door and latch. The modules are not intended to be air tight, thus allowing equalization of changes of atmospheric pressure. All are fully exposed to the sun throughout the day. The modules have a flat roof covered by 3/8 inch panel board insulated on the under-side with a sheet of *Energy Shield,* a product of Atlas Roofing, that is a foil-faced foam board with an R-rating of 5.4. A sheet of this foam board is also used on the floor of the modules.

Module #1. Six-inch Mexican concrete (cinder) blocks were used in the construction of the module. The module was stuccoed with cement and painted with an off-white cement paint to match the color of the two lime stuccoed earthen modules.

Module #2. Traditional adobe was used with an appropriate soil mixed with horse manure.

Module #3. A compressed adobe (or compressed earth block) structure, 6 x 12 inch, using the same soil as was used to made adobes of Module #2 but without additives save moisture. Blocks were made using a CINVA Ram, a hand operated machine using mechanical leverage to exert pressure.

Data Logging

VERITEQ data loggers, *Spectrum 2000*, were utilized inside the modules and set to record temperature, relative humidity every three hours continuously during the time of the experiment. Doors were kept closed at all time. Temperatures were read to the nearest whole number.

Data loggers were used in Modules #1 and #3 only during a period of prolonged hot and humid conditions from the 6^{th} to the 11^{th} of August, 2004 in Del Rio, Texas. A separate data logger was used to record ambient condition in the immediate vicinity of the experiment for the same time intervals as used in the modules. Results of the data logging are recorded in Figures 1 and 2.

Temperature Data (Figure 1). The cinderblock module recorded temperatures higher than ambient during the highest temperature values for the 6^{th}, 8^{th} and $10^{th.}$ of August (Fig 1). During the same time intervals the compressed adobe was always significantly lower than ambient. Highest temperature for each of the three recording are: ambient - 106°, compressed adobe - 101°, and cinderblock - 110°. Thus the compressed adobe registered some 9° cooler than the cinderblock module. These data are in accord with similar type studies by the author using these and other like modules. Cinderblock modules were consistently higher in temperature than highest ambient temperatures during hot weather. Residents living in cinderblock homes on either side of the Rio Grande River report higher indoor temperatures than outdoor during high heat conditions. However, the significance of the temperature data is heightened when taking into account concurrent humidity data.

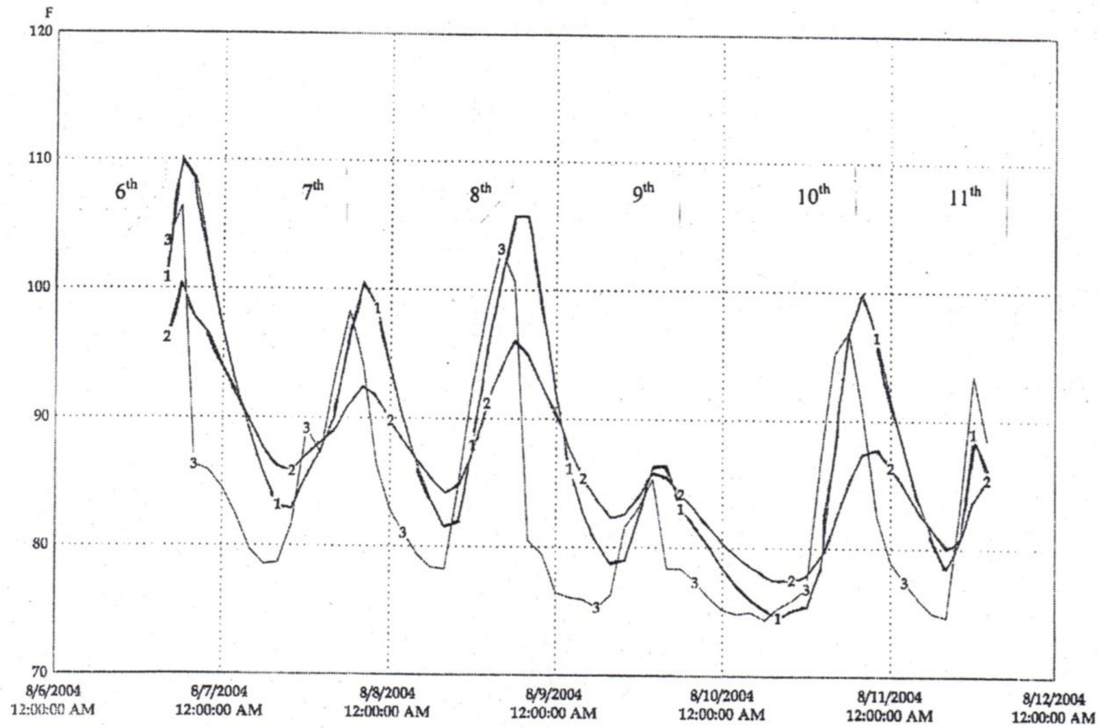

Figure 1. TEMPERATURE, August 6-11, 2004. Experimental modules and ambient conditions. Southwest Texas Junior College, Del Rio, Texas. *#1 Cinderblock, #2 Compressed adobe, #3 Ambient temperature.*

Humidity Data (Figure 2): There was a pronounced rise in humidity in the cinderblock module during a prolonged hot and humid period from the 9th to the 11th when the experiment was terminated. On the 10th, when the cinderblock was 100°F the RH was some 90% then peaking at near saturation. Residents of cinderblock houses along the Border report high humidity and mold growth during certain times of the year, especially late spring and summer. In marked contrast, the RH in the compressed adobe remained below mid-60%. An explanation is that the clay content of the earthen walls succeeded in absorbing a major portion of the accumulated moisture. *Thus, a plausible explanation for the lowered interior humidity of the adobe module was that the water vapor was* *absorbed by the walls.* There are important implications to be considered. Perhaps foremost is the need to avoid a wall covering, especially a render or plaster that would interfere with vapor transfer into or out of the walls.

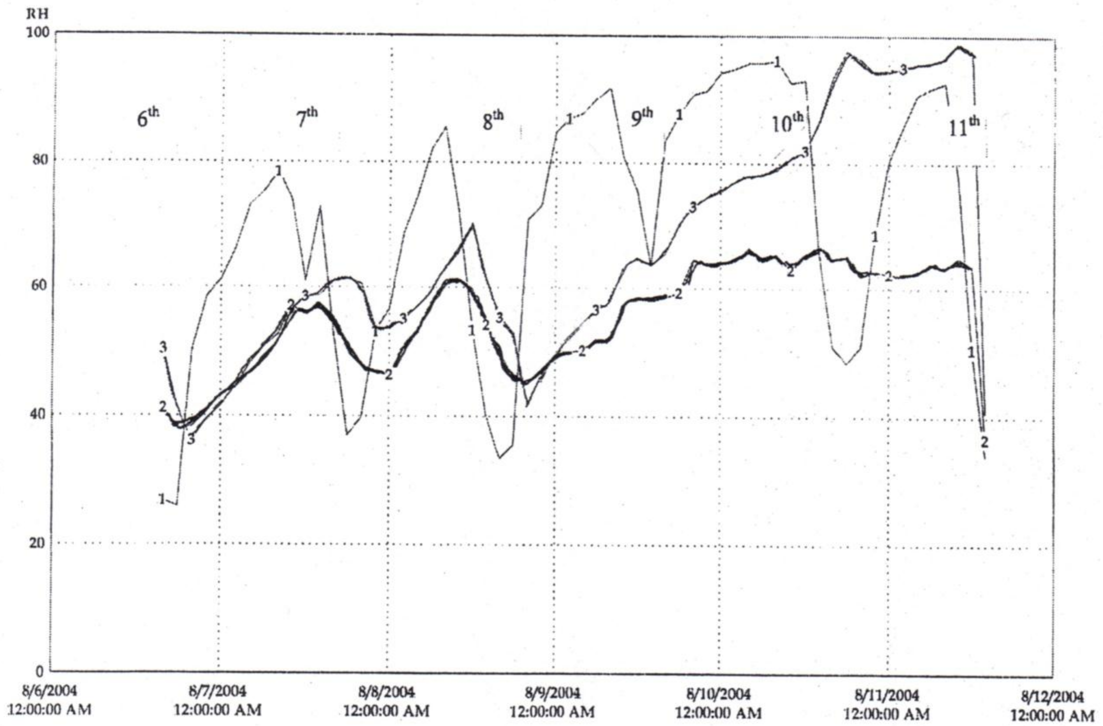

Figure 2. HUMIDITY, August 6-11, 2004. Experimental modules and ambient conditions. Southwest Texas Junior College, Del Rio, Texas. *#1 Ambient temperature, #2 Compressed adobe. #3 Cinderblock.*

Discussion

Why the profound difference between the adobe and the cinderblock with respect to humidity and temperature? In essence, adobe and other type earthen material, left unbaked or unstabilized, constitutes *phase change material (PCM);* a terminology of the building industry. The term applies to any chemical substance deemed useful for temperature control for some industrial purpose (Ruth Kelly, 1999). The nature of phase change phenomena was explained at length in a previous publication (Morony 2005). All matter is subject to existing in one of three phases: solid, liquid or vapor. A phase change from one to the other either releases or absorbs thermal energy in response to critical temperatures changes.

An explanation centers on the hygroscopic (water attracting) qualities of clay in the adobe. The clay carries a negative charge and bonds with the positive pole of a water molecule. Clay is thus capable of absorbing water in a *vapor phase* as well as liquid. Phase-change of water form solid/liquid and from liquid/vapor results in an exchange of thermal energy. In the case of liquid/vapor changes the energy involved is very great relative to the phase-change in other chemical compounds. In a liquid to vapor change one kg of water at 100° C converts to 2260 kj/kg of heat (540 cal/gm) that is released to the surroundings (P. Hewitt, 1981). While cinderblocks and other conventional building material may readily absorb liquid water, as with rain, by way of capillary action but it is otherwise with respect to atmospheric water vapor.

The aforementioned qualities attributed to adobe apply as well to clay plasters as detailed in a study by Neil May (2004, p. 2). He noted that clay plasters absorbs ambient moister and that the hygroscopic qualities of clay "... means that moulds caused by condensation are minimized, and that a relative humidity of 50%-60% is maintained. This is the ideal level for mucus membranes of the human body, and also for the control of dust mites and other organisms which affect human health." Additionally, he notes clay plasters have very good capillary qualities but less capillary draw than materials like lightweight brick, and even certain cerement products. However, they have more capillary draw than most types of timber. They thus draw condensed water away from a timber frame building but will not dry out the timber itself.

Temperature and Humidity

To what extent can the temperature and humidity be lowered inside an earthen residential structure with minimal expenditure of energy? In South Texas the problem with evaporative coolers is that excess humidity tends to build up creating conditions for mold growth and is uncomfortable to a building's occupants. However, resorting to the use of refrigerated air in summer months is generally the most expensive item on a monthly utility bill. One may thus ask, what would be the consequences of using one of the newer, highly efficient, evaporative coolers within an adobe building? A sustained build up of humidity on the inside would be prevented. The earthen walls would absorb excess humidity at the same time the interior temperature could be significantly lowered. However, it is important to note that for latent heat flux to occur an earthen building fabric would have to remain free of a vapor barrier on either side. Additionally, efficient evaporative coolers, that use direct current, are available that can run off a 12-volt solar panel to be used in the afternoon when RH is lowest. Currently, the Adobe Association of Del Rio (Texas) is in the process of constructing a small experimental building to test the possibilities of a more extensive use of evaporative coolers using an adobe fabric.

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