LOGGED DATA FOR HEAT WAVE
Del Rio, Texas
31 May - 2 June 2004

- A Preliminary Report -

By

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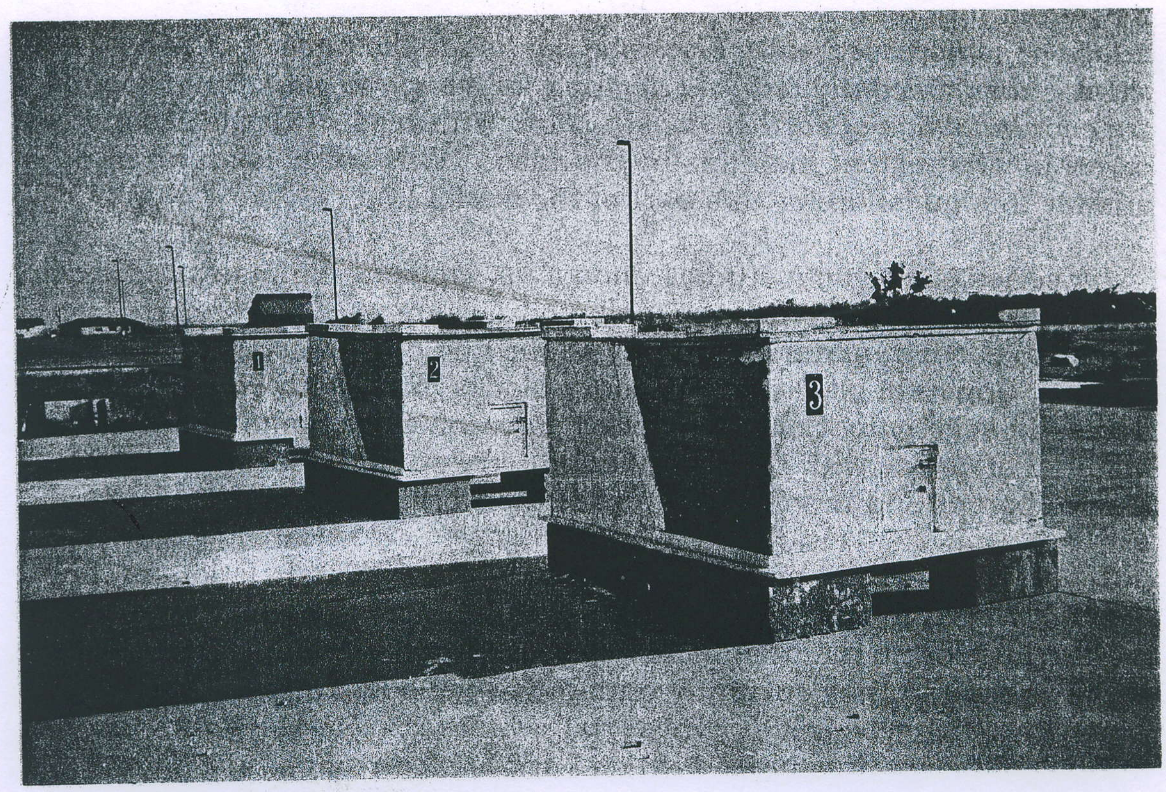

Three modules facing due north. From left to right: #1 concrete block, #2 adobe and #3 compressed earth block. The partial render on the two earthen modules allows exposure to the wall for taking moisture data and to illustrate a two-coated lime render. Modules rest on 8-inch concrete blocks.

2004

ABSTRACT

Three experimental modules were constructed and differed only in wall material consisting of one each of concrete block, adobe and compressed earth. Data was collected from each module from 31 May to June 3, 2004 during a heat wave in Del Rio, Texas.

Results indicate that the interior temperature of the adobe and compressed earth block modules were significantly lower than for the module of concrete blocks. The extreme is illustrated for May 31st. With a maximum ambient temperature of 107° the interior temperature of the concrete block was 111° or 4° *above* ambient. The adobe module was 95°, 12° *below* ambient, and the compressed earth block was 91° or 16° *below* ambient. The compressed earth block module was consistently cooler inside than the adobe by about 3°.

INTRODUCTION

The cost of building material for conventional construction is closely tied to the price of crude oil as is the price for public utilities. As the price of oil gradually spirals upward so will the cost of home building and home utility bills. What might be a sensible public response to this seemingly inevitable increase in the cost of living? One response is to turn to earthen building material for home construction. It would serve a two-fold function: 1st, *soil, the basis of earthen building material such as adobe or compressed earth blocks, is not tied to the price of oil,* and 2nd, *there is a significantly reduced demand for energy to maintain a comfort zone for buildings of earthen construction.* With respect to the second point, to what extent may this be the case? This study is an attempt to answer this question for this part of the world.

A series of on-going studies, indoor vs. ambient temperature, is being conducted in Del Rio, Texas. Small modules are used to compare cement blocks to earthen material, notably adobe and compressed earth blocks (CEBs). Concrete blocks are masonry blocks made with Portland cement and sand aggregate. Concrete block has become the home-building material of choice with the building industry on both sides of the U.S.-Mexico border and much of the rest of the world.

Concrete blocks are especially favored for home construction as they are easily used in construction, proven to be exceptionally durable, and require little or no maintenance. They are readily available in most parts of the world and they currently remain fairly modest in price in compare-ison with other type building material. *However, concrete blocks, as well as other masonry structures such as brick or stone work, have high thermal conductivity. They require careful attention to insulation to aid in maintaining an indoor temperature within the human comfort zone for extremes of cold and hot environments.*

In Del Rio, Texas, it is heat, not the cold that intrudes into the human comfort zone to the point that air conditioning is required. It is used every month of the year and, in summer, every hour of the day for several months running. Air conditioning is currently the only effective, but very expensive means, to significantly lower the indoor temperature when needed. Air conditioning is often the most costly item on the monthly energy bill for a significant part of the year. Thus these studies focus on the heat problem in summer rather than the cold problem in winter as is the case for most of the country.

THE MODULES

A new series of three modules, as illustrated in the frontispiece, have been built on property adjacent to the Southwest Texas Junior College campus in Del Rio, Texas. All are fully exposed to the sun throughout the day. The walls of the modules are composed of either concrete blocks, conventional adobe or compressed earth blocks (CEBs). 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 barometric pressure in the course of the day.

The modules all have a flat roof covered by 3/8 inch panel board insulated on the underside with a sheet of *Energy Shield,* a product of Atlas Roofing that is a foil faced foam board. It has an R-rating of 5.4. A sheet of this foam board is also used on the floors of the modules.

CONCRETE BLOCKS (CB): Mexican concrete blocks were used in the construction of the module and they differ from the American counterpart in being 6 inches rather than 8 inches thick but they are otherwise similar in appearance. The concrete block module is stuccoed with cement and painted with an off white cement paint to match the color of the two lime stuccoed earthen modules.

ADOBE BLOCKS: soil used for the adobe is the same as for the compressed earth blocks and processed with a ½ inch sieve. Horse manure was added to the adobe soil. A 6" x 12" x 3" mold was used to form the blocks.

CEBs: same soil and same dimensions of length and width of blocks as for the adobe. Soil is thoroughly moistened and then compressed in a CINVA Ram and allowed to dry about 3 days before use.

METHODS

ONSET data loggers (U12-011) were utilized inside the modules and set to record temperature, relative humidity and dew point every three hours continuously during the time of the experiment. Doors were kept closed at all time. Only the temperature data is here considered. Temperatures were read to the nearest whole number.

Data was also collected of the moisture content of the walls, morning and late afternoon, of the two earthen structures using a DELMHORST J-Lite moisture meter. Analysis of these data awaits study.

DATA ANALYSIS

Data was collected from each module from 31 May to June 3, 2004 during a heat wave in Del Rio, Texas. Data is provided by the National Weather Service, Daily Summary, Del Rio Airport. All temperature is recorded in Fahrenheit. The maximum ambient temperature is given followed by the maximum inside temperature of each module. For the two days of June, extremes of temperature variation are recorded for themodular interiors.

May 31st

Max. ambient - 107°

CONCRETE - 111° 4° > ambient

ADOBE - 95° 12° < ambient

CEB - 91° 16° < ambient

Comment: The earthen materials were both well under ambient as opposed to the CONCRETE BLOCK that was 4° *above* ambient. The CEB was 20° and the ADOBE was 16° *lower* than the CONCRETE BLOCK. Data recording began late on the 31st thus average extremes not provided.

June 1ST

Max. ambient - 104° ***max. variation - 39°***

CONCRETE - 109° 5° > ambient; max. variation - 32°

ADOBE - 97° 7° < ambient; max. variation - 17°

CEB - 93° 11° < ambient; max. variation - 14°

Comment: it is noteworthy that the extremes of variation of temperature of the CEB was less than half that of the concrete block and 3° less than the ADOBE.

June 2nd			
Max. ambient 101°			***max. variation - 13°***
CONCRETE - 107°	**6° > ambient;**	**max. variation - 24°**	
ADOBE - 96°	**5° < ambient;**	**max. variation - 11°**	
CEB - 93°	**8° < ambient;**	**max. variation - 8°**	

DISCUSSION and SUMMARY

When the highest ambient temperature on 31st of May was 107°F the concrete module registered 111° for a gain of 4° above ambient. At the same time, the compressed earth block module registered an interior temperature of 91° -- thus the CEB module was 16° below ambient and 20° lower than the concrete module. We have here a persuasive example of the power of latent heat of vaporization, or evaporative cooling. We may well ask at this point, what would be the energy cost to bring an interior temperature down 20° in an over heated home to match the interior of a house experiencing latent heat of vaporization? This is an important question awaiting further study.

Adobe and CEBs are "phase-change materials" – they will either gain or loose heat due to latent heat phenomena depending on local atmospheric conditions related to moisture. They thus profoundly differ from conventional building materials. When relative humidity is high, as in the mornings, water vapor is absorbed and stored as a liquid and earthen material gains in heat as a consequence of *latent heat of condensation*. In late afternoon, when relative humidity is lowest, stored water is released as a vapor and thus the earthen material loses heat as a consequence of evaporative cooling or *latent heat of vaporization*. These important physical phenomena must be recognized to appreciate the results of the experiments just discussed. The relationship of adobe to latent heat was covered in depth in an earlier paper (Morony 2004),

The CEB block module was consistently lower in internal temperatures by about 3 degrees compared to the adobe. No attempt is made at this time to explain why they should have differed. They were constructed from the same soil as the adobes. However, the adobe had organic matter added (horse manure) as is typical with adobe making. They were formed the customary way with a wooden mold. The CEBs had only moisture added and were then formed into blocks using a CINVA Ram. However, caution must be used in generalizing from this relationship with this particular soil. Adobe soil varies very extensively in the nature of clay and aggregates that may have an important bearing in their final outcome as either adobes or CEBs.

In conclusion, for the climate as here in Del Rio, earthen building material should be given consideration as the possible building material of choice. There is a long list of advantages using earthen material for building but the fact that it is naturally a 'phase-change' material is, perhaps, its most significant quality in this part of the world. An excellent reference to earthen construction in general is found in Houben and Guillaud (1989).

ACKNOWLEDGEMENTS

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LITERATURE CITATIONS

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Morony, John J. 2004. *Adobe and Latent Heat: A Critical Connection.* Second Annual Conference of the Adobe Association of the Southwest, Northern New Mexico Community College, El Rito, New Mexico