Project #2: Building Heating Design

Due Thursday, 20 October 2005

The objective of this project is to evaluate the heating equipment requirements of a low-income residence. Specifically, you will develop a conceptual design of a 1000 ft² residence and evaluate the heating requirements of the building. You may work individually or in teams of two.

The building has the following program requirements.

- Located in suburban Chicago
- Single story rectangular house with total floor area between 950 - 1050 ft².
- Three bedrooms, each with floor area of about 100 - 120 ft².
- Kitchen, dining, and living area. (separate dining room not necessary)
- Bathroom, with floor area of about 60 ft².
- Space for laundry and utilities (water heater, furnace)
- Slab-on-grade foundation.
- Ventilated attic with insulation between the indoor room ceiling and the attic space.
- Wood construction with framed walls or structural insulated panels (SIPs). Wall framing should be 16” on center. Ceiling trusses should be 24” on center.
- Windows are double hung, and either 3’0” x 5’0” or 3’0” x 3’0” (rough-in areas) with white vinyl frames. (Windows can be doubled-up to give 6’x5’ or 6’x3’ combined size.) Total window area can not exceed 140 ft²
- Two exterior doors, 3’0” wide.

You are expected to develop a basic conceptual design for the building. Several sample designs are attached, which you are welcome to use or modify. (These designs were obtained from a Purdue University website for a Habitat for Humanities project. [http://epics.ecn.purdue.edu/hfh/sub_websites/web_project/](http://epics.ecn.purdue.edu/hfh/sub_websites/web_project/)

The thermal characteristics of the envelope construction must comply with ASHRAE Standard 90.2-2001. The Standard prescribes maximum $U$ values for building envelope components depending on climate as characterized by the heating degree days below 65°F, $HDD_{65}$, and cooling degree hours above 74°F, $CDH_{74}$. For Chicago, $HDD_{65} = 6183$ °F-days and $CDH_{74} = 9736$ °F-hr. The table below gives the prescribed values. For ceiling with attic, ceiling $U$ values is calculated from the inside air to the attic air, including surface conductances. The wall, window, and door $U$ values are calculated from inside to outside air.

Assume that the building is relatively tight construction. You should select a generic window from the tables of the text.

<table>
<thead>
<tr>
<th>Assembly</th>
<th>Thermal Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling</td>
<td>$U \leq 0.036$ Btu/hr ft²°F</td>
</tr>
<tr>
<td>Wall</td>
<td>$U \leq 0.063$ Btu/hr ft²°F</td>
</tr>
<tr>
<td>Window</td>
<td>$U \leq 0.36$ Btu/hr ft²°F</td>
</tr>
<tr>
<td>Door</td>
<td>$U \leq 0.19$ Btu/hr ft²°F</td>
</tr>
<tr>
<td>Slab-on-Grade</td>
<td>Vertical perimeter insulation with R-8 extending 2 ft below grade (F₂ = 0.55 Btu/hr ft²°F)</td>
</tr>
</tbody>
</table>
Deliverables

Your submittal should take the form of a technical report. Your report should include the following elements:

1. Executive summary giving project objective and overall conclusions.
2. Description of the project and your building design, including conceptual drawings of your proposed design. The design should be detailed enough to assess the impact of building thermal characteristics. (For example, you do not need to show kitchen cabinetry or toilet locations, since they do not impact the thermal performance.) You should prepare basic drawings of your building floor plan and elevations.
3. Description a set of building envelope characteristics that would just comply with the minimum requirements of ASHRAE Standard 90.2-2001. The description should include the physical and thermal characteristics of the walls, roof, windows, doors, and slab-on-grade foundation.
4. Calculations of the design heating requirements for the building. Select an indoor air temperature that you expect to provide comfort in winter. Your calculations must include the heat transfer through the walls, roof, windows, doors, foundation, and infiltration. Detailed calculations of all $U$ values should be given in appendix.
5. Calculation of window, wall, and ceiling surface temperatures for the building under the design winter conditions. Discussion of the potential for condensation on windows.
6. An evaluation of the thermal comfort conditions in the house. Perform PMV calculations for a person in the living room and for a person in one of the bedrooms. Assume that the furniture and floor are at the air temperature. Does the air temperature you selected provide a comfortable condition in winter?
Project #2 Evaluation

Names: __________________________________________________________

Overall Presentation  _____________ /10
   Organization
   Grammar and Writing

Executive Summary  _____________ /5
   Descriptions
   Conclusions

Building Design and Description  _____________ /15
   Description
   Design
   Drawings
   Standard 90.2 compliance
   Low-energy design and description

Load and Energy Calculations  _____________ /50
   Wall and Roof U-values  20
   Other envelope components  10
   Infiltration and ground  10
   Design loads  10

Surface Temperature Calculations  _____________ /5
   Calculations
   Discussion

Comfort Calculations  _____________ /15
   Radiant temperature calculations
   PMV calculations
   Discussion

Total:  _____________ /100