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 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
Sources

http://www.aia.org/about/ethicsandbylaws/index.htm