HOT BOX

Matthew Duane Linn, Timothy Wallace Kremer
University of Oregon
Department of Architecture
Eugene, OR 97403
mlinn@uoregon.edu,
tkremer@uoregon.edu

Drew Wood Hastings
University of Oregon
Department of Architecture
Eugene, OR 97403
ahastin1@uoregon.edu,

Jocelynn Gebhart
University of Oregon
Department of Architecture
Eugene, OR 97403
jgebhart@uoregon.edu

ABSTRACT

The poetry of thermal delight has many subtle verses, and far too often we forget that the glow of our own warmth seems all the brighter when contrasted with the deep chill of nightfall. Combating cold is an easy task in most homes in our society, but our team decided to challenge our existing notions of space by building a new structure of more "improvisational means". Using items commonly discarded as the byproducts of everyday life, we created an outdoor sleeping shelter that takes advantage of a few kinds of power that don't come from an outlet; elbow grease and solar radiation.

1. INTRODUCTION

When asked to research and present a case study on an existing building, our questions about thermal delight and comfort led us down a different path. It would be a journey that would take us into the minds and lives of the homeless community, allowing us to extend our new scientific knowledge to something more human and emotional. Creating our own structure posed a more exhilarating challenge in our eyes, and we felt it also stood to teach us a great deal about design. With no money in the budget, we had no choice but to use what was easily found. We had the sun, and what materials could be scavenged.

Our initial concept involved creating a structure that could be easily reproduced and transported, constructed primarily of found low/no-cost materials. Through our field research we discovered that we would have to focus our energies on building a shelter that could provide warmth using readily available materials. Portability fell to the wayside, due to the fact that water is heavy and accounts for about 65% of the weight of the structure. It would take the structural abilities of wood to get what we wanted.

It was our hope that perhaps transient populations could reproduce the work we created to provide them with a reasonably comfortable place to sleep. Therefore, along the way we made sure to keep everything simple, not relying on motorized tools, or electricity. Instead we used a hammer (for fastening and demolition), a pry-bar (for demolition), a screwdriver (for fastening), and a chisel (for the few cuts we inevitably had to make). By sticking to our plan we were able to create something that took very little ability, or resources to erect.

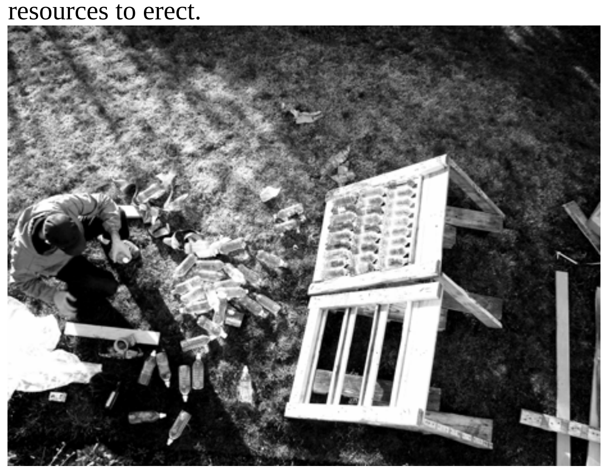

Fig. 1: Structural exploration of the water wall system.

The materials used for the structure also had to be easily found, and transported. This is why we chose to use plastic bottles (for the water wall), plastic bags (for insulation), and cardboard (as exterior and interior board). The pallets were more difficult to transport, but can be dismantled and carried longer distances with ease.

Fig 21: Found materials provide the recycled content of the structure.

2. HYPOTHESIS

The small shelter that we will create of readily available low/no-cost materials will maintain a nighttime temperature difference of 15-degrees between the interior and exterior.

3. METHODOLOGY

Early on, the team decided to use solar radiation to help heat the structure by means of a trombe wall. Water was a natural choice of materials, because of its high heat coefficient. As plastic soda and water bottles are abundant throughout most cities, we determined they would be good storage containers for water in the trombe wall.

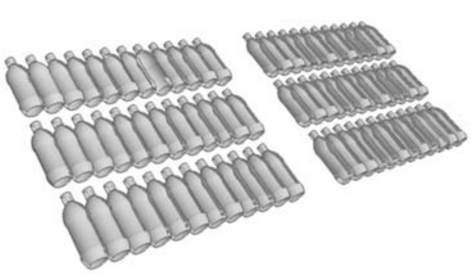

Fig. 3: Water bottles stacked along the south wall to comprise the water wall.

Our initial attempts at creating a trombe wall using duct tape, plastic bottles and plastic trash liners was met with failure, so we set about to devise a new strategy. In order to provide stability and a simple rustic charm to our structure we decided to use shipping pallets to our advantage.

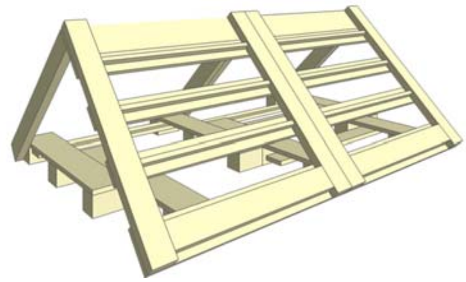

Fig. 4: Designing within the structural module of the pallet maintained ease of assembly.

Using the size of the pallet as a module, we were able to minimize the number of cuts made, and were able to put the wood and water bottles in compression, in turn holding them in place. The orientation of the pallets was selected to foster the basic human needs for sleep. Every facet of the pallet was utilized including the size, the nails, and the wood. As seen in (fig. 4) the wood pallets are the backbone of the structure, and also provide a floor for the shelter. This platform contains interior pockets that were packed with plastic bags acting as insulation. In (fig. 5) the exploded diagram of the shelter clearly shows all of the components explained.

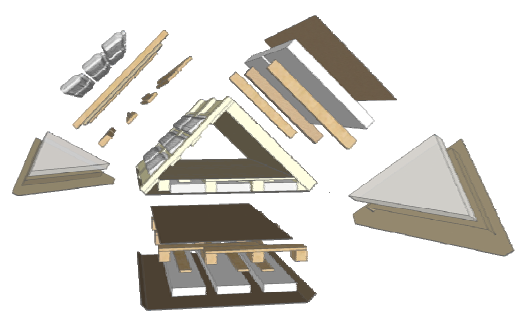

Fig. 5: An exploded view of the shelters materials, and construction.

The angle of the trombe wall was selected for two reasons; first it corresponded to the length of wood salvaged from the pallets, and secondly, to the angle of the sun. At latitude 44° our winter solstice angle is approximately 20.5°, and our summer solstice angle is about 67.5°. Staying within the module of the pallet, we were able to get an angle of close to 40°. To form the rest of the structure we used cardboard in lieu of drywall, and plastic grocery bags as insulation, thus creating a snug dwelling able to maintain warmth and privacy.

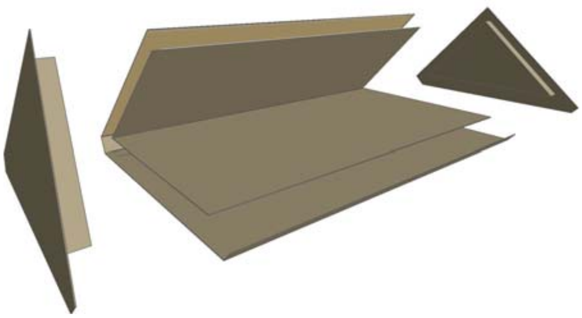

Fig. 6: Cardboard used as drywall, siding, insulation, and door material.

In order to intensify the absorption of heat, the bottles were filled with blue food coloring. In addition, black garbage bags were woven through, as well as laid across the bottles. The intention was to encourage heat inclusion, as well as air pockets for additional insulation. A further layer of 1/16" clear plastic was then attached to one side of the structure, in order to create both, greater insulation, and a barrier from the elements. This layer may be easily rolled up for maintenance.

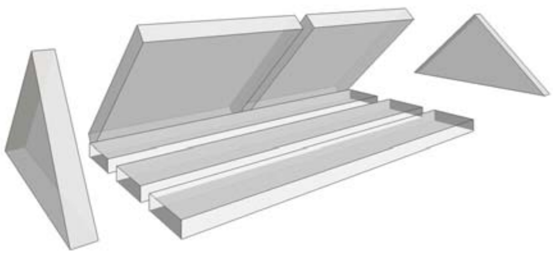

Fig. 7: Insulate before you insolate.

Through the use of data loggers, the group was able to better understand the modifications needed for our goal. While temperatures were initially maintained in the early portions of the night, insufficient insulation resulted in infiltration which actually caused lower interior temperature readings in the morning compared to exterior. (See Fig. 8)

In order to safeguard against infiltration and heat loss, an additional panel was installed along the bottom of the shelter. Comprised of cardboard and aluminum foil, this "flap" acts not only as additional insulation, but a reflective surface for greater thermal gain during the day. The panel can be lowered and raised in accordance with sun exposure. When raised and tied back, the panel radiates heat back into the structure, while also providing additional privacy and insulation for the occupant.

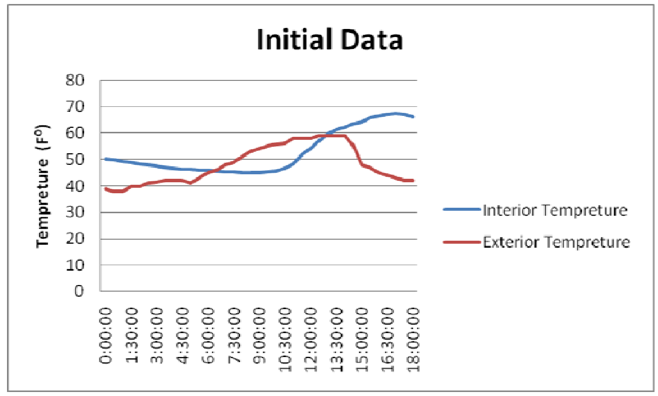

Fig. 8: Graph showing initial data gathered.

Further testing proved the shelter to be successful. Data loggers were placed on the interior of the structure at the entrance, the opposite end, as well as the peak. Additional loggers were used to measure the exterior environment and then compared and contrasted to data obtained from the National Oceanic and Atmospheric Administration for consistency and reliability.

4. <u>DATA ANALYSIS</u>

Data collected was astounding (Fig. 9). While the structure maintained the goal of a +15° F difference of interior and exterior, data collected from the south data logger (the peak of the shelter) proved the material to be overly successful and mildly dangerous. Temperature readings of over 150° F further prove the enormous influence that solar absorbent colors and materials have on a structure.

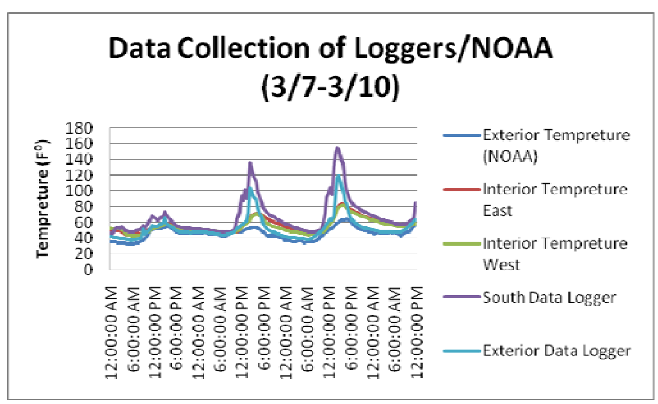

Fig. 9: Data collection using multiple data loggers.

Interior temperatures gradually increased throughout the day and maintain well above the exterior temperatures through the night. Peak interior temperatures coincide with climax of sun exposure at about 3:00 PM PST, resulting in interior temperatures of about 83° F. The panel was then raised, in order to radiate heat from the bottles back into the structure. The internal temperature then gradually declined throughout the night, however consistently stayed above the exterior temperature by about 15° F. The interior west data logger demonstrated interior temperatures to be greater when in close proximity to the trombe wall, as to be predicted.

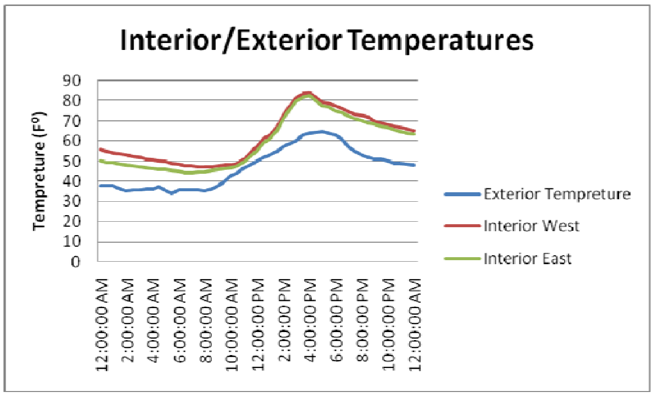

Fig. 10: Interior and exterior temperatures with addition of insulation and reflectant pad.

While the exterior temperatures fell more dramatically at approximately 7:00PM PST, the interior maintained a steady slope of declination. Interior and exterior readings are most similar at approximately 10:00 PM PST, as the outdoor temperature begins to rise, while the trombe wall has exhausted the stored energy from the previous day. At this point, the trombe wall begins to regain energy from morning sun exposure.

The most pertinent information was obtained while the shelter was occupied on March 8th from midnight to 8:00 AM PST. The interior data loggers demonstrated a slight decline as the occupant entered the structure, however temperatures increased over the next 15 min. with the door closed.

The most fascinating data was obtained from the south data logger, which continued to climb in temp for the next several hours. Due to the position of the logger being in the peak, we attribute this increase to the introduction of body heat into the shelter. These readings are higher than that of other interior loggers, due to heat rising and escaping through the peak.

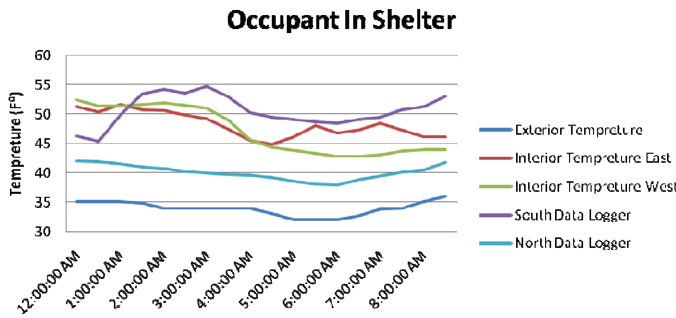

Fig. 11: Graph showing temperatures of occupied shelter.

Temperature readings from the interior east logger also begin to rise at approximately 5:00 AM PST. While this logger would logically read higher due to its placement further in the structure, the most reasonable and appropriate explanation would be that the occupant either rolled on top of the logger, or began to breathe on it. Regardless of the circumstance, interior temperatures remained well above the exterior temps by 15° F.

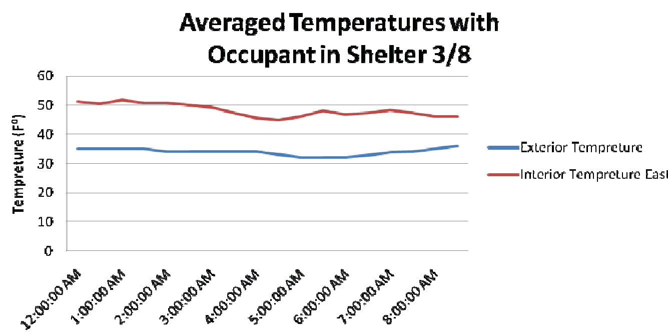

Fig. 12: Average temperature of occupied shelter.

While the structure proves to be very successful in absorbing and maintaining heat in a manner that meets and even exceeds the initial hypothesis, portions of the structure may be too successful, and even dangerous. (Fig. 13)

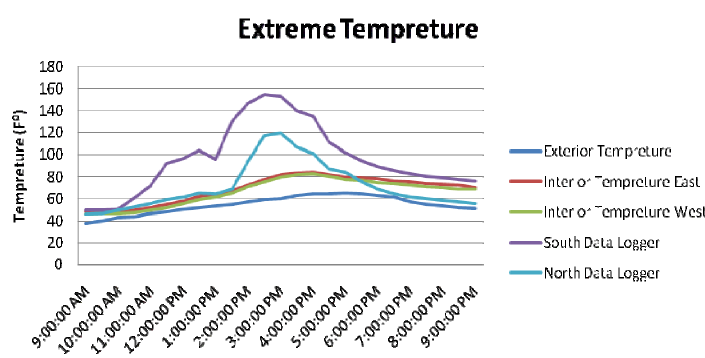

Fig. 13: Extreme temperatures

On March 8th, with exterior temperatures reaching about 65° F and the structure being in full sun exposure, the south data logger in the peak reached a high temp of close to 150° F. This extreme can only be explained by the position of the logger be at the highest point, while also being underneath the black garbage bags. While these temps are above and beyond what this group could have ever predicted, the emissions of volatile organic compounds (VOC) could create an unsafe air quality in the somewhat sealed interior of the structure.

In the production plastic bags, manufactures add several toxic chemicals to # 3 PVC in order to bring plastic into its flexible form. These chemicals are known as “plasticizers” and the most common effect of exposure to their VOC’s is comparable to second hand smoke.

While these extreme temperatures had diminished by the evening, these toxins may still be found in the structure. In order to prevent this occurrence, other materials may be necessary for assuring safety and clean air quality. In addition, further understanding of the sun exposure and ventilation of the structure would be beneficial in the development of this shelter.

5. CONCLUSION

Creating a small shelter of no-cost readily available materials that would maintain a +15° F difference between interior and exterior environments is not only feasible, but relatively simple. This structure, through further exploration of alternative materials, may be a cost effective and simple means of creating a more comfortable sleeping environment for the disenfranchised.

Further research and understanding of sun exposure and location would greatly enhance the feasibility of this structure in a variety of different locations. Alternative liquids or coloring may also be investigated for greater thermal gain.

6. ACKNOWLEDGEMENTS

The Authors of Hot Box: A Case Study in Search for Shelter would like to express appreciation to: Safeway, Paul’s Bicycle Way of Life, International Paper, University of Oregon Book Store, The National Oceanic and Atmospheric Administration, Jessica Hastings and Prof. Allison Kwok.

7. REFERENCES

1. Gerberding, MD, MPH,, Julie L. . "Agency for Toxic Substances and Disease Registry." Agency for Toxic Substances and Disease Registry. Department of Health and Human Services. 12 Mar 2008 <www.atsdr.cdc.gov >
2. "National Oceanic and Atmospheric Administration." National Oceanic and Atmospheric Administration. Mar 14, 2008. United States Department of Commerce. 12 Mar 2008 <http://www.noaa.gov/index.html>