CHAPTER 5 CONVECTION AND INFILTRATION IN ROOMS AND CAVITIES

5.4 Infiltration

Infiltration of outside air and exfiltration of inside air cause a net air flow through the building envelope called infiltration. Infiltration causes both sensible and latent heat loss or gain. First, we calculate this heat transfer based on a given volume of air entering the building.

Sensible heat gain/loss q_s calculation:

$c_p := 1000 \ \frac{J}{kg \cdot \Delta°C}$ specific heat of air

$\rho := 1.2 \ \frac{kg}{m^3}$ density of air

Let

$Q := 50 \ \frac{l}{s}$ volume of outside air entering building

Let

$Ti := 23 \ \Delta°C$ inside temperature

$To := 0 \ \Delta°C$ outside temperature

$q_s := \rho \cdot c_p \cdot Q \cdot (Ti - To)$

$q_s = (1.38 \cdot 10^3) \ W$

If moisture must be added to the indoor air to raise the humidity level to the comfort range, the energy required to evaporate an amount of water equal to that lost by infiltration is determined as follows (assume indoor relative humidity 30% and outdoor humidity 80%).

Latent heat loss calculation:

$h_{fg} := 2465 \cdot \frac{J \cdot 1000}{kg}$ latent heat of water vapor

Determine the humidity (kg_vapor / kg_dry air) from the psychrometric chart or the equations given in **Section 8.2**:

$W_i := 0.0052$

$W_o := 0.003$

interior and exterior humidity ratio

$q_l := Q \cdot \rho \cdot (W_i - W_o) \cdot h_{fg} = 325.38\ W$

The volume of air infiltrating a building depends on wind speed and its direction, cracks and openings, and other factors (ASHRAE 1989).

Infiltration may be determined by two methods -- the air change method and the crack length method. In the air change method, the air flow is calculated based on an estimated number of air changes per hour and the above equations are used. Values of air change (based on experience) for typical rooms in residential buildings are given below:

Type of room	Air changes per hour
No windows or exterior doors	0.5
Windows or exterior doors on one side	1.0
Windows or exterior doors on two sides	1.5
Windows or exterior doors on three sides	2.0
Entrance halls	2.0

(For windows with weather stripping or storm sash use two-thirds of these values).

Air Change Method

Example: Calculate the sensible heat loss by infiltration for a home with floor area equal to 200 square meters which has an infiltration rate equal to one air change per hour.

$acs := \frac{1}{3600\ s}$ air changes per second

$Volume := 200 \cdot 2.5\ m^3$ (estimated)

$\rho \cdot c_p = \left(1.2 \cdot 10^3\right) \frac{J}{m^3 \cdot \Delta°C}$

$Ti := 20\ \Delta°C$

$To := -10\ \Delta°C$

inside and outside temperatures

$U_{inf} := acs \cdot Volume \cdot \rho \cdot c_p$ infiltration conductance

$q_s := U_{inf} \cdot (Ti - To)$ $q_s = \left(5 \cdot 10^3\right) W$

In the crack length method, infiltration is assumed to take place in the windward side. Since this may change, it is recommended that the wall with most cracks be selected as the basis for infiltration calculation. The heat loss as a function of crack length L (m) and air leakage B per unit crack length is given by

$q_1 = 2940 \cdot B \cdot L \cdot \left(W_i - W_o\right)$ (latent)

$q_s = 1.2 \cdot B \cdot L \cdot \left(T_i - T_o\right)$ (sensible)

Crack length is given for various doors, windows and other building components in the *ASHRAE Handbook of Fundamentals (1989).*

References

ASHRAE. 1989. *Handbook- Fundamentals*, Atlanta, GA.