HvacLoadExplorer V1.1.0

USER'S GUIDE

For updates, go to:
http://www.mae.okstate.edu/hvac

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1.0– Introduction

Welcome to HvacLoadExplorer Version 1.1, the cooling/heating load calculation software that accompanies the book "Heating, Ventilating, and Air Conditioning – Analysis and Design, 6th Edition." This software uses the heat balance method (HBM) developed under ASHRAE Research Project 875 for calculating cooling and heating loads in buildings. It also is capable of calculating conduction transfer function coefficients and coefficients for the Radiant Time Series Method (RTSM), a simplified method.

HvacLoadExplorer uses the load calculation "Engine", developed by C.O. Pedersen Associates, Urbana, Illinois. This is a Fortran program, compiled into a DLL, capable of calculating the heating or cooling load for a single room. HvacLoadExplorer provides a graphical user interface (GUI) that collects information for the building, then will automatically call the Engine for each room, and then retrieves and collates the results.

HvacLoadExplorer performs two types of calculations.

- First, it allows a user to run a cooling or heating load calculation for an entire building to determine the cooling or heating loads and airflow rate of all the rooms in a building or zone.
- Second, it allows a user to calculate the conduction transfer function coefficients, response factors, radiant time series factors. The procedure for radiant time series factors is discussed in chapter 4.

For purposes of load calculations, a building may be thought of as being organized in a hierarchical fashion. That is, a building is made up of zones, zones are made up of rooms, and rooms are made up of walls, roofs, floors, and other heat gain elements such as people, lighting, equipment, and infiltration. In HVAC Load Explorer, zones are collections of one or more rooms, all controlled to the same air temperature. The primary purpose of zones in the program are to allow the user to compute total loads for collections of rooms. For example, a user may wish to include all rooms served by a

particular cooling coil in a single zone so that the peak load on the coil can be readily determined.

Users of personal computers are well aware that computer file systems are also organized hierarchically. Accordingly, the user interface for HVAC Load Explorer is somewhat analogous to the user interface for the Windows File Explorer. There are two views of the hierarchy in the building. Double-clicking on a zone will show all of the rooms in the zone; double-clicking on a room will show all of the heat gain elements in the room. The interface is described in Chapter 3 in more detail, but it should be reasonably intuitive for most PC users.

Quick Start Guide

A few features that may not be obvious are discussed here. First, to start describing a new building, go to the File menu and select "New". This will ask you to specify a file name. After this step, zones may be added to the building, rooms may be added to the zone, and heat gain elements may be added to the room, with the "Add Node" button shown in Figure 1.1.

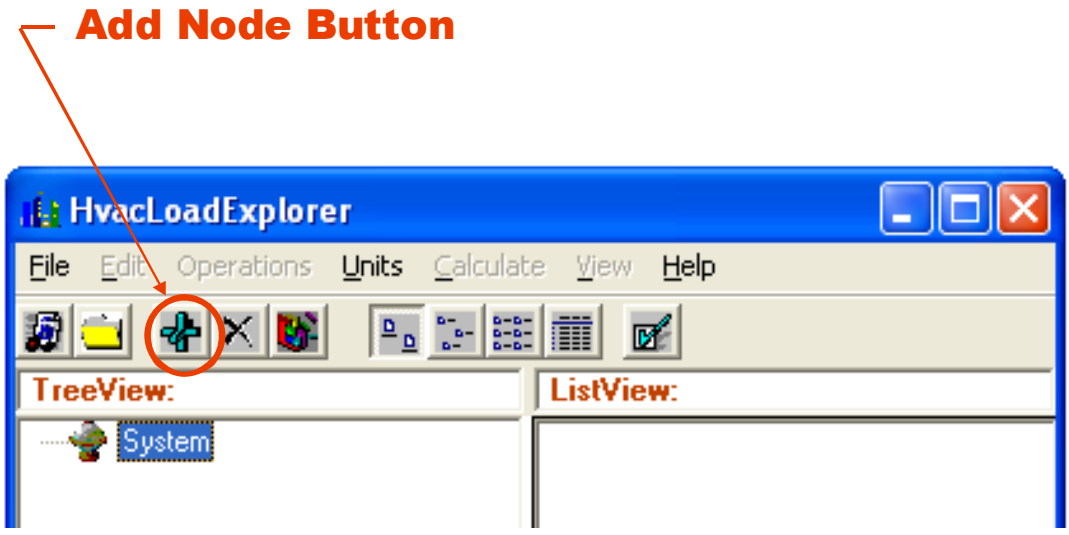

Fig. 1-1 Add Node Button

Jumping ahead (assuming many of the additional steps are intuitive) users need to be aware that when they specify a wall, roof, or floor, it is important to specify an

external boundary condition, as shown in Fig. 1-2. "TOS" should be used for exterior surfaces; "TA" for interior surfaces[1]

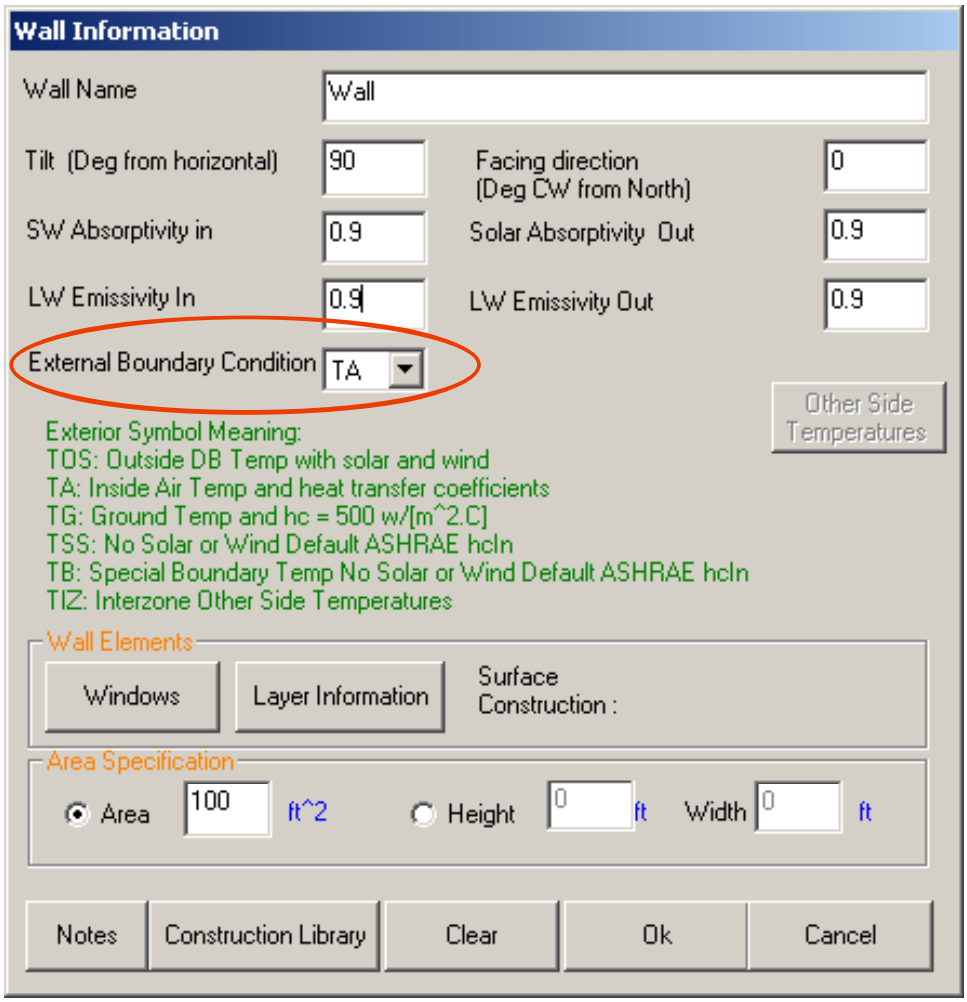

Fig. 1-2 Setting the external boundary condition.

[1] One difference between the heat balance method (HBM) and simplified methods is that, in the HBM, all surfaces are described, because they are important for radiative/convective exchange and zone response. In simplified methods, the zone response is usually pre-calculated in some fashion, so that interior surfaces need not be specified.

2.0 – Installation of HvacLoadExplorer

HvacLoadExplorer can be installed on a PC running Windows95,Windows98, WindowsNT, Windows 2000, WindowsME, or Windows XP. The drive where HvacLoadExplorer is to be installed needs to have 8.2 MB of free space. To install HvacLoadExplorer from CD, follow the procedure given below.

- Put the accompanying CD in your CDROM drive
- Select "Run" from the start menu.
- Type D:\Setup in the text box. If your CD drive has a different name, change the 'D' to your CDROM drive letter.
- Press OK button
- Setup program will ask you to select the path where you want the HvacLoadExplorer to be installed. By default, HvacLoadExplorer will be installed in the directory Program Files\HvacLoadExplorer, which will also contain Two subdirectories:
  - Database: contains the template building database file that is used for creating a new building file and library database with libraries like, location library & presets for the 24 hour schedules.
  - TextFiles: which contains the three text files
    - Default.txt: It contains the default setting for the location
    - Param.txt: It contains the parameter values required for the programs.
    - Timezone.txt: It contains the timezone values require for the locations.

3.0 – Using HvacLoadExplorer

As mentioned above, the building may be considered to be organized in a hierarchical fashion – the building has zones; zones have rooms; and rooms have heat gain elements. The user interface of HvacLoadExplorer has been developed to have some similarity to Windows File Explorer, which is also used to navigate a hierarchical system, in this case consisting of directories and files, and with which most users will be familiar. It has a tree view to show the hierarchy and relationships of the various elements of a building and a list view to show the details of the levels selected in the tree view. For example when the building is clicked in the tree view, it will show all the zones in the building in the list view part of the main window. Click on a zone, and it will show all of the rooms in the zone. In addition to navigation, input, and calculation of loads, HvacLoadExplorer can display the results in both text and graphical forms. In the current version, additional reporting features have also been added.

The main window, HvacLoadExplorer, of the program shown in Figure 3.1, appears when the program starts. This window shows a representation of the data related to a building. Like the Windows Explorer, the main window is divided in two main parts. One part shows the tree view of the building, and the hierarchy of the different elements in the building. List view shows a detail view of the current level selected in tree view. Size of the tree view and list view can be changed just like Windows Explorer. All the icons in the tree view as well as in the list view represent nodes or elements in the tree and lists. So building, zones, rooms and gains are nodes.

This window also contains a toolbar and a menubar, as shown in Figure 3.2. It also has a status bar with the loading indicator, which shows the status of the opening process when a new file is opened. It shows the calculation status when the calculate menu is selected.

3.1 Main Window

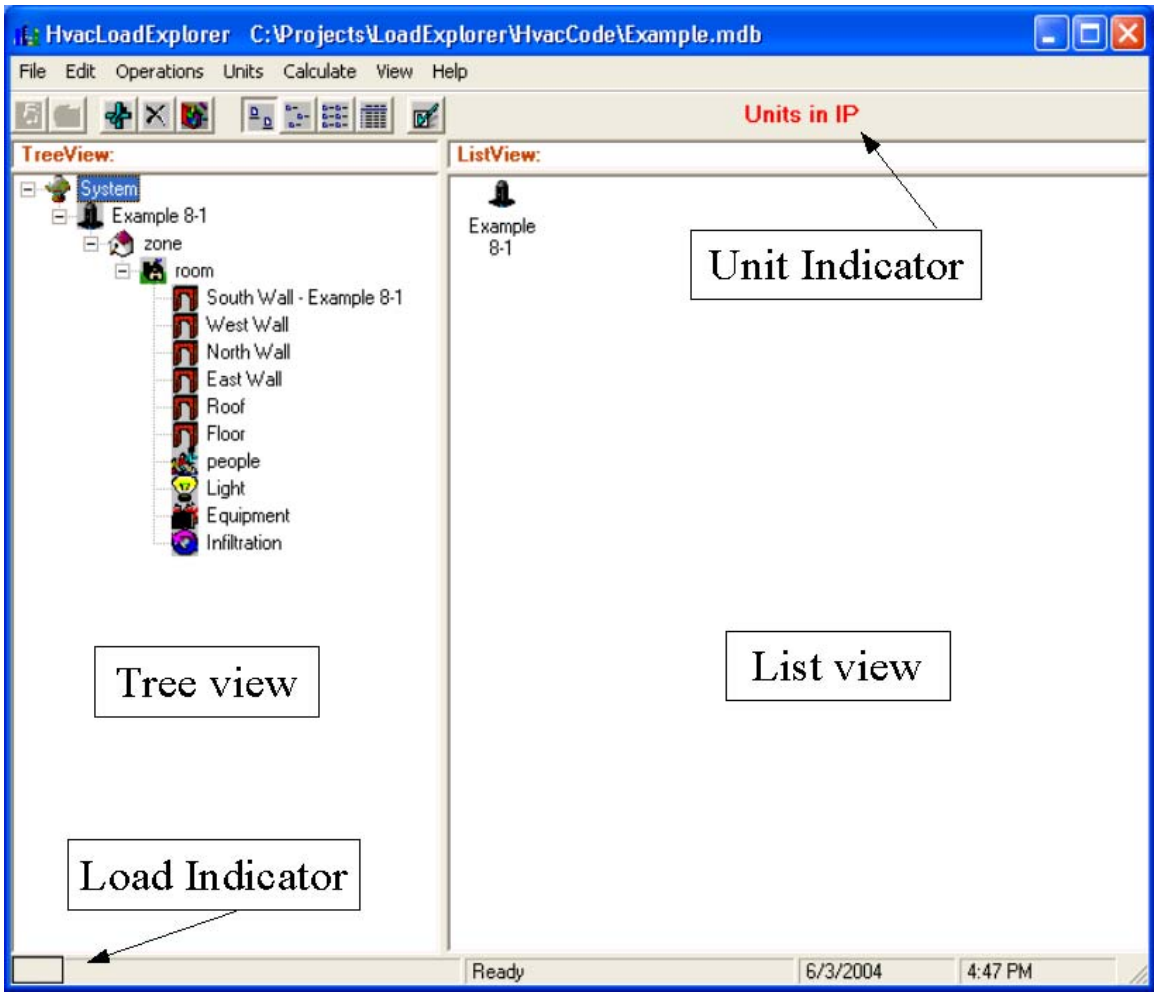

Figure 3.1: Main Window of HvacLoadExplorer

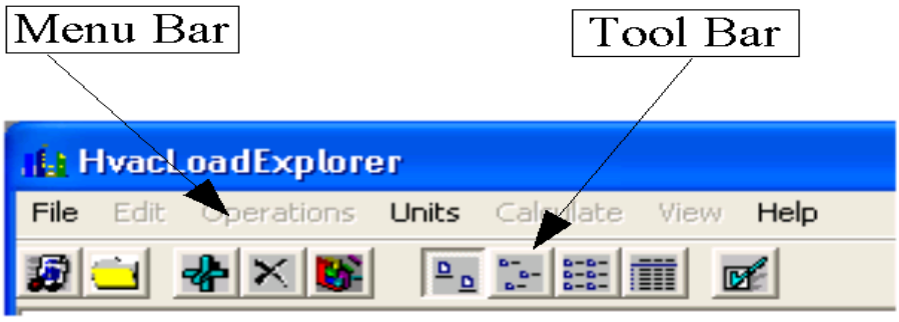

Figure 3.2: Zoom View of Menu and Toolbar

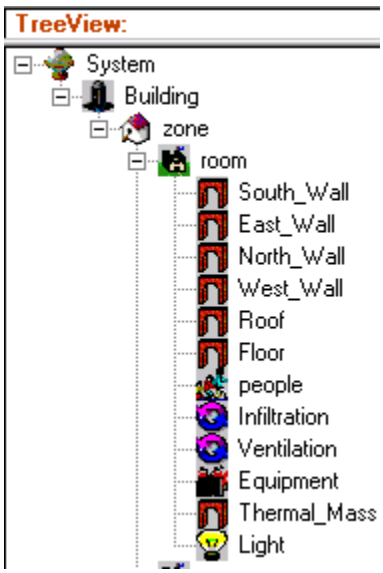

Figure 3.3: Zoom View Tree View

The relationship between different levels is shown in the tree view of the main window. Double clicking on the any of the elements can bring up the dialog box with the details of that specific node. Clicking on the + and - signs in the square box can expand or fold the tree. For calculation purposes one must select an item in the tree view part of the main window. Calculations for building, or any element at levels below building can be selected. Cut and paste operations using the edit menu or shortcut keys can be performed.

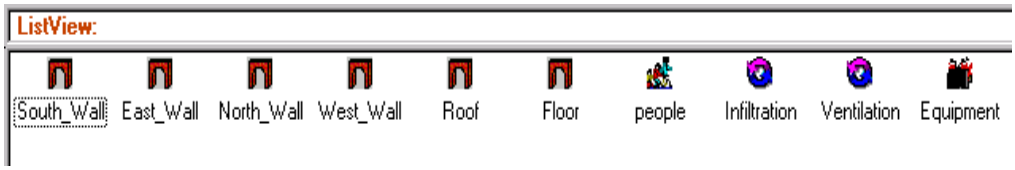

Figure 3.4 Zoom View of List View.

When a user clicks on an icon in the tree view part of the main window, all the items one level below are shown in the list box except when the icon representing heat gain (people, lights, equipment etc.) or wall are clicked, as those elements don't have any sub-elements. Double clicking on any element of the list view brings up the details about that particular element. Cut and paste operations using the edit menu or shortcut key can be performed.

3.2 Main Menu

Following is the overview of the menu bar options. The menus are explained in details in the following few pages along with the short cuts.

- File
  - New
  - Open
  - Close
  - Save As
  - Backup
  - Exit

- Edit
  - Copy
  - Paste

- Operations
  - Add
  - Details
  - Delete

- Units
  - SI
  - IP

- Calculate
  - Execute For Building
  - Execute for zone
  - Execute For Room
  - View Output For Building
  - Create Report File

- View
  - Toolbar
  - Status bar
  - Load bar
  - Large Icons
  - Small Icons
  - List
  - Details

- Help
  - Contents
  - Search Help On
  - About

3.2.1 File Submenu

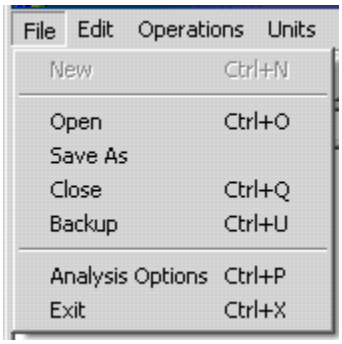

Figure 3.5 Zoom View of File Submenu

New

Shortcut keys: Ctrl+N

Function: Opens New Building File

Description: Brings up the new building dialog box with button to get the location dialog box.

Open

Shortcut keys: Ctrl+O

Function: Opens Existing Building File

Description: Brings up the Windows standard open file dialog box showing building files present.

Save As

Shortcut keys: -

Function: Saves a copy of the building (Changes current file to new copy)

Description: Saves a copy of the building under a new file name. Also changes the current working file to the new file name

Close

Shortcut keys: Ctrl+Q

Function: Closes Building File

Description: Closes the already opened building file so that user can open a new building

Backup

Shortcut keys: Ctrl+**U**

Function: Saves a copy of the building

Description: Saves a copy of the building under new name. Retains the original file as the current file

Exit

Shortcut keys: Ctrl+X

Function: Exits the application

Description: Closes the main window and exits the application

3.2.2 Edit Submenu

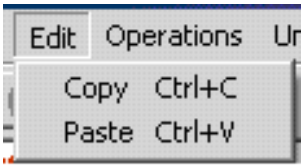

Figure 3.6 Zoom View of Edit Submenu

Copy

Shortcut keys: Ctrl+C

Function: Copies the selected element (i.e. building, zone, room, and gains).

Description: Select any icon in the tree view or list view, then use this menu to copy the data related to that icon.

Paste

Shortcut keys: Ctrl+V

Function: Pastes the copied element (i.e. building, zone, room, and gains).

Description: Select appropriate icon in the tree view, then use this menu to paste the data already copied.

3.2.3 Operations Submenu

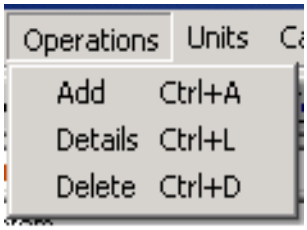

Figure 3.7 Zoom View of Operations Submenu

Add

Shortcut keys: Ctrl+A

Function: Adds New Element (i.e. building, zone, room, and gains)

Description: Add the element as a child (element one level below) of element selected on the tree view controls. The type of new element depends on the type of element selected by the user before using this menu.

Details

Shortcut keys: Ctrl+L

Function: Shows details of the element (i.e. building, zone, room, and gains)

Description: Brings up the details of element selected on the tree view controls or list view control.

Delete

Shortcut keys: Ctrl+D

Function: Deletes the element (i.e. building, zone, room, and gains)

Description: Deletes the element selected in the tree view of the main window. It also erases the corresponding entry in the building database.

3.2.4 Units Submenu

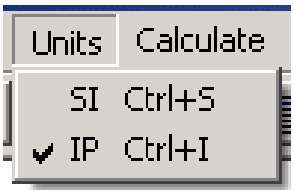

Figure 3.8 Zoom View of Calculate Submenu

SI

Shortcut keys: Ctrl+S

Function: Changes units to SI system.

IP

Shortcut keys: Ctrl+I

Function: Changes units to IP system.

3.2.5 Calculate Submenu

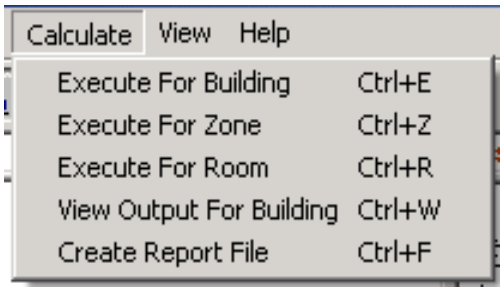

Figure 3.9 Zoom View of Calculate Submenu

Execute For Building

Shortcut keys: Ctrl+E

Function: Runs Load Calculation for the entire building

Description: Runs the simulation for the whole building, i.e. for all the rooms in the building. It also stores the cumulative result, for all rooms, of

the total air flow rate, cooling coil load (total, sensible and latent), sensible heat load in the same building file.

Execute For Zone

Shortcut keys: Ctrl+ Z

Function: Runs Load Calculation for the selected zone

Description: Runs the simulation for the zone selected in the tree view. It shows the result of the calculation immediately. These results are not stored.

Execute For Room

Shortcut keys: Ctrl+R

Function: Runs Load Calculation for the specific room

Description: Runs the simulation for the room selected in the tree view. It shows the result of the calculation immediately. These results are not stored.

View Output For Building

Shortcut keys: Ctrl+W

Function: Views and prints results of the calculation for the entire building.

Description: It shows the calculation results done by the 'Execute For building' menu.

Create Report File

Shortcut keys: Ctrl+F

Function: Creates an output report.

Description: Performs the necessary load calculations, then creates an output report file. The user can select to have either a text file or a comma delimited file (CSV), which can be imported into a spreadsheet. A wide range of options allows the reports to be customized.

3.2.6 View Submenu

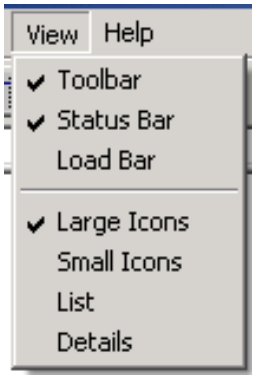

Figure 3.10 Zoom View of View Submenu

Toolbar

Function: Toggles the visibility of the toolbar

Status Bar

Function: Toggles the visibility of the status bar

Load Bar

Function: Toggles the visibility of the Load Bar

Large Icons

Function: Shows list view in the large icon form

Small Icons

Function: Shows list view in the small form

List

Function: Shows list view in the List form

Details

Function: Shows list view in the Detail form

3.2.7 Help Submenu

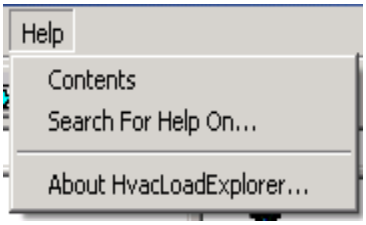

Figure 3.11 Zoom View of Help Submenu

Contents

Function: Brings up the help contents window

Search Help On

Function: Brings up find help window

About HvacLoadExplorer

Function: Brings up the About dialog box.

3.3 Building Dialog Box

The building dialog box, shown in Figure 3.12, shows the details of a building. The dialog box appears when either a new building is being created or the details of an existing building is required. It can be used for setting the calculation option and location details.

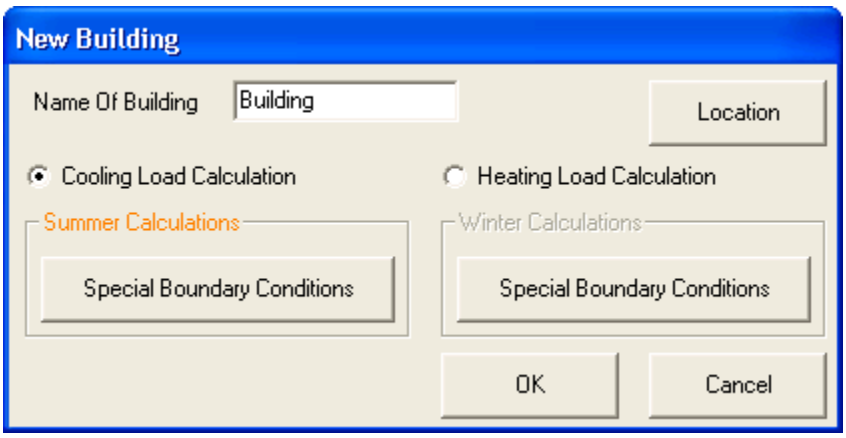

Figure 3.12 Building Dialog Box

Name Of Building: User-specified name of the building.

Location: Brings up the dialog box related to the location data

Cooling Load Calculation: Uses the summer data of the location for the calculation

Heating Load Calculation: Uses the winter data of the location for the calculation.

Special Boundary Conditions: Brings up the dialog box with the schedule of the special boundary temperatures for 24 hours. It stores the values of special outside boundary temperatures at each hour of the day. Walls that are specified to have an external boundary condition of "TS" will utilize this temperature. (It is also possible, with boundary condition "TIZ" to set external boundary conditions for each surface or use calculate values from free-floating rooms.

Only one mode, either heating or cooling, can be active at any time. However, the Create Report command will cause the program to calculate both heating and cooling loads, if requested. Clicking on 'OK' saves the changes if the new building is being created. The user will then be prompted to enter the name of the file where all the data will be stored. If the building is already created it saves the changes made in the file corresponding to the building.

3.4 Location Dialog Box

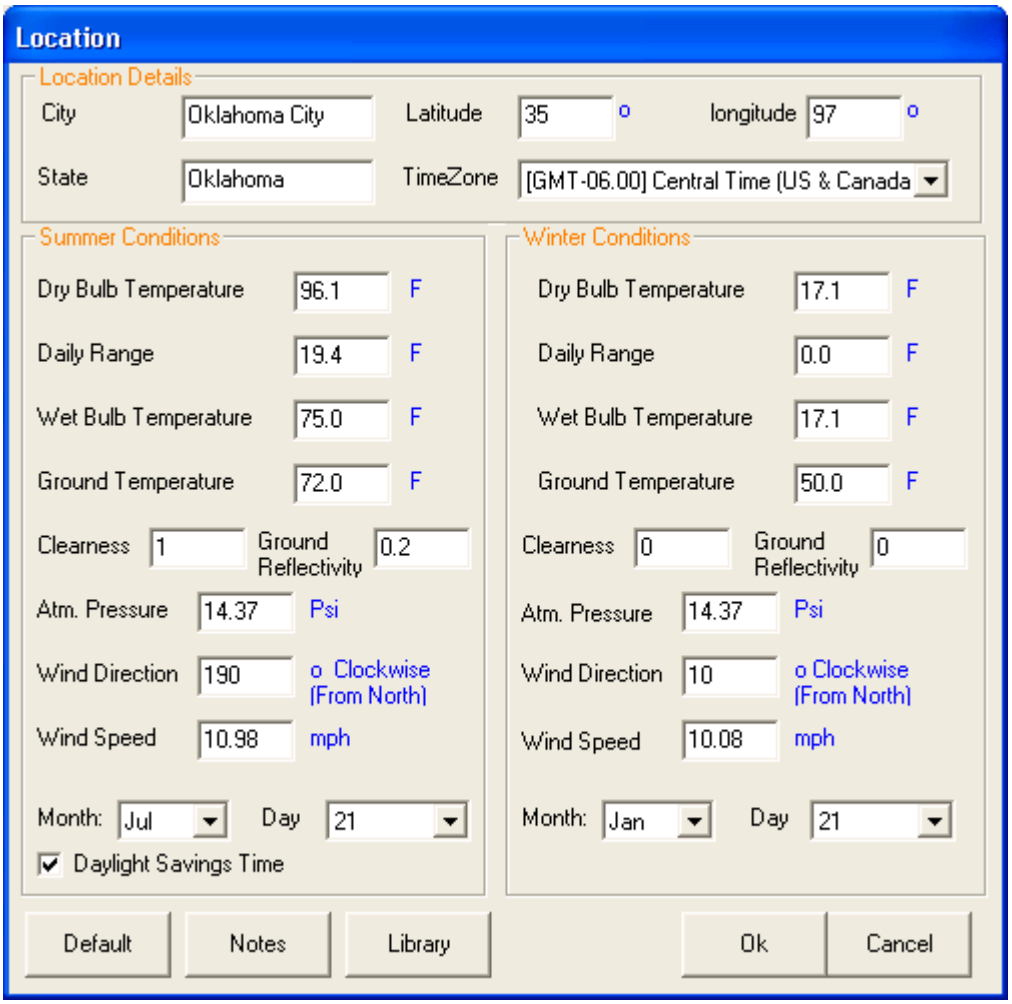

Figure 3.13 Location Dialog Box

The location dialog box, shown in Figure 3.13, appears when the 'Location' button on the New Building dialog is clicked. Locations are represented by the geographical information about the location and the weather data for the summer and winter conditions. All of these data can be selected from the library in one step, which stores the details about the different locations. For additional U.S. and international locations, refer to Appendix Table B-1 in the text or the 1997 ASHRAE Handbook of Fundamentals. One can also add new locations in the library or modify them.

Building City: Name of the city whose weather conditions are being applied for the calculation purpose.

State: Name of the state where city is located.

Longitude: Longitude, in degree, for the location. Refer Table B-1 in appendix B from text, for different locations

Latitude: Latitude, in degree, for the location. Refer Table B-1 in appendix B from text, for different locations

Timezone: Timezone with respect to the Greenwich Mean Time for the location. This is a combo box with preset values of timezones commonly found with windows.

All the weather related conditions are for the summer and winter design conditions.

Dry Bulb Temperature: The peak design dry bulb temperatures for a location in the summer or winter. Table B-1 in appendix B of text has the data for different locations

Daily Range: The daily range for the variation of the dry bulb temperatures for a location in the summer or winter. Table B-1 in appendix B of text has the data for different locations

Wet Bulb Temperature: The wet bulb temperatures for a location in the summer and winter. Table B-1 in appendix B of text has the data for different locations

Ground Temperature: The surrounding ground surface temperatures for that location in the summer and winter conditions, which helps calculating the heat loss from the floors and walls in contact with the ground (in $^{\circ}$C or $^{\circ}$F).

Clearness: Suggested values of clearness are given in Figure 7-7 of the text for non-industrial locations in the United States

Ground Reflectivity: Ground reflectivity is the fraction of global horizontal solar radiation reflected by the ground. Default value is 0.2.

Wind Speed: Wind speed (in m/s or mph) Default value is 3.35 m/s (7.5 mph) for summer and 6.7 m/s (15 mph) for winter.

Wind Direction: Wind direction in degrees clockwise from north.

Month: any month can be selected for summer or winter. Note: all buildings do not have peak cooling loads on July 21st! It may be useful and necessary to check cooling loads in other months, even December. If so, the "Summer month" would be set to be December, and the cooling load would be calculated.

Days: any of the days can be selected from the combo box.
Default for date is 21st July for summer and 21st January for winter.
For summer design conditions, daylight savings switch can be set to true/false.

Clicking on the 'Default' button can save the current location as the default location for the program. It writes all the information to the text file called default.txt in the directory named as 'textfiles' in the home directory of the application. Clicking on the 'OK' button saves the location changes with the building database file. Clicking on the 'Library' button will bring up the library of locations, from where user can select the location and then use it. User can also add new entries or modify the existing entries in the library. Clicking on the 'Notes' button will bring up the notes dialog box where user can add extra information about the location.

3.5 Zone Dialog Box

The zone dialog box, shown in Figure 3.14, appears when a new zone is to be added by selecting building Element in the tree view and clicking the 'Add Node' menu or details of an existing zone are shown.

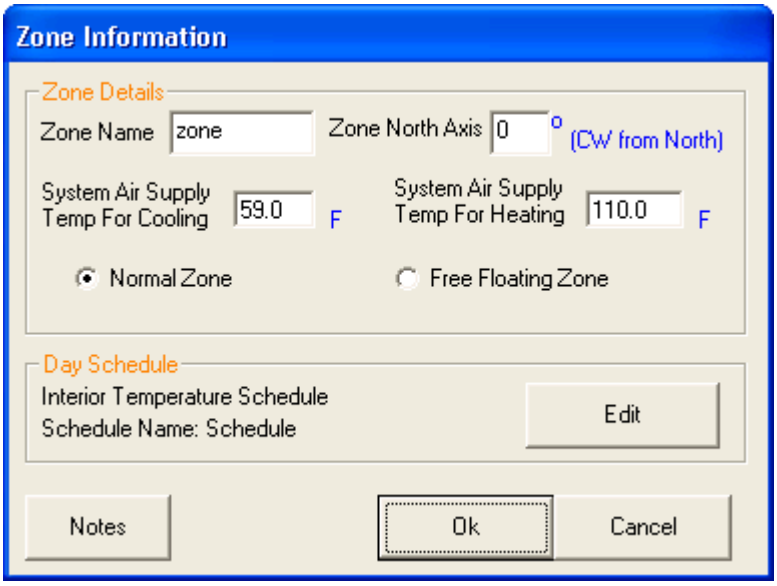

Figure 3.14 Zone Dialog Box

Zone Name: Name of the zone

Zone North Axis: orientation of zone with respect to north axis, measured in degrees clockwise direction. This rotation is applied to the facing angles of all the wall elements as shown in Figure 3.15. This allows a zone oriented like that shown in the right-hand-side of Fig 3.15 to be input as if it is oriented like that on the left-hand-side of Fig. 3.15. Then, the correct rotation can be specified by inputting the angle θ as the Zone North Axis.

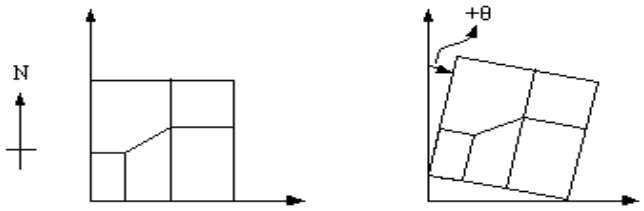

Figure 3.15 Zone North Axis Rotation

System Air Supply Temperature Cooling: Supply air temperature for the zone to be used when calculating air flow rates required to meet cooling loads (in $^{\circ}$F or $^{\circ}$C).

System Air Supply Temperature Heating: Supply air temperature for the zone to be used when calculating air flow rates required to meet heating loads (in $^{\circ}$F or $^{\circ}$C).

Normal zone option: On selecting this option all the rooms in this zone are conditioned according to the temperature schedule, and cooling or heating loads will be calculated for the rooms in this zone.

Free Floating zone: On selecting this option the rooms in this zone are not conditioned. The temperatures for each room are calculated based on the interaction with the boundary conditions. These temperatures can be viewed by clicking on the "Temperatures" button on the room dialog box. This option is used to calculate air temperatures for attics, garages, etc. These temperatures can then be used as boundary temperatures for other rooms.

Clicking on the 'Edit' Button will bring up the dialog box for a 24-hour schedule of the interior temperature. Clicking the'Notes' button will bring up the notes dialog box where user can add the extra information about the zone. Clicking on 'OK' will save the information about the zone and exit the dialog or it will create a new zone and exit the dialog box. A new node is also created in the tree view of the main window.

3.6 Room Dialog Box

The room dialog box, shown in Figure 3.16, appears when a new room is to being added by selecting a zone element in the tree view and clicking the 'Add Node' menu or details of an existing room are shown.

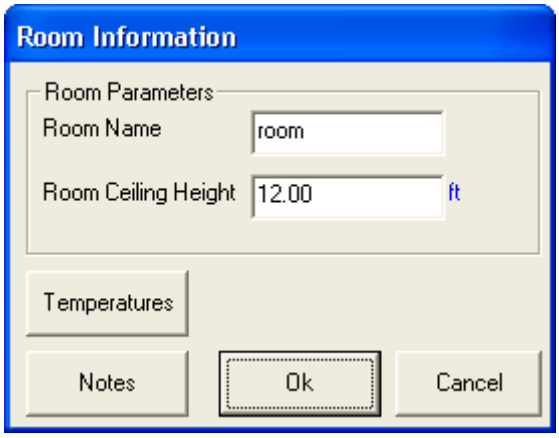

Figure 3.16 Room Dialog Box

Room Name: Name of the Room

Room Ceiling Height: Height of the room for volume (m or ft).

Temperatures: Shows the temperatures of the room if the room is in a free floating zone. If the room is not in a free floating zone the button is disabled

Clicking 'Notes' button will bring up the notes dialog box where user can add extra information about the zone. Clicking on 'OK' will save the information about the room and exit the dialog if the room already exits or it will create a new room and exit the dialog box. A new icon, representing the newly added room, is created in the tree view of the main window.

3.7 New Gain Dialog Box

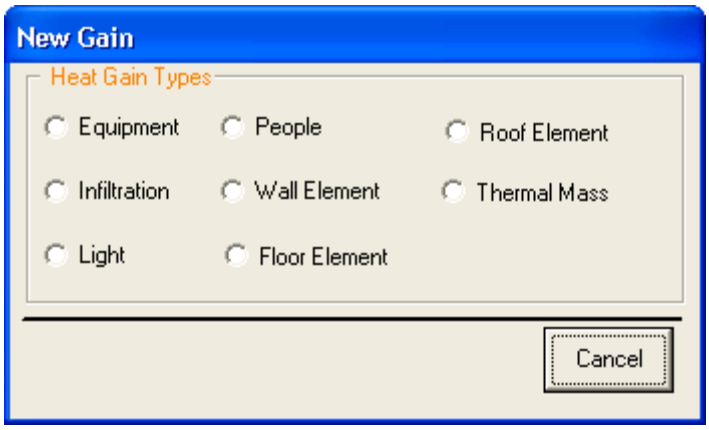

Figure 3.17 New Gain Dialog Box

The New Gain dialog box, shown in Figure 3.17, comes up when new heat gain is to be added in the selected room. There are eight different types of gains, which can be added, and depending on the button clicked, a dialog corresponding to the selected gain is shown.

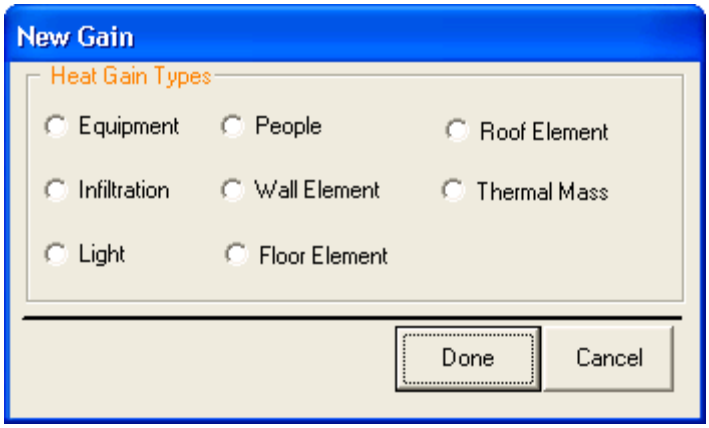

Figure 3.18 New Gain Dialog Box with 'Done' Button

Many gains can be added to the room without exiting this dialog box. When user enters the first node the 'Done ' Button appears.

3.8 Infiltration Information Dialog Box

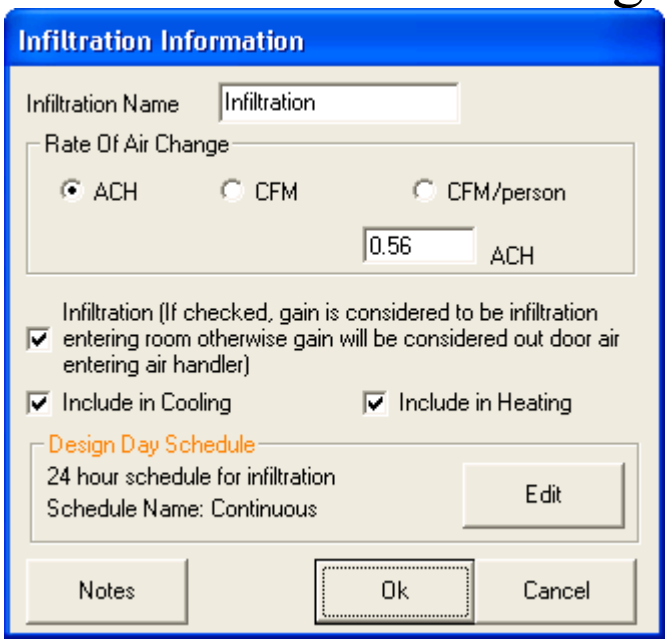

Figure 3.19 Infiltration Information Dialog Box

The infiltration information dialog box, shown in Figure 3.19, appears when the user adds infiltration or outdoor ventilation heat gain to the room or edits the details of existing gains. This box can be used to enter either infiltration (heat gain to the room) or ventilation (heat gain to the system, but proportioned at the room level.)

Infiltration Name: User-specified name of the infiltration/ventilation gain

Rate of Air Change Options

Air Changes/Hour: Peak flow rate in ACH. Room volume is taken from the product of the floor area and ceiling height

Cubic Foot/min: Peak flow rate in CFM

CFM/person: Peak flow rate in CFM/person. The number of people is obtained from the people schedule in the people gain.

Include in cooling check box: Specifies if the gain is to be used while calculating the cooling load

Include in heating check box: Specifies if the gain is to be used while calculating the heating load

Infiltration is the uncontrolled flow of air through unintentional openings such as cracks around windows and doors. There may be situations where outdoor air is intentionally supplied directly to the space for indoor air quality or other purposes. In this case, the outdoor air produces a heating or cooling load on the space in the same way as infiltration air and should be treated as such.

For purposes of the program, ventilation air is outdoor air that is introduced at the system. In this case, it affects the coil load, but does not affect the room load. However, because outdoor air requirements for IAQ purposes are often specified on a per person basis, it is convenient to be able to enter the quantity at the room level. Outdoor air requirements for commercial facilities are given in the Table 4-2 of the text.

One can specify whether the air inflow should be considered as infiltration or outdoor air entering the mixing box by checking the checkbox on the dialog box. If the checkbox is checked then the gain is considered as infiltration, otherwise as outdoor air entering the mixing box upstream of the coil.

Clicking on the 'Edit' button will bring up the dialog box for a 24-hour schedule for the selected day. Enter the fraction of the peak rate for each hour. Clicking 'OK' will save the information in the database and exit. Clicking the 'Notes' button will bring up the notes dialog box.

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3.9 Wall Information Dialog Box

The wall information dialog box, shown in Figure 3.20, is shown when a new wall is to be added or the details related to the existing wall are to be displayed.

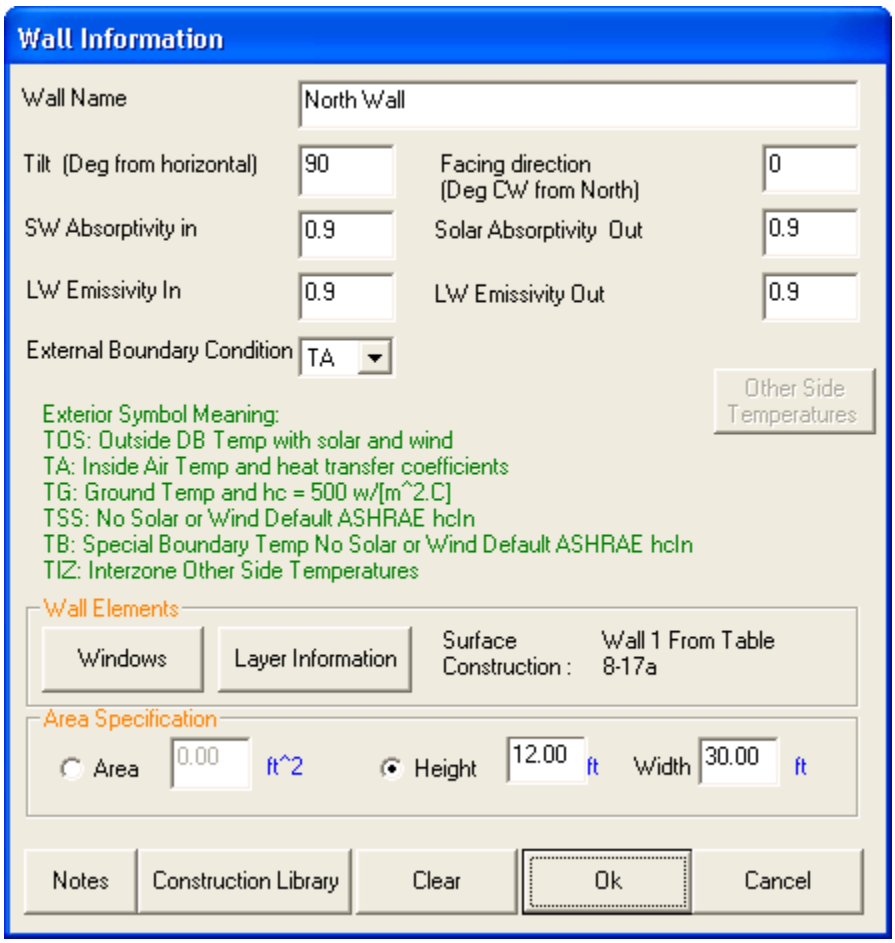

Figure 3.20 Wall Information Dialog Box

Wall Name: User-specified name of the wall

Tilt: Tilt is the angle made by the wall with the horizontal in degrees. Default is 90^0.

Facing Direction: Facing direction is the angle made by the normal vector of wall with north, in degrees clockwise . 0° represents a north facing wall; 90° represents an east-facing wall; 180° represents a south-facing wall; 270° represents a west-facing wall, etc.

Solar Aborptivity out: The solar (shortwave) absorptivity of the outside surface. It will have values between 0 and 1, with a default is 0.9.

SW Aborptivity in: The solar (shortwave) absorptivity of the inside surface. It will have values between 0 and 1, with a default is 0.9.

LW Emissivity in: The emissivity for thermal (longwave) radiation of the inside surface. It will have values between 0 and 1, with a default is 0.9

LW Emissivity out: The emissivity for thermal (longwave) radiation of the outside surface. It will have values between 0 and 1, with a default is 0.9

External Boundary Condition: Setting this parameter controls the boundary conditions on the outside of the wall. The different options are discussed below.

Area Specification: The wall area can be either directly specified or specified in terms of length and width.

Other side Temperatures: Brings up a dialog box where the other side temperature of the wall to be used can be specified. This is enabled only if the TIZ external boundary condition is specified for the wall.

This dialog box is also used for adding other elements-- Floor, Roof and Thermal Mass[2]. The default tilt in case of floor is 180° and in case of roof is 0°. In case of floor and thermal mass the windows button is disabled, as these types of elements cannot have a window.

A variety of exterior boundary conditions may be selected.:

TOS Used for exterior walls and roofs. The outside of the wall will be exposed to outdoor air, wind, and solar radiation.

TA Used for interior walls, ceilings, and floors, when the space on the other side is controlled to approximately the same conditions. A surface with this external boundary condition will have no net heat transfer, but may store and release energy.

TG Used for basement walls, basement floors, and slab-on-grade floors. These surfaces will have the user-specified ground temperature imposed on the outside.

TB Used for walls, ceilings and floors, when the space on the other side is at a substantially different temperature. In this case, the space temperature on

[2] Thermal mass is usually used to approximately model the effects of interior furnishings. It has the effect of providing some thermal storage, but also enhancing radiative/convective heat exchange. The surface area of the thermal mass should represent the total thermal mass exposed to the zone air.

the other side is set at the Building Dialog Box as a "Special Outside Condition". An example application might be a wall separating an office space from a refrigerated warehouse. When the office is being described, the wall boundary condition would be set as "TB", and from the Building Dialog Box, "Special Outside Conditions" would be set to the refrigerated warehouse air temperature. TIZ may also be used for this purpose with additional flexibility.

TSS The TSS boundary condition uses the outside DB temperature without solar radiation or wind. This might be used for walls with well-ventilated, uncontrolled spaces on the other side, e.g. a garage. It might also be used for walls that are always shaded by a large overhang or very tall building.

TIZ Like the TB boundary condition, the TIZ boundary condition is used when the space on the other side is at a substantially different temperature. However, the TIZ condition allows the other side temperatures to be specified individually for each wall. Alternatively, they can be calculated using a free floating room analysis. In a house, this would be useful for a ceiling below the attic. In the conditioned room, the ceiling can be set to have a TIZ boundary condition, with the other side temperature coming from the attic. In the attic, the floor can be set to have a fixed or scheduled other side temperature equivalent to the controlled temperature in the conditioned spaces..

Window area is subtracted from the wall area to get the effective area of the wall. So the total area bounded by wall's external edges should be entered.

Clicking the 'Windows' button brings up the window information dialog box for that particular wall. Clicking on the 'Layer Information' brings up the layer information dialog box where the wall construction corresponding to that particular wall is specified. Layer-by-layer information is usually most conveniently entered into the library, then chosen for repeated application inside the building. Clicking 'Notes' button will bring up the notes dialog box .

Clicking on the 'Library' button brings up the library of walls, floors and roofs from which user can pick from different construction types.

Also, while on the subject of walls, roofs, and floors, it should be noted that all of the walls, roofs, and floors of a room should be included, but:

1. The program will only allow 6 walls, roofs, and floors, plus a thermal mass surface. Therefore, some surfaces might have to be combined. Interior surfaces of the same construction may be lumped together (by specifying their total area) regardless of surface orientation. Exterior surfaces should only be lumped together if they have the same surface orientation.
2. The program must have at least a floor and a wall or roof to run.

3.10 Window Information Dialog Box

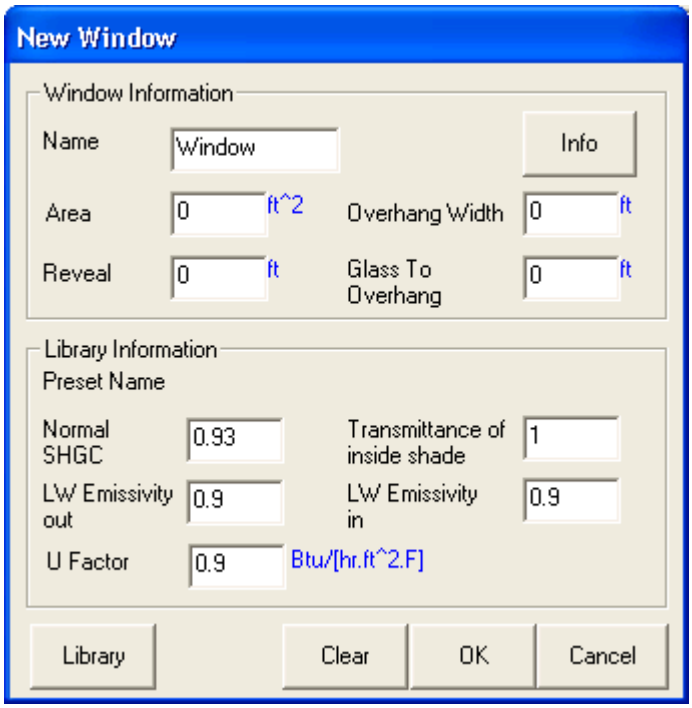

Figure 3.21 Window Information Dialog Box

The window information dialog box, shown in Figure 3.21, appears when a new window is added or details of an existing window are to be displayed.

External shading surfaces reduce the transmitted solar radiation by intercepting the direct beam component of the solar radiation. One of the most common shading devices is a window overhang.. The simplified overhang model included in the program assumes that the overhang is long relative to the width of the window. Thus only the horizontal projection of the overhang is specified. It also assumes the window is square so only the area of the window is expected.

Name: This is a name of the window

Area: Area of the window in m^2 or ft^2. This area is subtracted from the respective wall area to get the effective wall area. Refer to Figure 3.22.

Overhang Width: The distance the overhang protrudes out from the face of the wall. The overhang is assumed to extend far enough from side to side to shade the entire width of the window (m or ft). Refer to Figure 3.22.

Reveal: Specifies the distance the outside surface of the window is set back from the outside surface of the wall. This can produce a shadow on the window that must be taken into account when calculating the solar gain (m or ft). Distance from the overhang specifies how far above the top edge of the window the overhang is attached to the wall (m or ft). Refer to Figure 3.22.

Normal SHGC: The Normal Solar Heat Gain Coefficient (SHGC) for the window.

LW Emissivity out: Specifies the emittance for long wavelength radiation for the outside. This value is used for the surface heat balance calculation.

LW Emissivity in: Specifies the emittance for long wavelength radiation for the inside. This value is used for the surface heat balance calculation.

U Factor: Specifies the U-Factor for the material used for the window (w/m^2 or $Btu/[hr.ft^2]$). The ‘U factor’ specified for the window should not be zero.

Transmittance of inside shade: The fraction of the solar radiation transmitted through the window, which is, in turn, transmitted through the shade/drapery into the room. The remainder is assumed to be convected to the zone air.

At present, the procedure utilized in the program does not match the method described in the book. Given the information in the book, the best approach is probably to simply multiply the SHGC by the IAC and enter the modified value as the SHGC. Then, the transmittance of inside shade should be set to 1.

Clicking ‘Library’ brings up the Library of windows. Clicking ‘Delete’ deletes the window details and exits the dialog box. Clicking ‘OK’ saves the information and then exits the dialog box. Clicking the ‘Info’ button brings up the window details dialog box, shown in the next section.

The ‘Delete’ button is not shown when the new window is being created. The caption of the dialog changes depending whether the new window is being created or the details of the existing one are being shown.

3.11 Window Details Dialog Box

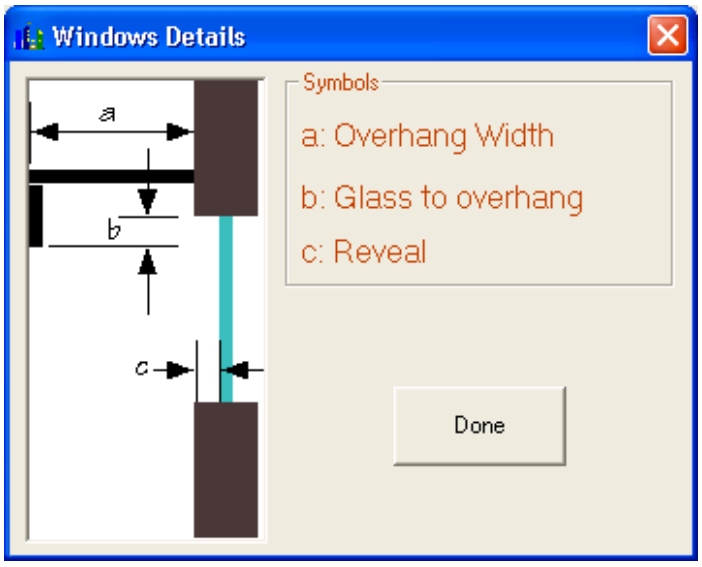

Figure 3.22 Window Details Dialog Box

The windows details dialog box, shown in Figure 3.22, comes up when user clicks on the 'Info' button on the windows dialog box.. Clicking on 'Done' exits the dialog box.

3.12 Layer Information Dialog Box

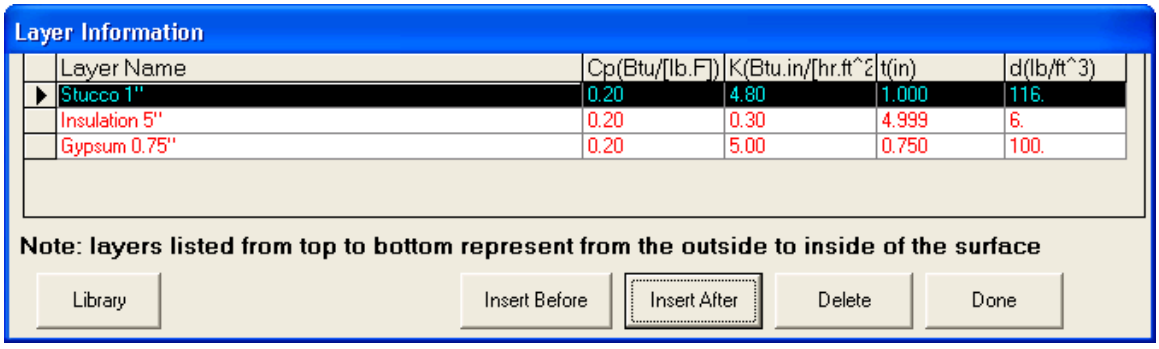

Figure 3.23 Layer Information Dialog Box

The layer information dialog box, shown in Figure 3.23, appears when the user clicks the 'Layer Information' button on the wall dialog box. The layers are specified from the outside of the surface to the inside.

Clicking the ‘Insert Before’ will insert a new layer before the layer selected. Then all the required values can be entered in this new row. Clicking the ‘Insert After’ will insert a new layer after the layer selected. Then all the required values can be filled entered in this new row. Clicking the ‘Library’ button will bring up the external library of materials from which a layer can be selected. Clicking ‘Delete’ will delete the selected layer. ‘Done’ exits the dialog box. All data for a layer should be filled in before proceeding. The appropriate units are shown in the column headers.

In some cases, the user may be interested in adding a purely resistive layer, e.g. fiberglass insulation. In that case, the user may set the specific heat and density to zero, set the conductivity to 1 and set the thickness to the desired resistance.

Table 5.1a and Table 5.1b of the text have values for thermal properties of different materials normally used.

3.13 Wall construction library dialog box

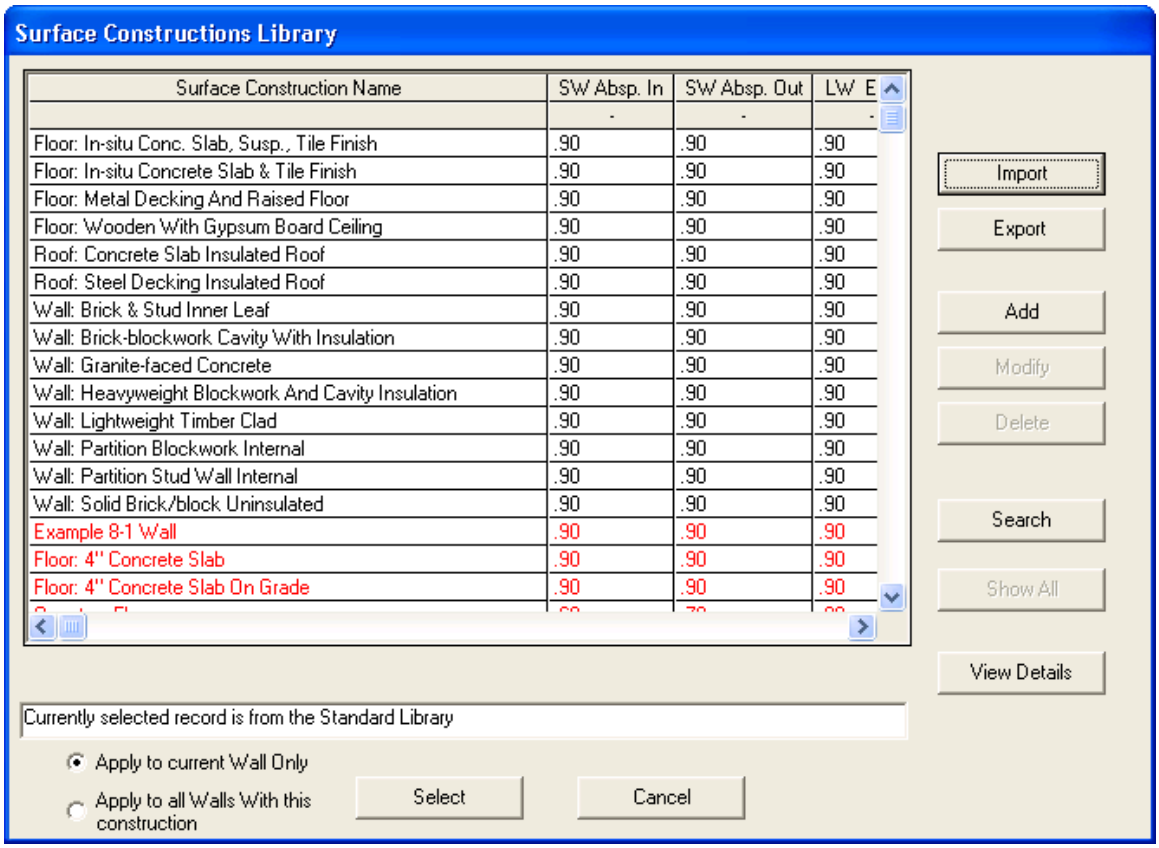

Figure 3.24 Wall Construction library Dialog Box

This window is brought up when the user clicks the construction library button from the wall information dialog box. The user can then select a construction for the wall. Further information about libraries is given in the "Generic library section" below

If the user wishes to change all the walls in the building with a certain construction to different one then the user can select the "apply to all walls with this construction" option before selecting the wall.

3.14 Wall other side temperature dialog box

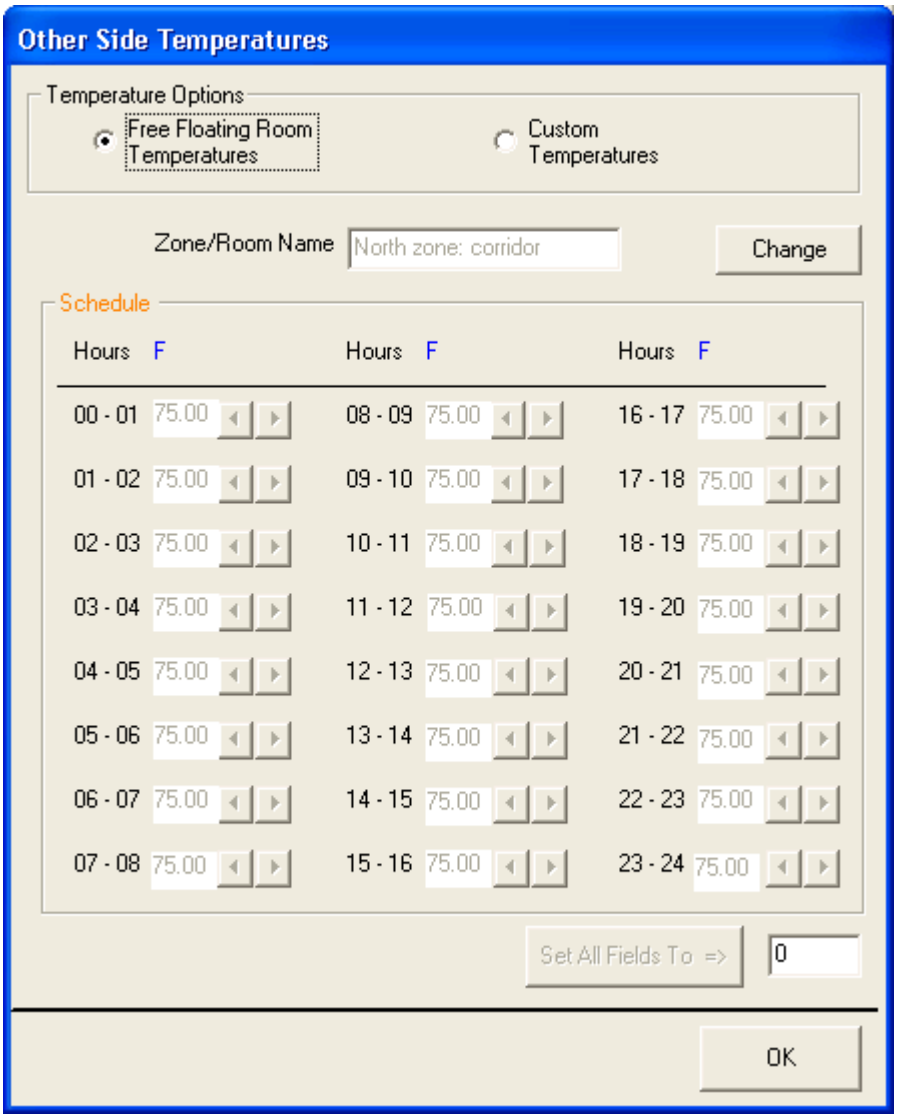

Figure 3.25 Wall other side temperature Dialog Box

This dialog box is shown when the user selects the TIZ boundary condition for a wall and clicks the ”Other side temperatures” button.

This dialog allows the user to specify a constant or scheduled set of other side temperatures, or to specify a free floating room from which to take the temperatures as the boundary condition.

Clicking on the “Free Floating room temperatures” option brings up a dialog box that lets the user select the free floating zone and room. The user can then the change the selected room by clicking the “Change” button.

Clicking on the “Custom temperatures” option lets the user edit the temperature for each hour.

3.15 Other side room selection dialog box

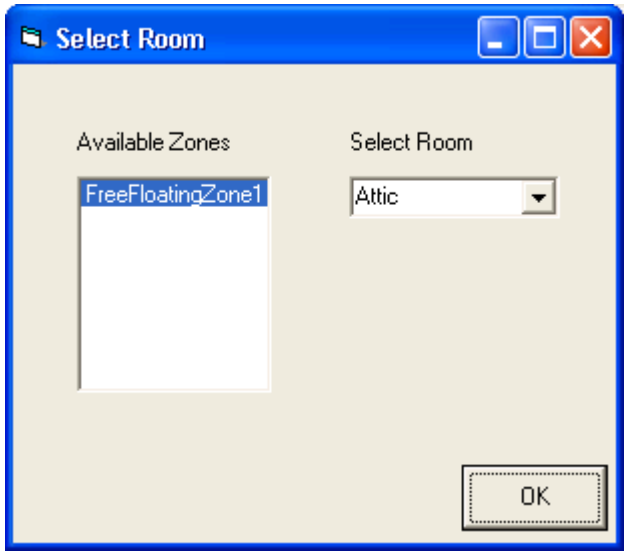

Figure 3.26 Wall other side temperature dialog box

This dialog box is brought up when the free floating room is selected in the other side temperature dialog box. The Available zones list box is populated with all the free floating zones in the building. The select room list is populated with the rooms in the zone selected in the list box. The user can then select the desired room by clicking on the arrow.

3.16 People Information Dialog Box

The people information dialog box, shown in Figure 3.24, appears when either new heat gain due to people is added or the details of existing people heat gain due to people are to be displayed.

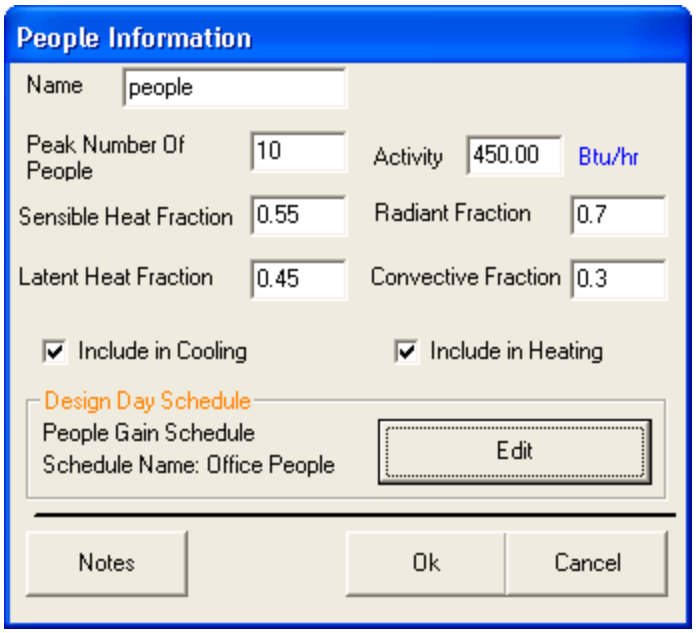

Figure 3.27 People Information Dialog Box

Name: Name of heat gain due to people

Activity: Specifies the total sensible and latent heat gain per person (Watts or Btu/hr)

Peak Number of People: Specifies the maximum number of people at any time during the day. This is used along with the fraction specified in the schedule to create a 24-hour schedule of the people in the room.

Sensible Heat Fraction: Specifies the fraction of heat gain due to people that is sensible often referred to as the sensible heat factor or sensible heat ratio.

Latent Heat Fraction: Specifies the fraction of heat gain due to people that is latent.

The latent heat fraction and sensible heat fraction must sum up to one.

Radiant Heat Fraction: Specifies the fraction of the sensible heat gain that is radiative.

Convective Heat Fraction: Specifies the fraction of the sensible heat gain that is convective.

Include in cooling check box: Specifies if the people gain is to be used while calculating the cooling load

Include in heating check box: Specifies if the people gain is to be used while calculating the Heating load

The radiant heat fraction and convective heat fraction must sum up to one. Typical metabolic heat generations for various activities are given in Table 4.4 of the text. Also rates of occupants of conditioned spaces are given in the Table 8.7 of the text.

Clicking on the 'Edit' button will bring up the dialog box for the 24-hour schedule for the day. The fraction of the peak heat gain is entered for each day. Clicking 'OK' will save the information and exit. Clicking the 'Notes' will bring up the notes dialog box to add the extra information about the people gain.

3.17 Light Information Dialog Box

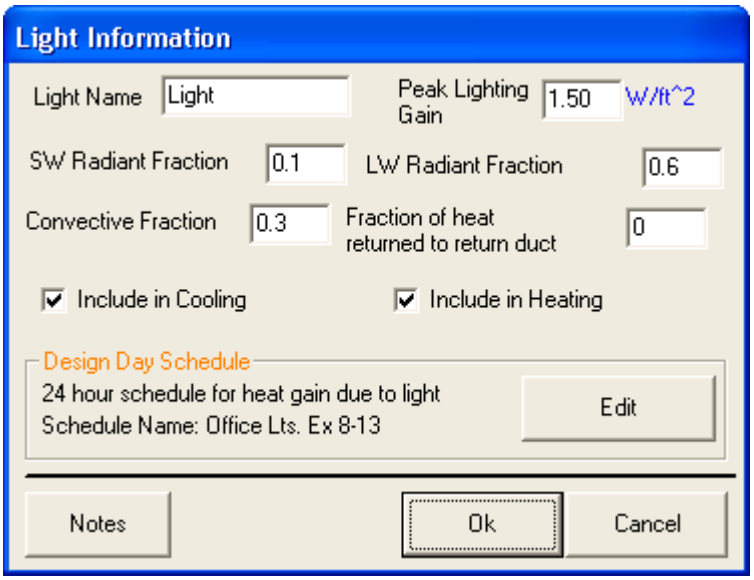

Figure 3.28 Light Information Dialog Box

The light information dialog box, shown in Figure 3.25, appears when either new lighting heat gain is added or the details regarding existing lighting heat gain are to be displayed. Since the light is often the major internal load component, an accurate estimate of the space heat gain it imposes is needed.

Peak Light Gain: The peak lighting heat gain in the design day schedule. This value is used along with the fraction of the peak heat gain to create the 24-hour schedule of the light gain (W/m^2 or $Btu/[hr.ft^2]$).

SW Radiant Fraction: The fraction of lighting heat gain in the short wavelength (visible) radiation form

LW Radiant Fraction: The fraction of lighting heat gain in the long wavelength (infrared) radiation form

Convective Heat Fraction: The fraction of lighting heat gain in the convective heat form

Fraction of Heat Returned to the Duct: The fraction of total heat that goes directly to the return air duct.

Include in cooling check box: Specifies if the light gain is to be used while calculating the cooling load

Include in heating check box: Specifies if the Light gain is to be used while calculating the heating load

Convective heat fraction, LW Radiant Fraction and SW Radiant heat fraction must sum to one.

Clicking on the 'Edit' button will bring up the dialog box for the 24-hour schedule for the fraction. Clicking 'OK' will save the information and exit. Clicking the 'Notes' will bring up the notes dialog box to add the extra information about the light gain. Recommended radiative and convective fractions are given in Table 8.20 of the text.

3.18 Equipment Information Dialog Box

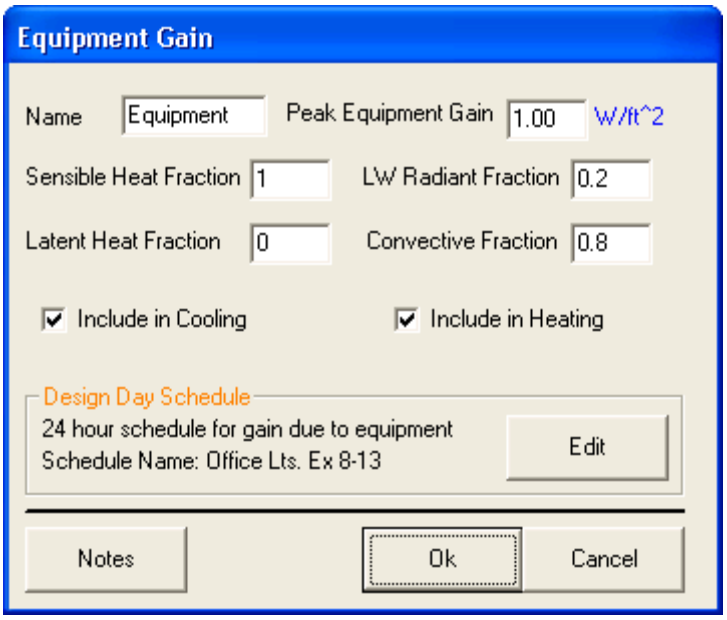

Figure 3.29 Equipment Information Dialog Box

The dialog box, shown in Figure 3.29, comes up when either new equipment heat gain is added or the details regarding existing equipment heat gain are to be displayed.

Peak Equipment Load: Specifies the peak equipment heat gain in the design day schedule at any time during the day. This is used along with the fraction specified below in the schedule to create a 24-hour schedule of the equipment gain in the room (w/m^2 or $Btu/[hr.ft^2]$).

Sensible Heat Fraction: Specifies the fraction of heat gain due to equipment that is sensible.

Latent Heat Fraction: Specifies the fraction of heat gain due to equipment that is latent.

The latent heat fraction and sensible heat fraction must sum up to one.

Radiant Heat Fraction: Specifies the fraction of the sensible heat gain that is radiative.

Convective Heat Fraction: Specifies the fraction of the sensible heat gain that is convective.

Include in cooling check box: Specifies if the Equipment gain is to be used while calculating the cooling load

Include in heating check box: Specifies if the Equipment gain is to be used while calculating the heating load

The radiant heat fraction and convective heat fraction must sum up to one.

Clicking on the 'Edit' button will bring up the dialog box for the 24-hour schedule for the fraction. Clicking 'OK' will save the information and exit. Clicking 'Notes' will bring up the notes dialog box to add the extra information about the equipment gain.

3.19 Daily Schedule Dialog Box

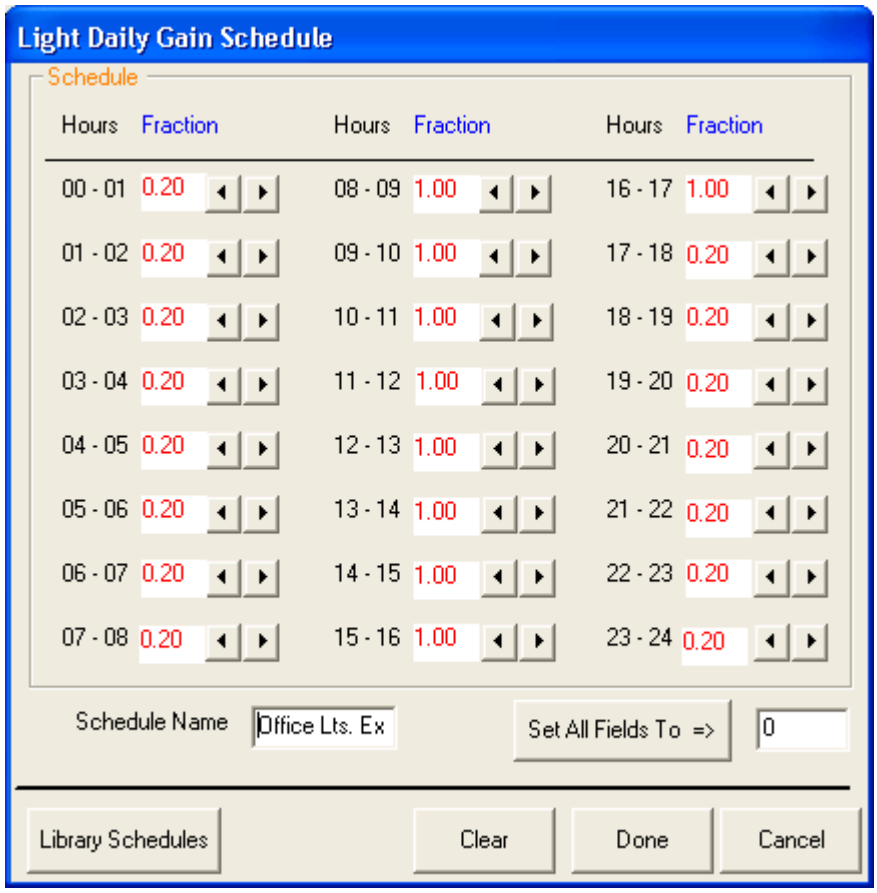

Figure 3.30 Daily Schedule Dialog Box

The dialog box, shown in Figure 3.30, appears whenever a 24-hour schedule is to be displayed. It is used for displaying the fraction of peak gain for lighting, equipment and people heat gains and displaying temperatures for the special outside boundary conditions and internal temperatures.

When it is used for fractions it checks whether all the values in the dialog box are between 0 and 1.

Clicking on the 'Library Schedules' brings up the library database, which give several preset schedules for different conditions. 'Done' saves the value and exits the dialog box. Clicking on the 'Set All Fields to =>' button sets the values in the all the text fields.

3.20 Notes Dialog Box

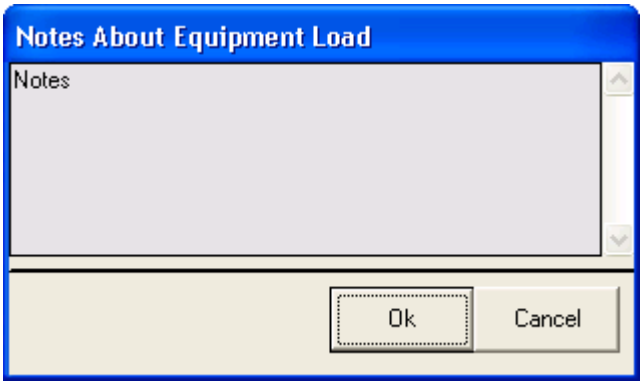

Figure 3.31 Notes Dialog Box

The dialog box, in Figure 3.31, shows up whenever there is extra information to be stored related to any element of the building.

Clicking 'OK' saves the information entered and exits the dialog box. The changed value is stored in buffer. The change reflects in database only when 'OK' on the parent dialog box is clicked.

3.21 Result Display Dialog Box

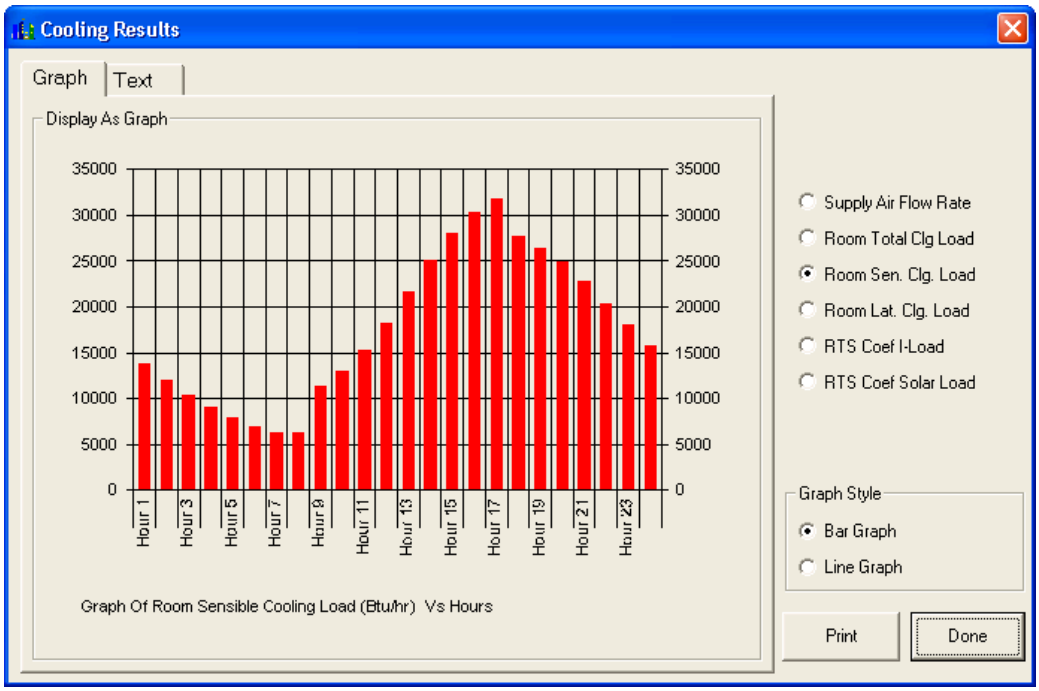

Figure 3.32 Result Display Dialog Box Showing graph

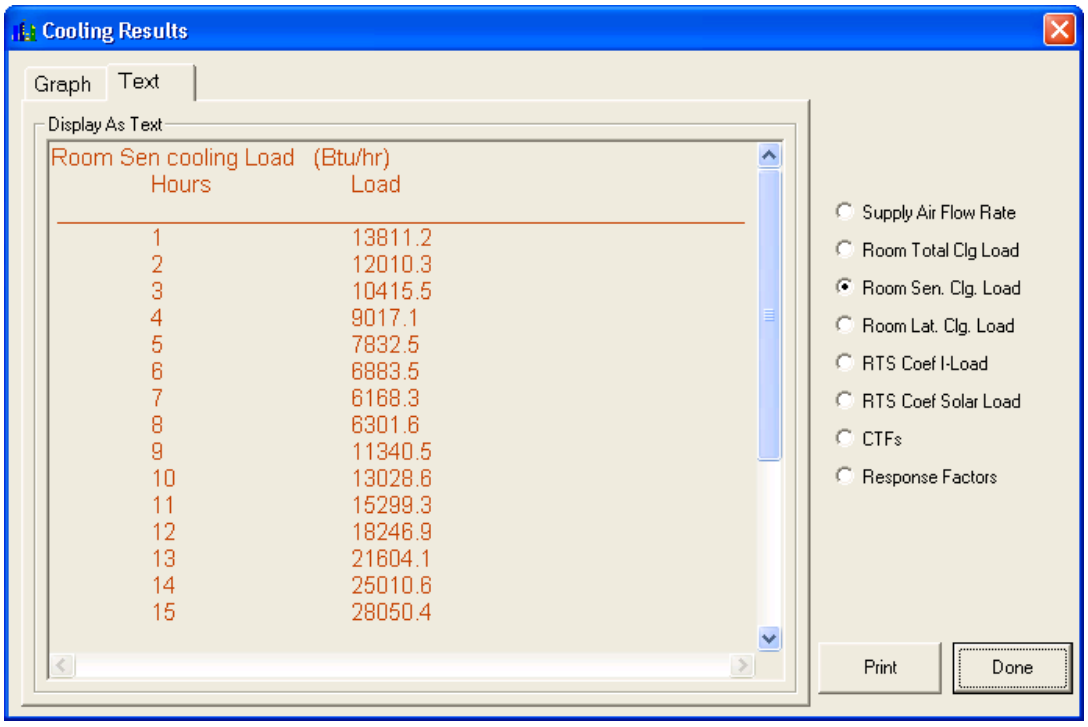

Figure 3.33 Result Display Dialog Box Showing Text

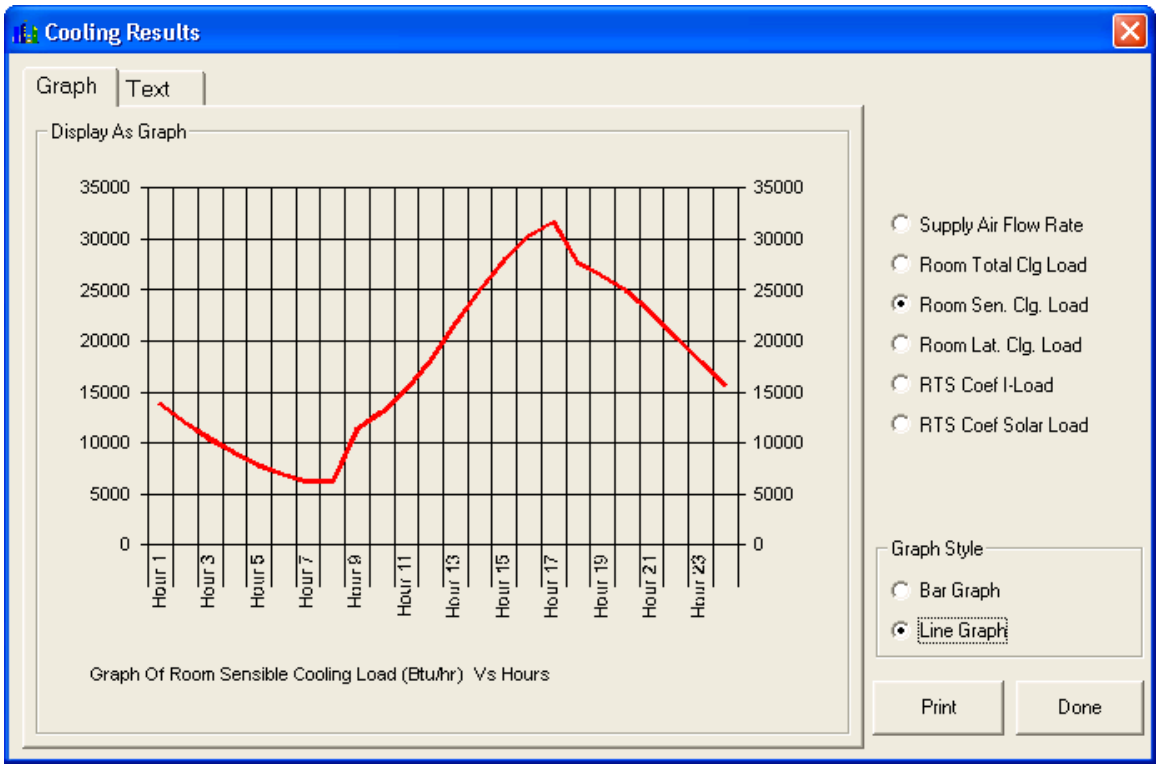

Figure 3.34 Result Display Dialog Box Showing graph in Line mode

Once a cooling or heating load calculation is performed for a room, zone, or building, the results will be displayed in a dialog box, as shown in Figures 3.32-3.34. The actual results displayed vary, depending on what type of load is calculated. Also, some outputs, such as CTF coefficients are only given in the text display. For whole building calculations, all loads can be displayed in the text display by selecting "Show all rooms and zones."

For an entire building calculation, the following outputs are displayed, either as cooling loads or heating loads:

- Total Coil Load: Total load on coil (W or Btu/hr).
- Sensible Coil Load: Sensible load on coil (W or Btu/hr).
- Latent Coil Load: Latent load on coil (W or Btu/hr).
- Show All: Shows report about all the rooms. For each room the sensible load, airflow required, coil loads (total, sensible and latent) are shown.

For zone load calculations, all of the outputs for the building are displayed, plus the required air flow rate for the zone.

For a room load calculation, the following outputs are displayed. For loads, they will be given as either cooling or heating loads.

- Supply Air Flow Rate: supply air flow rate for the room (m^3/s or CFM)
- Room Total Load: The total cooling or heating load for the room as determined by the heat balance method (W or Btu/hr).
- Room Sensible Load: The sensible cooling or heating load for the room as determined by the heat balance method (W or Btu/hr).
- Room Latent Load: The latent cooling or heating load for the room as determined by the heat balance method (W or Btu/hr).
- Sensible Cooling Coil Load: Sensible load on coil (W or Btu/hr).
- Latent Cooling Coil Load: Latent load on coil (W or Btu/hr).
- RTF Coef I Loads: RTS coefficients for processing internal gains. As described in Chapter 8, these coefficients may also be used for processing solar heat gains.
- RTF Coef Solar Loads: RTS coefficients for processing solar gains
- Conduction Transfer Coefficients: Conduction transfer coefficients for all the surfaces. (Only shown in the text display)
- Response Factors: Steady periodic response factors for RTS calculation, all surfaces (Only shown in the text display)

In addition to these reports, additional reporting capabilities are described below in Section 3.23. One can also cut and paste the information from the text box and use it to plot or print. The text data can be printed out using the 'Print' button on the dialog box.

3.22 Calculate For Building Dialog Box

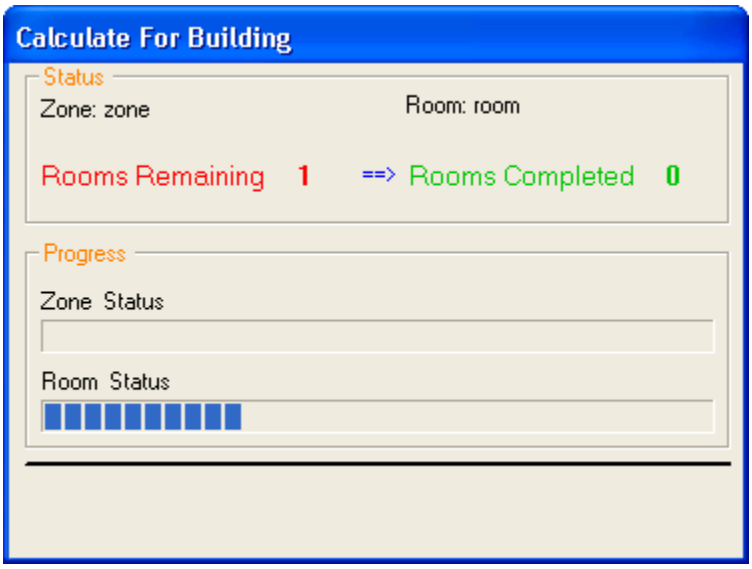

Figure 3.35 Calculate For Building Dialog Box

The dialog box, shown in Fgure 3.35, appears when the menu for running the calculation for the entire building is chosen. Zone and room names are displayed as the calculations are performed, and the number of rooms remaining and completed are also displayed.

3.23 Output Report Dialog Box

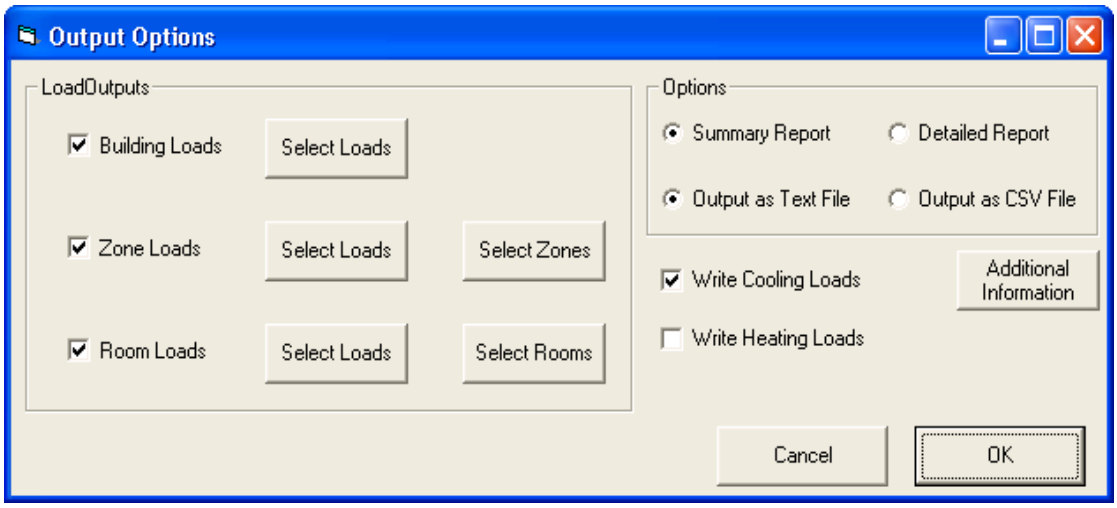

Figure 3.36 Report Options Dialog Box

This dialog box is brought up when the user selects the create report file option in the calculate menu. This can be used to output the results of the calculation or details about the building. The output can be in either text form or comma separated variable (CSV) format for exporting to spreadsheets, such as Excel ™.

The user can select the various loads to be included in the output by clicking the select loads button. The rooms and zone whose results are to be included can be selected by clicking the “select Zones” and “select Rooms” button.

The options section allows the user to select the type of report and the type of output file. In the case of a summary report only the peak loads are reported. In the case of a detailed report the loads for all 24 hours are reported..

By clicking the “write cooling loads” or “Write heating loads” check boxes the user can select either to output the cooling load or heating load or both. The loads are calculated once the OK button is pressed.

The additional Information dialog box allows the user to select the various construction details of the building.

3.24 Select loads dialog box

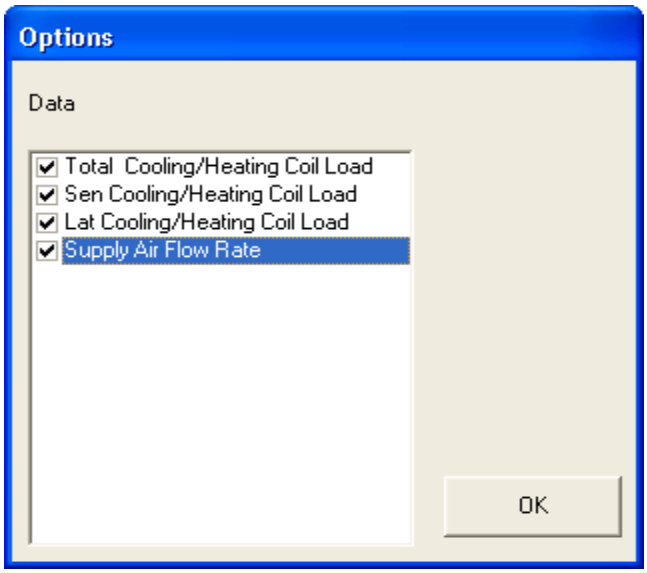

Figure 3.37 Load Options Dialog Box

This dialog box is brought up when the user clicks the select loads button in the output report dialog box. The loads in the list-box that are checked will be included in the output report. The above dialog box shows an example of zone loads selected.

3.25 Select Zone/Room dialog box

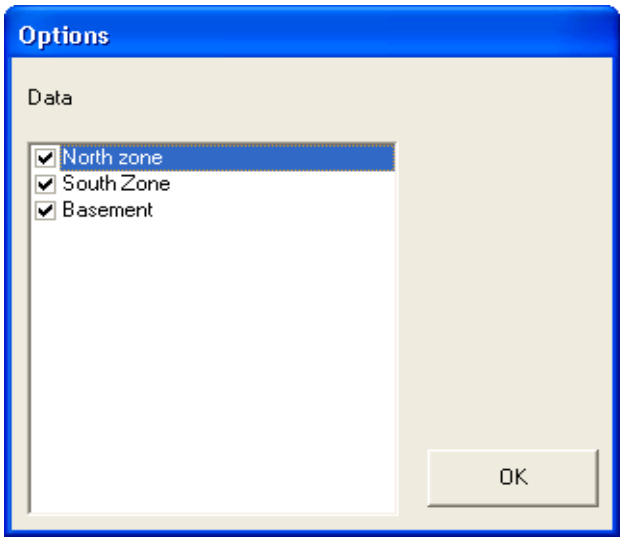

Figure 3.38 Zone Options Dialog Box

This dialog box is brought up when the user clicks the select zone or select room button in the output report dialog box. The dialog boxes allows the user to select the rooms or zones which are to be included.

3.26 Additional information dialog box

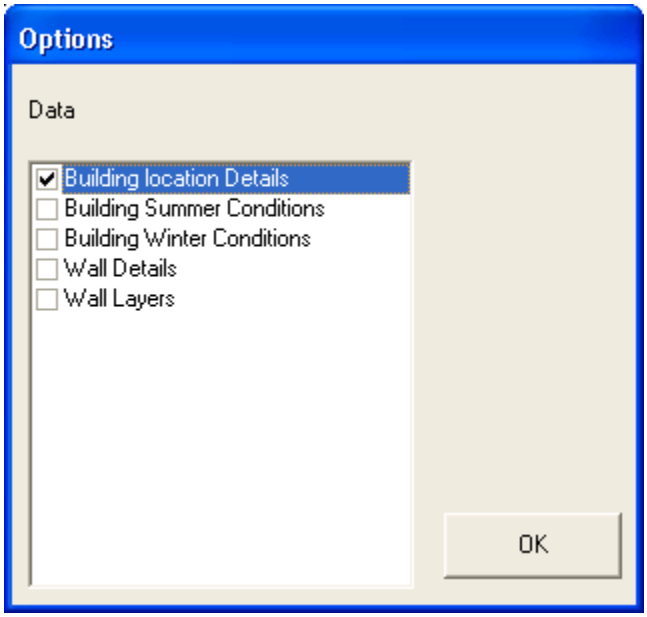

Figure 3.39 Additional information Dialog Box

This dialog box is brought up when the user clicks the “Additional Information” button on the create report dialog box. It allows the user to select the additional information about building construction to be output in the report.

3.27 Example of summary Output

Summary Report(Peak Loads)

Name Of Building: Office Building

##Cooling Load Calculations##

Coil Loads

Load	Hour	Total CLg Coil Load (BTU/Hr)	Sensible CLg Coil Load (BTU/Hr)	Latent CLg Coil Load (BTU/Hr)	Air Flow (CFM)
North zone	17	43828.4	38145.9	5682.5	1734.7
South Zone	17	37936.2	30552.4	7383.8	1389.9
Sum	17	81764.6	68698.3	13066.3	

Room Loads

Load	Hour	RoomTot Clg.Load (Btu/hr)	RoomSen Clg.Load (Btu/hr)	RoomLat Clg.Load (Btu/hr)	Supply AirFlowRate (CFM)
North zone					
office no 1	17	20239.2	18488.6	1750.6	840.3
office no3	17	7150.9	5888.6	1262.3	267.6
Store	17	5299.6	4442.3	857.3	201.9
toilet	17	3926.5	3412.1	514.4	155.1
corridor	17	7077.9	5934.8	1143.1	269.7
South Zone					
Office no 2	17	7034.3	5772.0	1262.3	262.3
ConferenceRoom	17	18140.3	12947.2	5193.1	588.5
Lobby	15	12885.5	12172.9	712.6	553.3

3.28 Generic Library dialog box

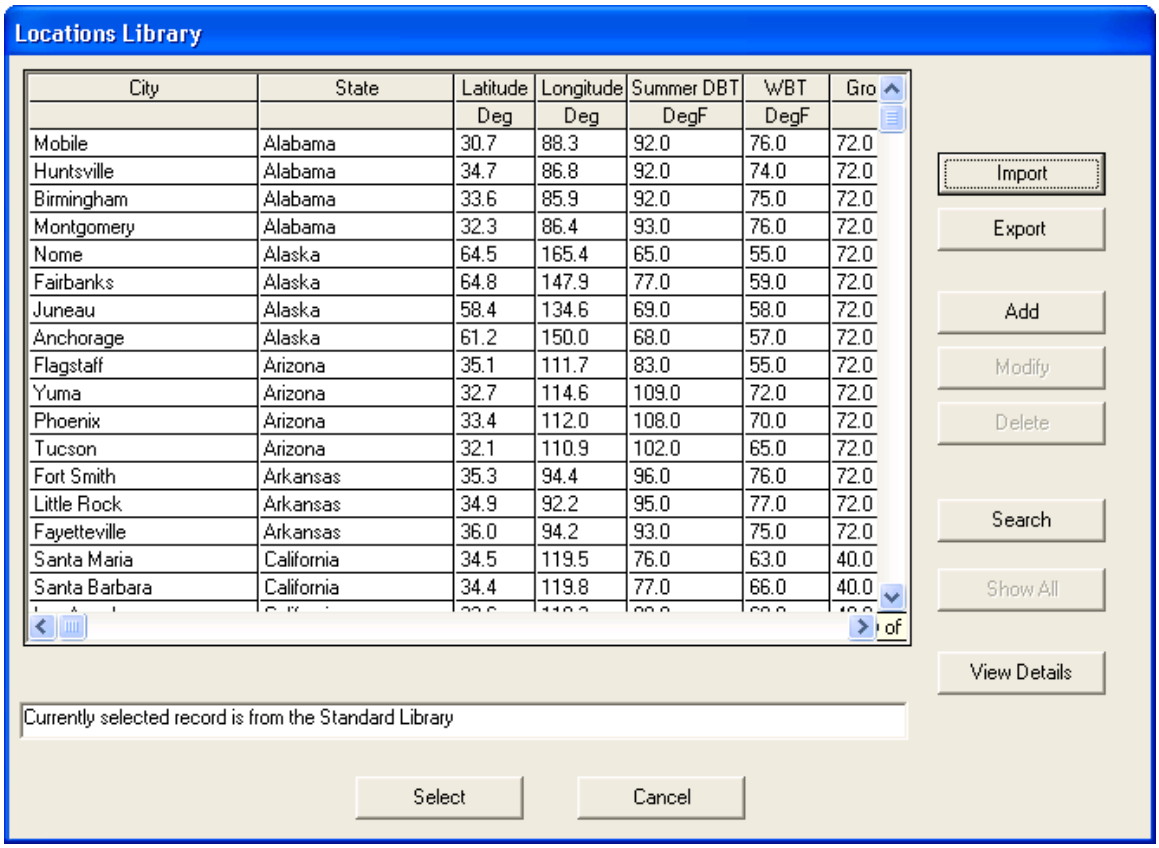

Figure 3.40 Generic Library dialog box.

Many parts of HvacLoadExplorer utilize a library, e.g. locations, walls, roofs, etc. Each library uses dialog boxes as shown in the Figure 3.40.

The data are displayed in a tabular format in a grid. This grid displays data from both the standard library and the User library. The information from the standard Library is displayed in black text and the information from the User library is displayed in red text.

Only one row in the grid is can be selected at any instant. Hence, there should be no confusion about the record that is selected or that has to be modified or deleted. A status bar has been included which gives information about the currently selected record, whether it is from the standard library or the user library. Double clicking a particular row brings the control back to the main form, which initiated the library form.

Alternatively the user can also press the ‘Select’ push button after clicking on the row of interest

The dialog box has push buttons with captions ‘Add’, ‘Modify’ and ‘Delete’. The ‘Add’ push button will always be enabled. The ‘Modify’ and ’Delete’ push buttons will be enabled only when the currently selected record is from the user library. This prevents the user from modifying or deleting records that belong to the standard library.

The dialog box also includes buttons with captions ‘Search’ and ‘Show All’. The ‘Search’ button brings up a search dialog box. When records matching the search criteria are found, they are displayed in the grid. The user can revert to displaying all the records by clicking the ‘Show All’ push button. The ‘Show All’ push button will be enabled only when the grid displays search results.

The user can also ‘Import’ and ‘Export’ the libraries. Clicking the ‘Export’ button while search results are being displayed will result in exporting the matching records from the User Library to an ASCII text file with the ‘.lib’ extension. Clicking the ‘Export’ button with all records displayed will export the entire User Library to an ASCII text file. With this file, one or a few library items can be moved between computers or users.

3.29 Add Layer dialog box

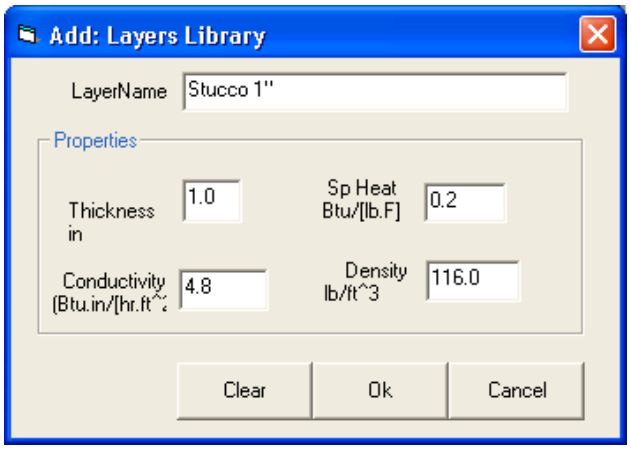

Figure 3.41 Add Layer dialog box.

The dialog box, shown in Figure 3.41, appears when a new layer is to be added in the layer library. It shows the layer name as well as text fields for entering the properties of the layer. Properties include conductivity, density, thickness, specific heat and layer name. As the values of L/K (Thickness/Conductivity) are used to calculate the effective thermal resistance of the wall. None of those two values should be zero as a 'division by zero' error will occur in the solver. This check is made in the program.

In some cases, the user may be interested in adding a purely resistive layer, e.g. fiberglass insulation. In that case, the user may set the specific heat and density to zero, set the conductivity to 1 and set the thickness to the desired resistance.

Clicking on 'Ok' adds a new layer in the library database. The initial values in the dialog box depend on whether user has clicked on any layer in the database. Name of the layer has to be unique in the database.

3.30 Search Help dialog box

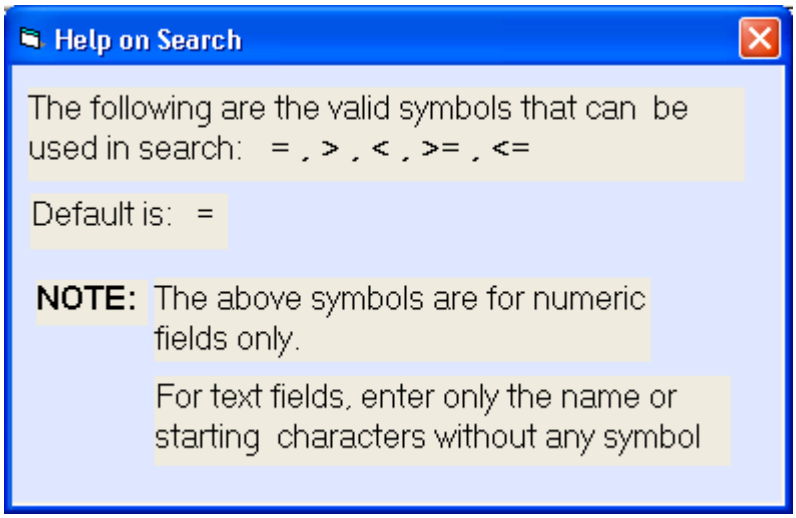

Figure 3.42 Search Help dialog box

This search help dialog box, shown in Figure 3.42, tells about the different options that user can have while searching the library. This dialog box comes up when the user clicks on the 'help' button on the dialog box, which comes up when he clicks on the 'Search' button.

4.0 – Calculation of Radiant Time Series Factors and Response Factors

The Radiant Time Series Method (RTSM) is an approximation of the heat balance method. A heat balance simulation is required to produce the coefficients of the radiant time series for a given zone construction. A series of 24 radiant time series factors, which completely describes the zone response to the steady periodic input, can be generated using HvacLoadExplorer. Likewise HvacLoadExplorer can also calculate periodic response factors used for computing conduction heat gains with the RTSM.

In order to use the heat balance method to generate the radiant time series, a zone description consisting of geometric and construction information is needed. All surfaces are represented as 'partition' heat storage surfaces that do not interact with the outside environment. It is not necessary to describe weather conditions, internal heat gains (people, lights, equipment), infiltration, zone axis orientation, or supply air temperatures. But, it is necessary to describe all surfaces, including windows, and the room air temperature must be set to a fixed value for all 24 hours.

If only periodic response factors are needed, only the minimal number of surfaces must be described. (HvacLoadExplorer needs at least one wall type surface and a floor type surface in a room to be able to complete the calculation successfully.

Once the above information has been entered, 'Execute for Room' will perform a heat balance simulation and provide the radiant time factors and periodic response factors as shown in Figures 4-1 and 4-2.

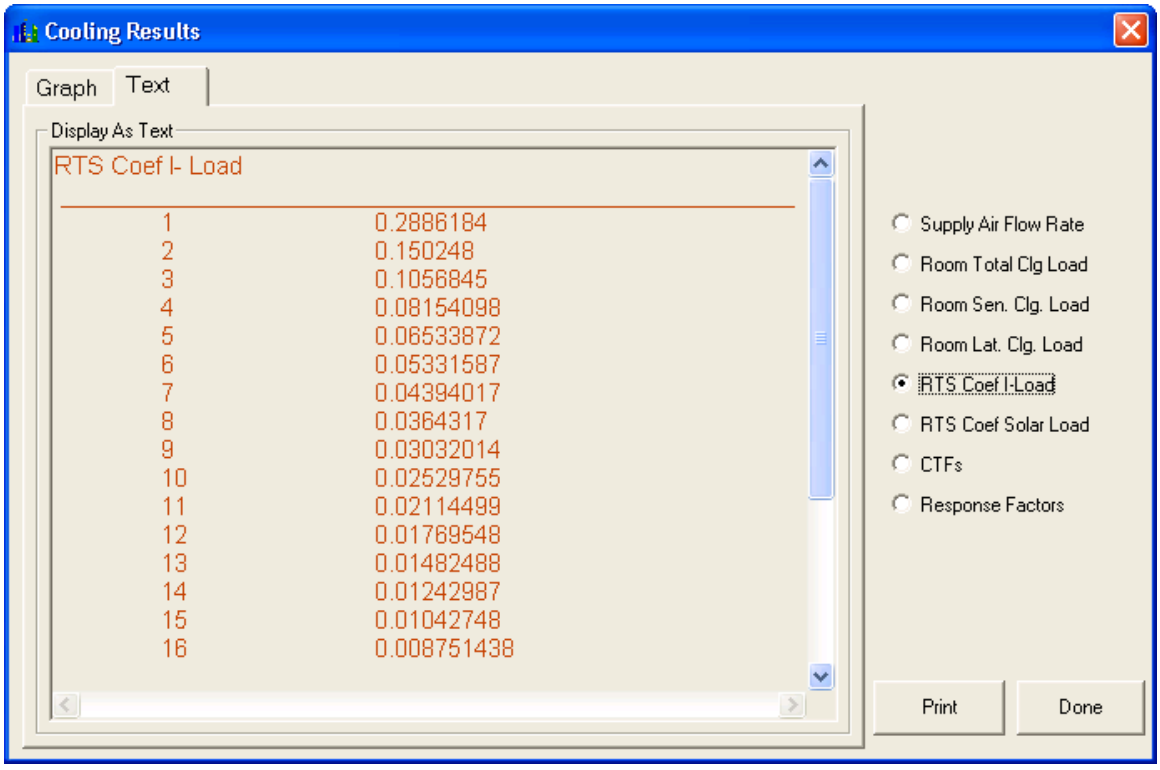

Figure 4.1 Radiant Time Series Factors Displayed in Text Form

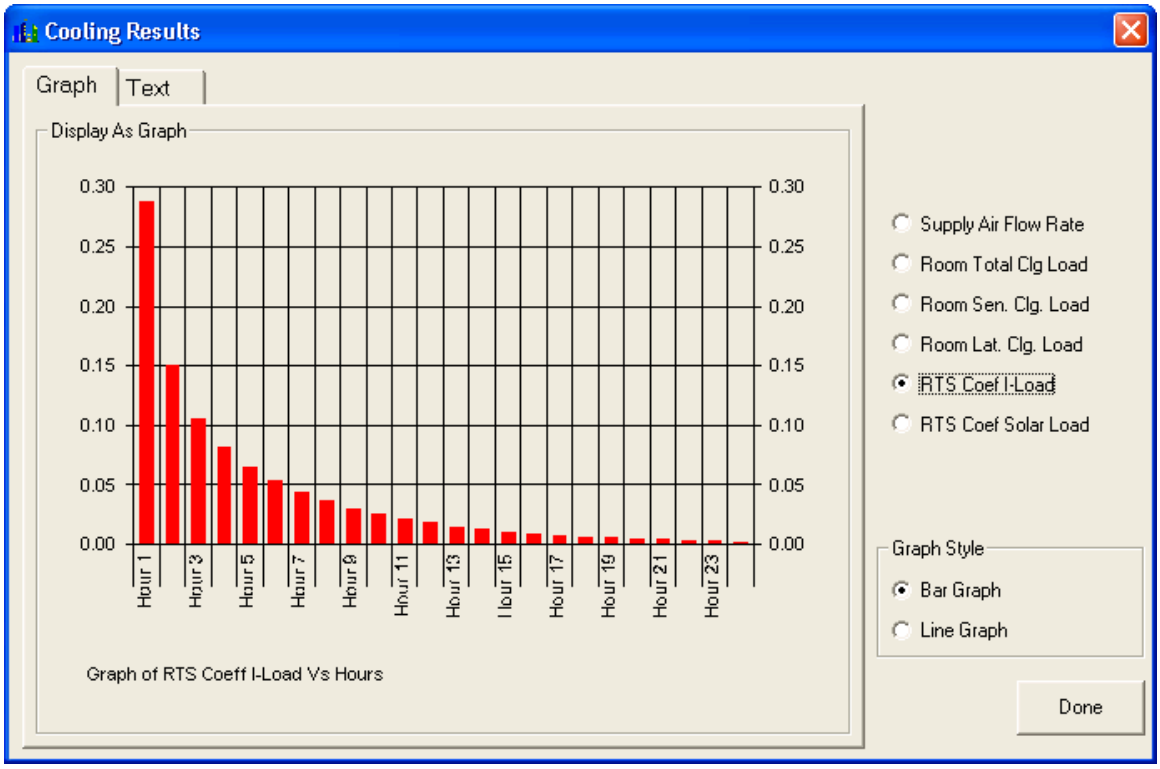

Figure 4.2 Radiant Time Series Factors Displayed in Graph Form

Appendix 1
HVAC Load Explorer Version 1.1.0 new features

Version 1.1.0 has added several new features, summarized below. Many of these features previously appeared in incremental releases made on the book website..

1. In order to support calculation of airflow rates for heating, it was necessary to allow users to specify the supply air temperature for heating. This is done in the Zone information dialog box, as shown below. The Zone Information dialog box can be opened by double-clicking the zone icon, or by right-clicking on the zone icon in the tree view, and choosing "Properties".

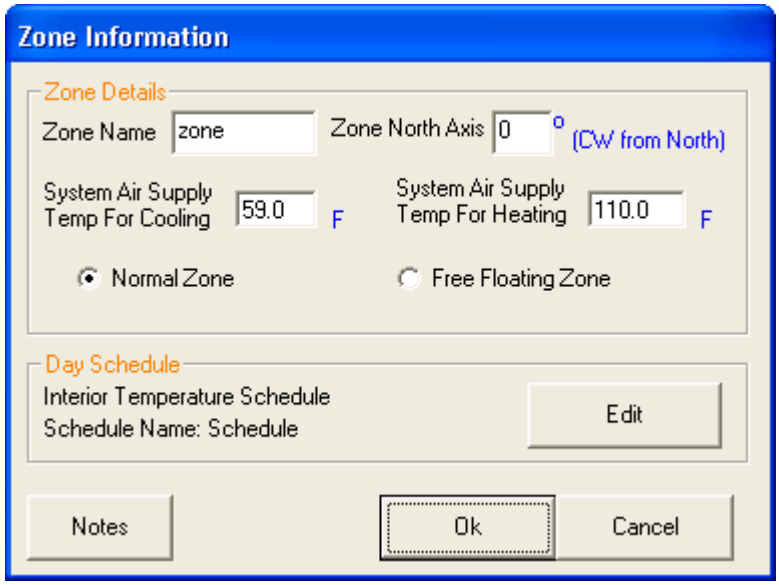

Figure A1-1 Zone Information Dialog Box

2. Calculations can now be done for all rooms in a zone. This allows the user to get a "sub-total" of all the cooling or heating loads for the rooms in a particular zone. This may be useful for sizing equipment that only serves a particular zone. To do this, choose "Execute for Zone" from the Calculate menu, after selecting a specific zone, as shown below.

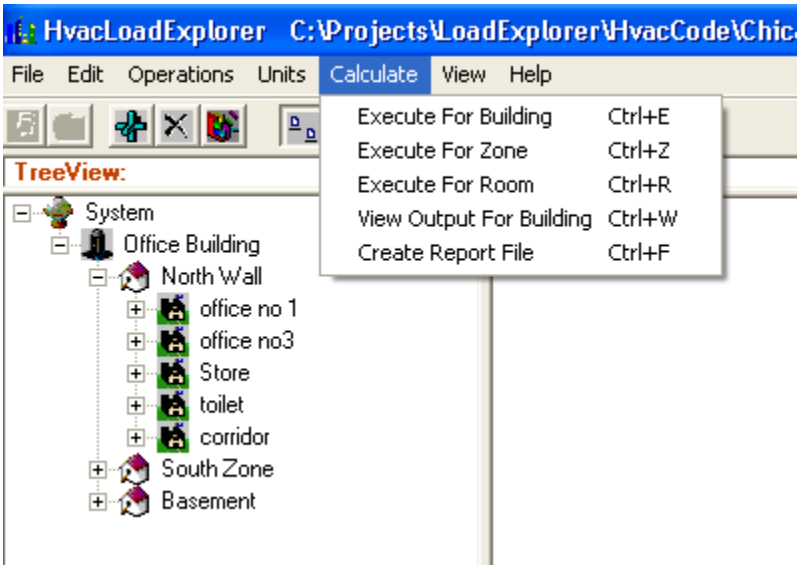

Figure A1-2 Calculate Menu

3. Heat gains such as lighting, people, equipment, infiltration, and ventilation may now be independently included or excluded from the cooling and heating load calculations. As shown in the Light Information dialog box, two check boxes have been added. If both boxes are checked, the program will work as before, calculating the effect of the lighting heat gain on both the cooling and heating load.

   This feature is intended to support heating load calculations, where it is often desirable to calculate the heating load without taking credit for heat gains due to lights, people, and equipment.

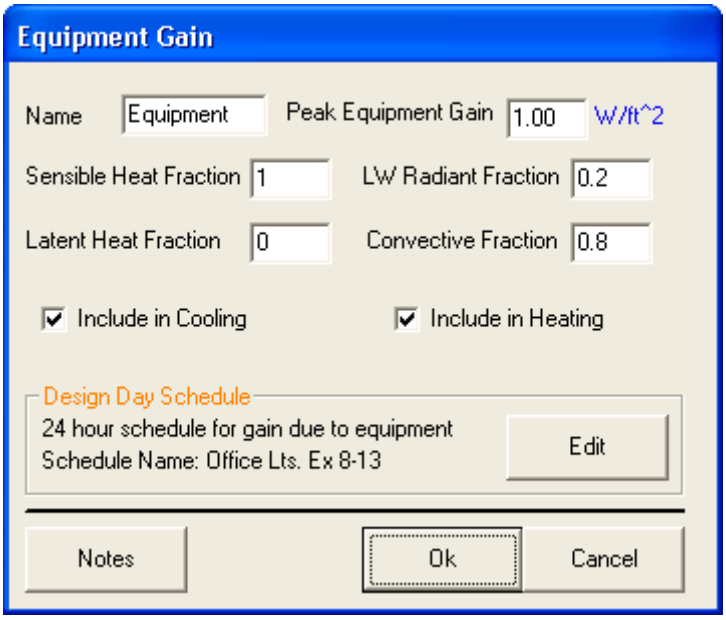

Figure A1-3 Equipment Gain Dialog Box

4. Items in the Tree View may be right-clicked; an appropriate menu will come up. See example below.

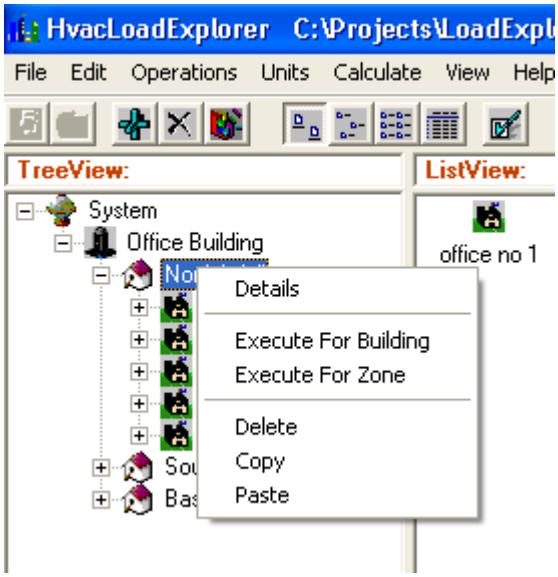

Figure A1-4 Menu that Appears when Right-Clicking on Tree View Item

5. A feature to update all the walls with the same name to a different construction has been added. This may be useful for cases where a user wishes to change the

construction of a number of walls at once. For example, if the user has a construction called "My House Wall" that appears in a number of rooms, and the user wishes to increase the insulation level everywhere, this option may be used to make the changes everywhere at once. This can be done from the construction library dialog box that can be accessed through the wall information dialog box.

6. Free floating zones can now be included the building construction. This allows the user to model attics, garages, crawlspaces, etc. . The free-floating room temperature can then become a boundary condition for rooms in normal (or, for that matter, in free-floating) zones. A common application would be attics above conditioned rooms. In the conditioned room, the ceiling can be set to have a TIZ boundary condition, with the other side temperature coming from the attic. In the attic, the floor can be set to have a fixed or scheduled other side temperature equivalent to the controlled temperature in the conditioned spaces. The temperature of the free floating zone after the simulation can be viewed after the simulation.

7. Output reports can be generated in either text or comma-separated-variable format. The user can choose the types of output in the report. Specific zones and rooms may be specified and/or specific load types may be specified. In addition, the report can contain details of the building geometry and construction, etc. For loads, either a comprehensive report, containing values for all 24 hours, may be generated or a summary report containing only the peak loads may be produced.