EQUIVALENT WALL MODEL IMPLEMENTATION

Transient energy analysis programs use a variety of techniques to model the transient behavior of building envelope components: nodal network (e.g. ESP-r), response factors (e.g. DOE 2.1), and z-transfer function coefficients (e.g. TRNSYS). The equivalent wall technique is a relatively simple way to model complex building assemblies in whole-building energy programs that use a nodal network or require input of thermo-physical properties of the wall layers. It represents all the thermal information about the wall using thermo-physical properties of a specified number of fictitious, homogeneous material layers. The equivalent wall method is much simpler than the alternate use of a long series of response factors (60 to as many as 150 numbers, multiplied by 3 would be required for massive walls).

This section describes how to implement equivalent wall properties into whole building simulation software. Any whole building simulation program that allows the specification of wall assemblies according to resistance and capacitance or other thermo-physical properties (see Table 6.1) can be employed. For this report, DOE 2.1 has been chosen as representative of these types of programs.

All the information necessary to account for three-dimensional effects for the 20 building assemblies studied, is included in the Wall Assembly Information Sheets (Appendix C). The information sheets provide a graphical representation of the wall assembly, along with a detailed description of the wall layers, thermo-physical and equivalent layer properties and response factors. The response factors generated by the 3-D model are included as supplementary data, for modelers who prefer this approach.

To account for three-dimensional effects in a given wall assembly, one must substitute the wall layers of the actual wall assembly with the three equivalent wall layers. The reader is assumed to be familiar with the specification of walls in DOE-2.1, specifically the MATERIAL and LAYER instructions.

The MATERIAL instruction is used to specify the heat transfer properties for one layer of a construction in an exterior wall, exterior floor, or roof. These properties are subsequently used to calculate thermal response factors of the composite wall. The LAYERS instruction is used to specify the sequence of material layers of a construction, or cross-section of the wall assembly.

The calculation of response factors is internal to DOE-2.1. The processor uses a one-dimensional model to calculate a series of response factors. The response factors are obtained by sampling the response function to a triangular excitation at equal transient

intervals. The X response factor series represents the response (the heat flow at the inside surface) to a triangular temperature excitation at the inside surface. The Y response factor series is the response (heat flux at the inside surface) to a triangular temperature pulse at the outside surface. The Z response factor series represents the response (heat flow out of the outside surface) to a triangular excitation in temperature at the outside surface.

Note that DOE-2.1 calculates response factors and z-transfer function coefficients corresponding to transient time steps. However, these values may be determined for sub-transient steps as well. The only restriction is that the equivalent wall model may not accurately reproduce responses to very rapid temperature variations; each case should be examined individually (Section 5.3).