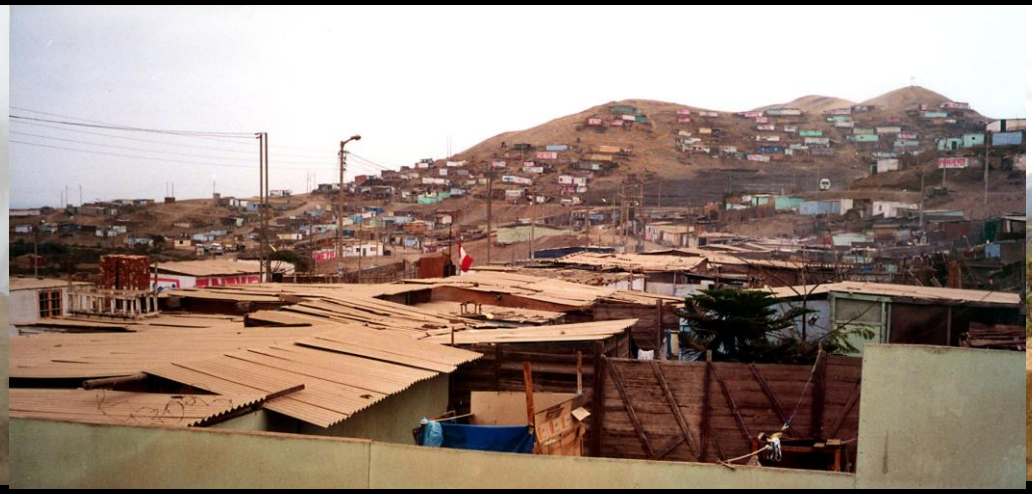
IPRO 325: Affordable and Sustainable Quality of Life Improvements for the World's Poor

Innovative Roof Design


The Team

Lulu Al-Awadhi	**4th Year Architecture**
Louis Fernandez	**4th Year Architecture**
Dan Rankin	**5th Year Architecture**
Jacob Williams	**5th Year Architecture**
Richard Rokita	**3rd Year Mechanical Engineer**
Maruja Yoshimura	**4th Year Chemical Engineer**

The Problem: Friaje

Winter of 2009

- State of emergency declared due to extreme cold

- Temperatures reached -22 C (-7.6 F)

- Death of approximately 250 children

- Thousands more suffered from acute respiratory infections and pneumonia

- Malnutrition intensifies due to poor crop yield

- Mass death and sickness of livestock

Objectives

Improve extant housing through an innovative roof alteration

- Add insulating materials to the roof

- Create a more robust roof structure

- Reduce overall air infiltration

- Prevent roof leakage

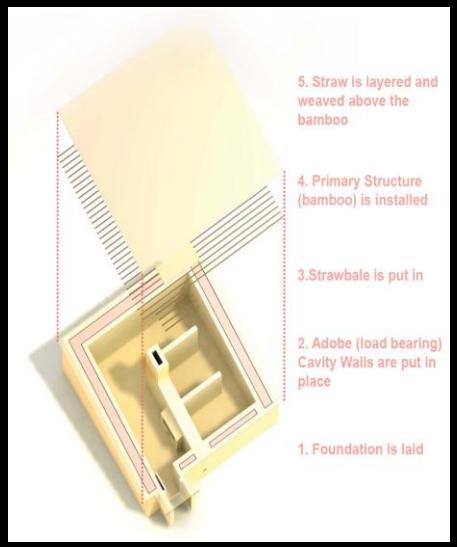
Last Semester's Project

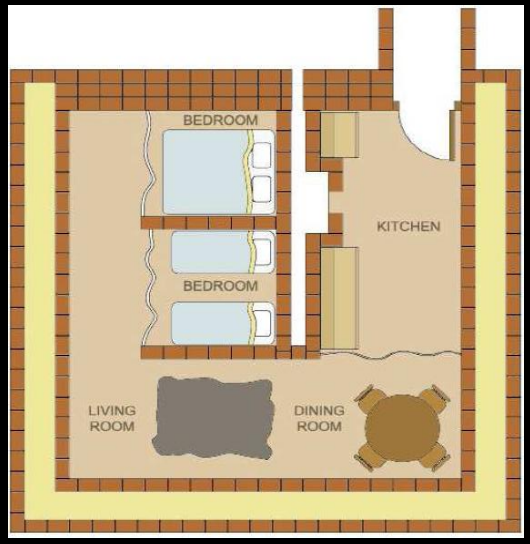
- Conceptually design an adobe house to withstand the friaje

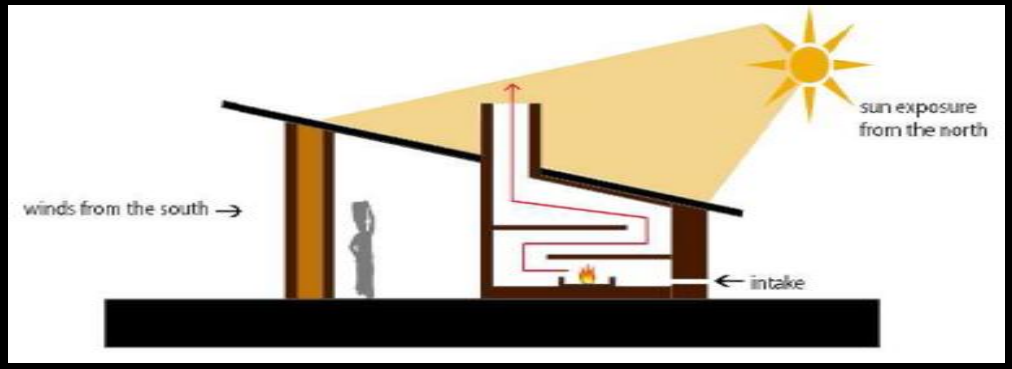
- Utilize locally available materials

- Lacked detail

- Project scale too large to practically implement beyond a prototype







Location: High Altitude & Cold Weather

- **Model location:**
  - **Mountain Highlands**
  - **(i.e. Langui, Peru)**

- **May through October**
  - **Dry season**
  - **Hot days, cold nights**

- **November through April**
  - **Wet season**
  - **Mild temperatures**
  - **Heavy rain**

Action Being Taken

- Adventist Development and Relief Agency (ADRA)

- United Nations Children's Fund (UNICEF)

- Practical Action

Current Roofing Construction

- Single sheet of corrugated metal

- Sometimes secondary structural beams are included

- No insulation

- Poor connection between materials

Ethics and Design Constraints

- Inexpensive

- Utilizes exclusively locally available materials

- Can easily be communicated to locals

- Can be built relatively quickly using unskilled labor

- Requires no special tools to construct

- Must have a long lifespan

Structural Concerns

- Heavy snow loads (uniformly distributed live loads)

- Heavy wind loads (somewhat erratic lateral loads)

- Roof must be supported on an existing adobe wall (basic load-bearing structure)

Materials

Materials that are locally available:

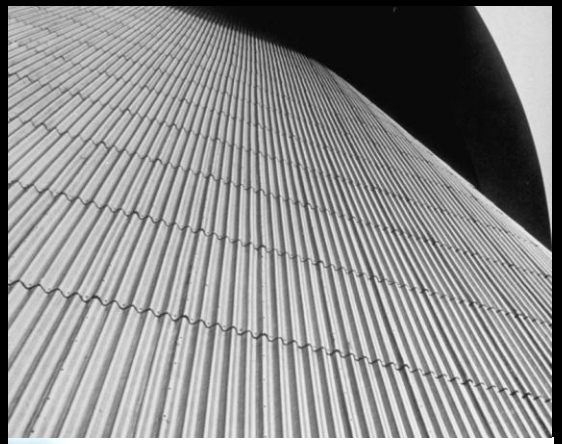
- Framing Materials:
Bamboo or Eucalyptus

- Fasteners:
Rope, Leather Strips, Nails

- Roof Covering:
Corrugated Sheet Metal, Fired Clay Tiles

- Insulation Materials:
Straw with Clay Binding

- Waterproof Patching:
Tree Sap, Bitumen (tar-like with a petroleum base), Animal Fat

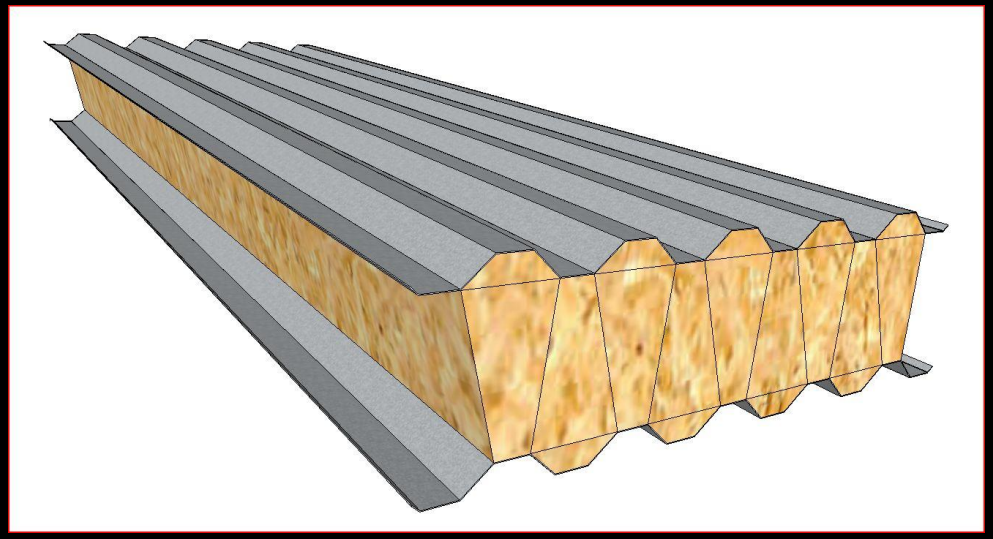


Sandwich Panel System

- Straw Bale
  - Good insulator
  - Flammable

- Adobe Clay
  - Serves as a binder
  - Somewhat fire resistant

- Corrugated Sheet Metal
  - Water proof
  - Fire proof

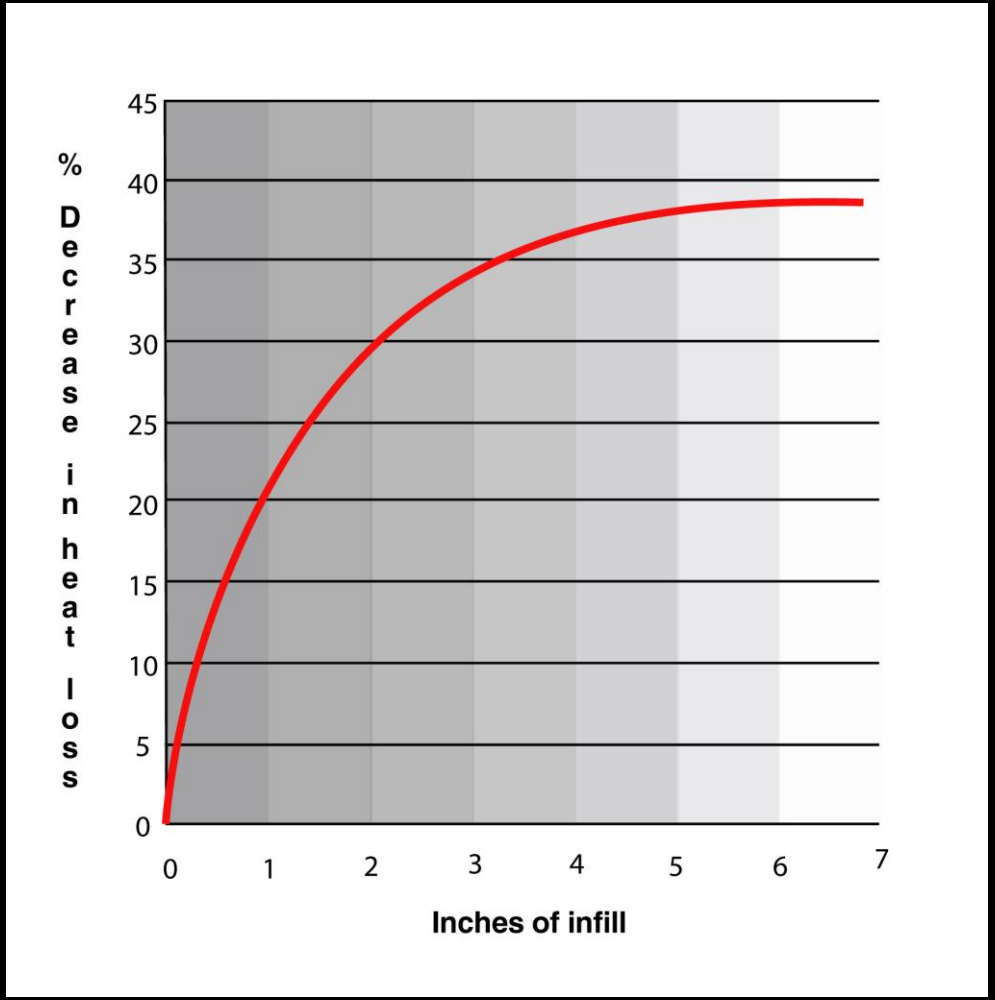


- Utilize all materials in a novel assembly

Thermal Testing

- **Graph showing percent decrease in heat loss vs. inches of infill.**

- **Diminishing returns after four inches of infill**



Final Design

Full Scale Roof Model

- **The model tests the strength and durability of the design as a whole**

- **The model also portrays all of the details as designed by the team**

Benefits of the Design

- 40% decrease in heat loss

- Reduces moisture and air infiltration considerably

- Extremely low cost; sheet metal is the most expensive component: .83 x 1.8m for $4.10; quote from company in Lima

- Simple construction method; uses no tools

- Does not depart significantly from the vernacular aesthetic

Problems & Obstacles

- Team was not able to perform strength tests on the roof design

- Thermal test of insulation not completed; but calculations have been done

- Graphic construction manual still needs to be completed

Next Steps

-Test the design on site in Langui, Peru

- Inform Peruvians about the design

- Assess whether or not Peruvians would realistically use the design

- If the project is a success in Peru then a graphic-driven design manual should be created




Questions

Sources

1. "Surviving the Friaje". Practical Action. 03 Oct 2009 <http://practicalaction.org/climatechange_friaje>.
2. Collyns, Dan. "Children Die in Harsh Peru Winter". BBC News, Lima. 03 Oct 2009 <http://news.bbc.co.uk/2/hi/8146995.stm>.
3. "Peru Declares State of Emergency Due to Record- Breaking Cold Spell". Andean Air Mail and Peruvian Times . 03 Oct 2009 <http://www.peruviantimes.com/peru-declares-state-of-emergency-due-to-record-breaking-cold-spell/>.
4. "Puno Regional President Accused of Negligence in Child Deaths From Cold ". Andean Air Mail and Peruvian Times . 03 Oct 2009 <http://www.peruviantimes.com/puno-regional-president-accused-of-negligence-in-child-deaths-from-cold/> .
5. "Deadly Cold Wave Brings Misery to Southern Peru". Adventist Development and Relief Agency (ADRA) International. 03 Oct 2009 <http://www.adra.org/site/News2?page=NewsArticle&id=10259> .
6. "Peru: Cold Weather Deadly for Children". UNICEF. 03 Oct 2009 <http://www.unicef.org/infobycountry/peru_27539.html>.
7. "Climate change: intense cold front has killed 20,000 alpaca in Puno ". Andean Mail and Peruvian Times. 08 Oct 2009 <http://www.peruviantimes.com/climate-change-intense-cold-front-has-killed-20000-alpaca-in-puno-so-far-this-year/>.
8. <http://www.andeantravelweb.com/peru/tips/weather.html>.

Sources

9. “Code of Ethics and Bylaws”. American Institute of Architecture. 01 December 2009. http://www.aia.org/about/ethicsandbylaws/index.htm
10. “Adobe Houses: Peru”. World Encyclopedia. 01 December 2009. http://www.eeri.org/lfe/pdf/peru_adobe_house.pdf