

1.101 Introduction to Civil and Environmental Engineering Design
Fall, 2005
Design Project 3-Thermal Design
Laboratory Exercise

Purpose: In this exercise, teams will cooperate in the construction of six lab-scale 'houses', each built with a different standard construction technique, including:

- Conventional Frame construction, uninsulated
- Conventional Frame construction, with fiberglass batting insulation and interior drywall
- Conventional Frame construction, layered reflective foil insulation and interior drywall
- Frame construction with window
- Single-width brick construction
- Hollow-core masonry unit ('cement block') construction

Each unit will be tested to i) illustrate the nature of heat flow through a wall, ii) determine an overall heat loss coefficient, iii) provide a target for use of thermal infrared imagery to remotely determine interior wall construction, possible defects, and absolute temperature

Procedure:

- 1) Each team or consortium of teams will construct a 3 ft by 3 ft by 3 ft 'house' structure at a location specified in the laboratory.
- 2) Each structure will be heated to an interior temperature approximately 50 degrees F above ambient laboratory temperature by an electric heater equipped with a watt-hour meter to measure total energy input.
- 3) After steady state is reached, teams will measure total power required to heat the structure, and skin temperature of both inside and outside surfaces. Teams will also obtain thermograms using an infrared camera.
- 4) The data will be used to determine the effective R value of the construction, and the R value associated with air films both inside and outside. This will be compared with calculations carried out using standard, published parameters.
- 5) The infrared imagery will be used for: a. practice with the cameras and software, b. evaluation of the internal structure of the walls of the model 'houses', including defects, thermal short circuits, and other leaks, and c. comparison of inferred wall surface skin temperature with actual contact measurements, to assess the ability of the infrared cameras to estimate absolute temperatures

Data and interpretation are to be reported by each team in the form of a lab exercise on the following form. Data will also be pooled and made available for the entire class.

Thermal analysis of your structure.

Details of wall construction:

Use tabulated thermal data for the various types of construction to estimate the effective R value of the walls. Note that if the walls are very heterogeneous you will need to calculate an R for each different type of wall. Assume a 'still air' boundary on both inside and outside. Show the calculations here, and clearly indicate the resulting R values:

Calculate the predicted heat loss from your structure, in both BTU/hr and in watts, for a temperature difference of 50 degrees F. Be clear about the areas that you are invoking when you make the calculations. Use an average of inside and outside wall areas to account for corners.

Predict the difference between outside temperature and the skin temperature of the outside of the structure once steady state has been reached. How does this compare with actual measured temperatures as determined i. by a contact thermometer, and ii. by remote infrared imagery? What percentage of the total heat loss do you figure is lost by radiation?

Note here any conclusions that you may draw from thermal imagery concerning the thermal performance of the structure you helped to build. Specifically note any issues related to workmanship or to materials performance that have a bearing on overall thermal performance.

Based on data obtained by the whole class, rank the thermal performance of the different wall types. Do you have any conclusions that would be relevant for architects and builders who are interested in creating 'sustainable' buildings?