# CE 507: Building Science and Technology

## Assignment #2 (6% of final grade)
## Heat Flow and Energy Use (Chapter 4 and 5)

Please provide concise and clear answers, stating all assumptions. Hand in the assignments in *groups of four*. Please confirm with TA any different group size or marks will be subtracted (20% reduction for a group of 3 and 25% reduction for five).

The assignment should be submitted as a technical report, with the date, title, and the names and ID#'s of each of the members prominently displayed on the first page/cover. It should be permanently fastened (staples, or similar). Considering the marks awarded for this assignment, one should expect at least 10 hours per member involvement.

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1. Using *hand* methods, calculate the is the R-value and the U-value (in both metric and imperial units) overall through a 200 mm thick concrete wall, with no insulation, a 25 mm airspace, and 90 mm clay brick veneer. Under extreme design conditions in Waterloo, the wall must separate interior conditions of 21 ºC and exterior conditions of a windy -20 ºC. What is the heat flux under these conditions.

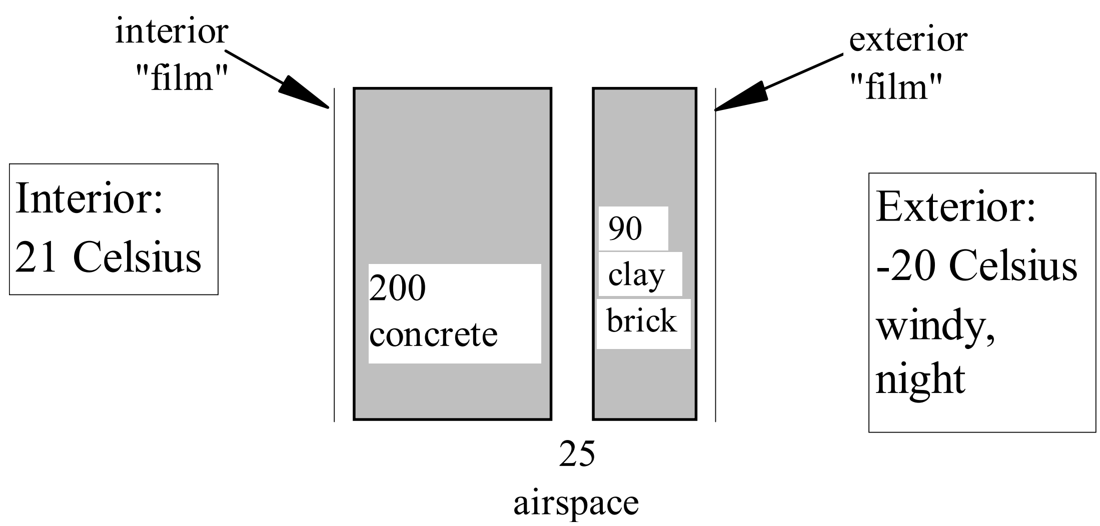


**Figure 1: Wall Assembly**

2. Now develop a spreadsheet to:
   i) calculate thermal resistance and heat flow through enclosure assemblies with an arbitrary number of layers, AND
   ii) calculate the temperature conditions at each wall layer interface.

   Use the spreadsheet to calculate the temperature and heat flow through the wall system in question #1

a) Plot the temperature distribution through the thickness of the wall, preferably by hand.

b) If the exterior design summer temperature is 29 ºC, what is the temperature distribution? Plot the results on the same plot as in a)

c) What would be the effects of summer sun on such a wall if it faced south? Plot the results on the same plot as in a).

3. Calculate the heat transfer through the wall of Question #1 for winter design conditions, with 0, 25, 50, 75, and 100 mm of EXPS Type 4 insulation on the outside of the concrete structure. Plot the temperature gradient through the wall on the same plot for comparison (e.g. pretend the insulation has the same thickness and compare the temperature drop through the other layers).

   Give your opinion of the effect of insulation thickness on the temperatures experienced (on average and in extreme winter and summer conditions) by i) the brick and ii) the block?

4. Consider a building 15 m wide, 9 m high, and 50 m long comprised of a wall enclosure built in the same way as the wall described in question 1 and windows with an RSI value of 0.50. The flat roof has an RSI value of 3.50. Windows comprise 20% of the wall area.

a) What size of a heating source would be required to maintain the temperature inside at 21 ºC under the exterior design conditions for each of the five possible walls, e.g. 0-100 mm of insulation? (Ignore foundation losses). What is the relative contribution of each component to the heat loss when 0 mm and 100 mm are installed.

5. Many well-insulated buildings loose a significant amount of heat energy by convection, e.g., air-leakage.

a) If the building in Q4 were to leak approximately one-half building volume per hour (i.e, 0.6 air change per hour, or 0.6 ACH), what contribution would air leakage have to the overall design heating load. How does the air leakage affect energy consumption?

b) Based on a), Is the R-value an accurate or useful measure of space heating energy consumption of the building described?

6. Perform a simple cost-benefit analysis on the building. If heating energy costs $0.05/kWhr, and you wish to recoup your investment in 7 years (a compound rate of return of 10% per year):

   a) how much money would you be willing to spend to reduce air leakage from 0.6 ACH to 0.3 ACH?

   b) How much money would you spend to change the windows from $R_{SI}$0.5 to $R_{SI}$0.25?

   c) What should be considered to reduce energy consumption in this building? Which do you think will be the least cost?