Whole-House Model

This section describes how one uses equivalent wall results to model a whole house in transient building simulation programs. For the purposes of this example, a simple model house of typical construction is used as a reference, as shown below.

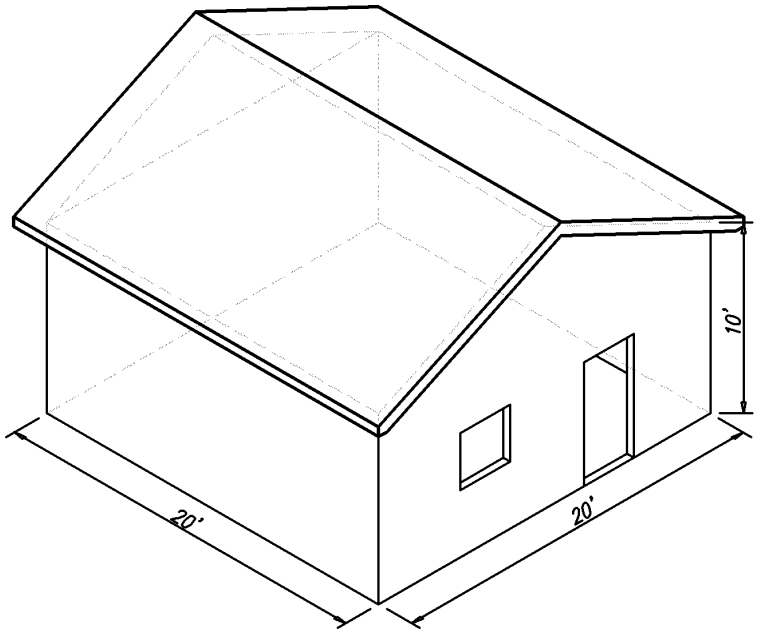

Figure 6.1 Whole-House Model

Successful implementation of the equivalent wall approach largely depends on the proper dimensioning of building envelope components. A wall elevation for the house shown above is depicted in Figure 6.2. The wall system is comprised of 2x4 steel stud with R-11 insulation, and contains one door and one window. Only one wall is shown here, since it is assumed that the procedure that follows can be applied to construct the remaining walls of the house.

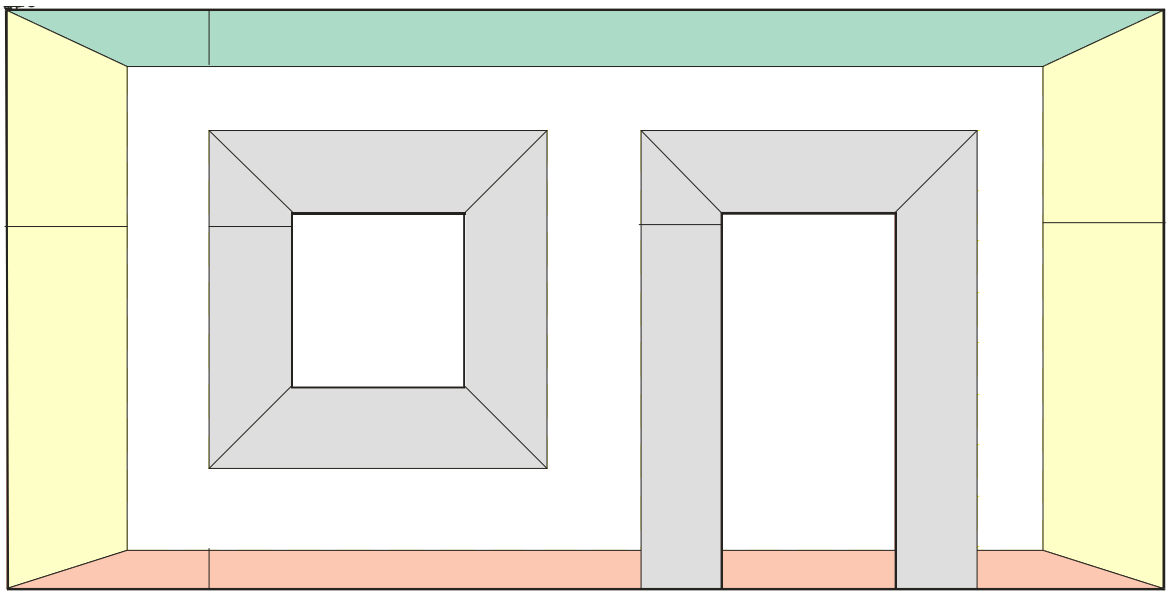

Figure 6.2 Sample Building Elevation

The first step is to list the building envelope sections that exhibit transient and multi-dimensional effects. The sample wall elevation contains the following sections of dissimilar thermal response: wall/floor, wall/ceiling, corner wall interfaces, window header, window framing, door header and door framing. In this example, the thermal response of the door header and window header are assumed equal. Figure 6.2 distinguishes each of these zones by colour, with the dimensions of the transient and three-dimensional effects as indicated in the Wall Assembly Information Sheets (Appendix C).

The second step is to determine the building envelope areas for each dissimilar section. As noted previously, it is important not to double-count building envelope areas. The easiest way to avoid this problem is to first calculate the areas of the building envelope that contain three-dimensional effects. These values can then be subtracted from the total building envelope area to determine the clear wall area.

The procedure described in Step (4) of Section 6.1 can be used to determine the simulation area for composite assemblies included in the Wall Assembly Information Sheets. For building sections not included in the Wall Assembly Information Sheets (e.g. window/wall, door/wall, corner walls/floor and corner walls/roof interfaces), it is left up to the reader/user to develop an equivalent wall model or conduct a three-dimensional analysis.

In some cases, three-dimensional effects may overlap (e.g., floor/wall interface contacts the corner/wall interface). This impacts the area to be simulated, since the composite

assemblies that comprise the overlapping areas may exhibit a different thermal response. A simple approach to account for these effects in area calculations is to "mitre" the overlapping areas. Figure 6.3 depicts three building sections of varying thermal response, with overlapping three-dimensional effects.

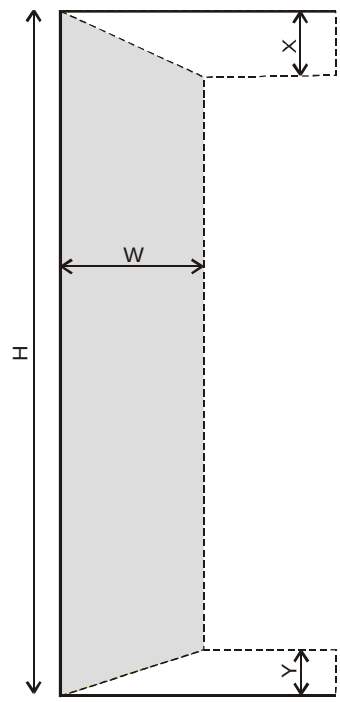

Figure 6.3 Building Sections with Overlapping 3-D Effects

This configuration can represent various scenarios in building design (e.g., ceiling/corner/wall and corner/wall/floor interfaces or door header/door frame/floor interfaces). The area shaded in gray can be determined from Equation (17).

$$\text{Area} = \left[H - \frac{X}{2} - \frac{Y}{2} \right] W$$

(17)

where

H = Height of wall section (shaded)

W = 3-D- effect dimension of wall section (shaded)

X = 3-D- effect dimension (overlapping wall section 1)

Y = 3-D- effect dimension (overlapping wall section 2)

Area calculations for each dissimilar section are summarized in Table 6.2.

Table 6.2 Summary of Area Calculations

Interface	Calculation
Corner/Wall	$\text{Corner} - \text{Effect Area } (A_c) = \left[\text{Wall Height - } \frac{\text{Roof Effect Dimension}}{2} - \frac{\text{Floor Effect Dimension}}{2}\right] \text{x}$ $\left[\text{Corner Effect Dimension}\right]$ $A_c = \left[10 \text{ ft. - } \frac{11.5 \text{ in.}/12}{2} - \frac{8 \text{ in.}/12}{2}\right]\left[25 \text{ in.}/12\right]$ $A_c = 19.11 \text{ ft}^3 \ (1.85 \text{ m}^3)$
Floor/Wall	$\text{Floor} - \text{Effect Area } (A_F) = \left[\text{Floor Length - } \frac{\text{Corner Effect Dimension}}{2} - \frac{\text{Corner Effect Dimension}}{2}\right.$ $\left[\text{Floor Effect Dimensio}\right.$ $A_F = \left[20 \text{ ft. - } 25\text{in}/12\right]\left[8 \text{ in.}/12\right]$ $A_F = 11.94 \text{ ft}^3 \ (0.34 \text{ m}^3)$
Roof/Wall	$\text{Roof} - \text{Effect Area } (A_R) = \left[\text{Roof Length - } \frac{\text{Corner Effect Dimension}}{2} - \frac{\text{Corner Effect Dimension}}{2}\right.$ $\left[\text{Roof Effect Dimensio}\right.$ $A_R = \left[20 \text{ ft. - } 25 \text{ in}/12\right]\left[11.5 \text{ in.}/12\right]$ $A_R = 17.17 \text{ ft}^3 \ (5.18 \text{ m}^3)$
Window Header/Wall	$\text{Window} - \text{Effect Area } (A_W) = \left[\text{WindowHeader Length - Window Header Effect Dimension}\right] \text{ x}$ $\left[\text{Window Header Effect Dimension}\right]$ $A_W = \left[3 \text{ ft. - } 17 \text{ in}/12\right]\left[17 \text{ in.}/12\right]$ $A_W = = 2.24 \text{ ft}^3 \ (0.64 \text{ m}^3)$ Assumptions: (1) Vertical dimension of window header thermal effect is equal to that of the lateral dimension (as dimensioned in Wall Assembly Information Sheets – Window Header). (2) Thermal response of window framing not included.

Door Header/Wall	Door – Header Effect Area (A_D) = [WindowHeader Length - Window Header Effect Dimension] [Window Header Effect Dimensic $A_D = [3\text{ ft.} - 17\text{ in}/12][17\text{ in.}/12]$ $A_D = 2.24\text{ ft}^3\ (0.64\text{ m}^3)$ Assumptions: (1) Thermal response of window header equals that of the door header. (2) Vertical dimension of door header thermal effect is equal to that of the lateral dimension (as dimensioned in Wall Assembly Information Sheets – Window Header). (3) Thermal response of window framing not included.
Clear Wall	Clear Wall Area = (Floor length x Wall Height) - A_c - A_F - A_R - A_W - A_D

It is not necessary to calculate individual areas for repeated building elements of the same thermal response. For example, if there are three window headers of the same size, construction and thermal response, the area for only one needs to be determined, and a simple multiplier of three may be applied to determine the aggregate total.