TESS Basement Model Tutorial and Example

Introduction

The TESS Basement Model interacts with one or multiple zones in Type56 to simulate building to ground energy exchange. There are three important steps to implement the TESS Basement Model. The first step is to create the component input file that contains the locations of the soil nodes. The second step is to create the necessary inputs and outputs in Type56/TRNBUILD and connect them to the basement model in TRNSYS. The third step is post-processing the output file.

The following figure is Google Sketchup model of provided example. It contains four zones: three basements with various levels of insulation and one slab.

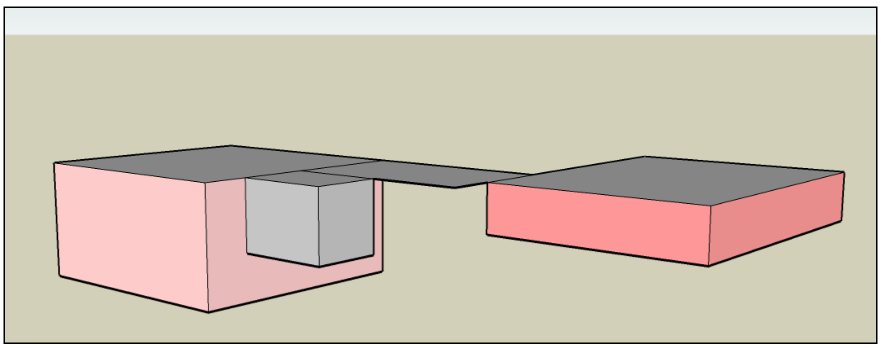


Figure 1: Multizone Basement Example in Sketchup

1 TESS Basement Model Input File

The input file is a text, tab-delimited file that contains the number of nodes in the x-direction, y-direction, z-direction, node locations in the three directions, and the zone locations. It is necessary to create more nodes close to the building/ground boundaries as shown in the following figure.

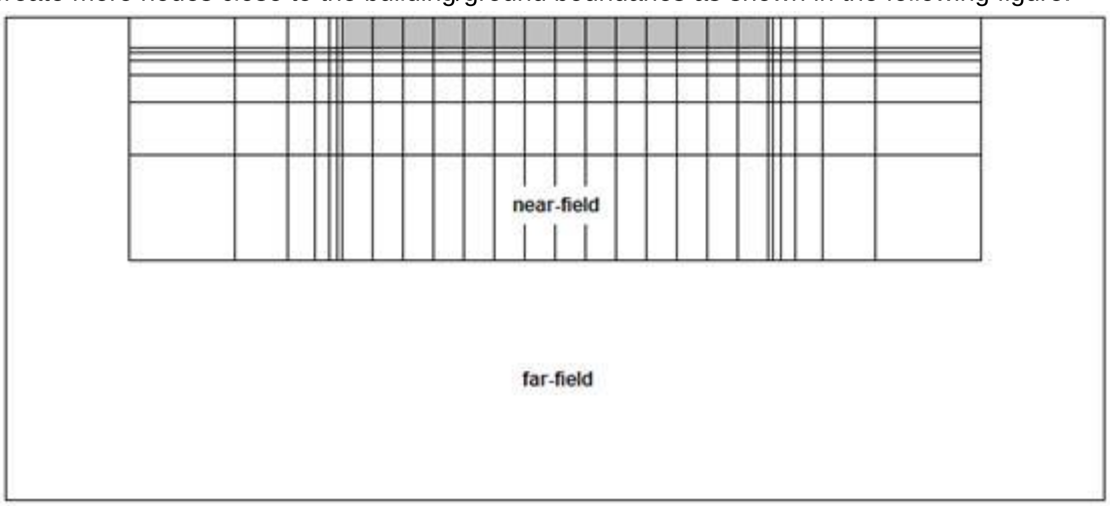


Figure 2: Nodes Near Boundary Walls

1.1 Mapping the Basement

As mentioned previously, all of the significant boundary wall lengths must be defined. These will be used for an application that will create the nodes for the input file. Starting with the x-direction, determine the dimensions of all of the boundary walls. Do the same for the y-direction and z-direction.

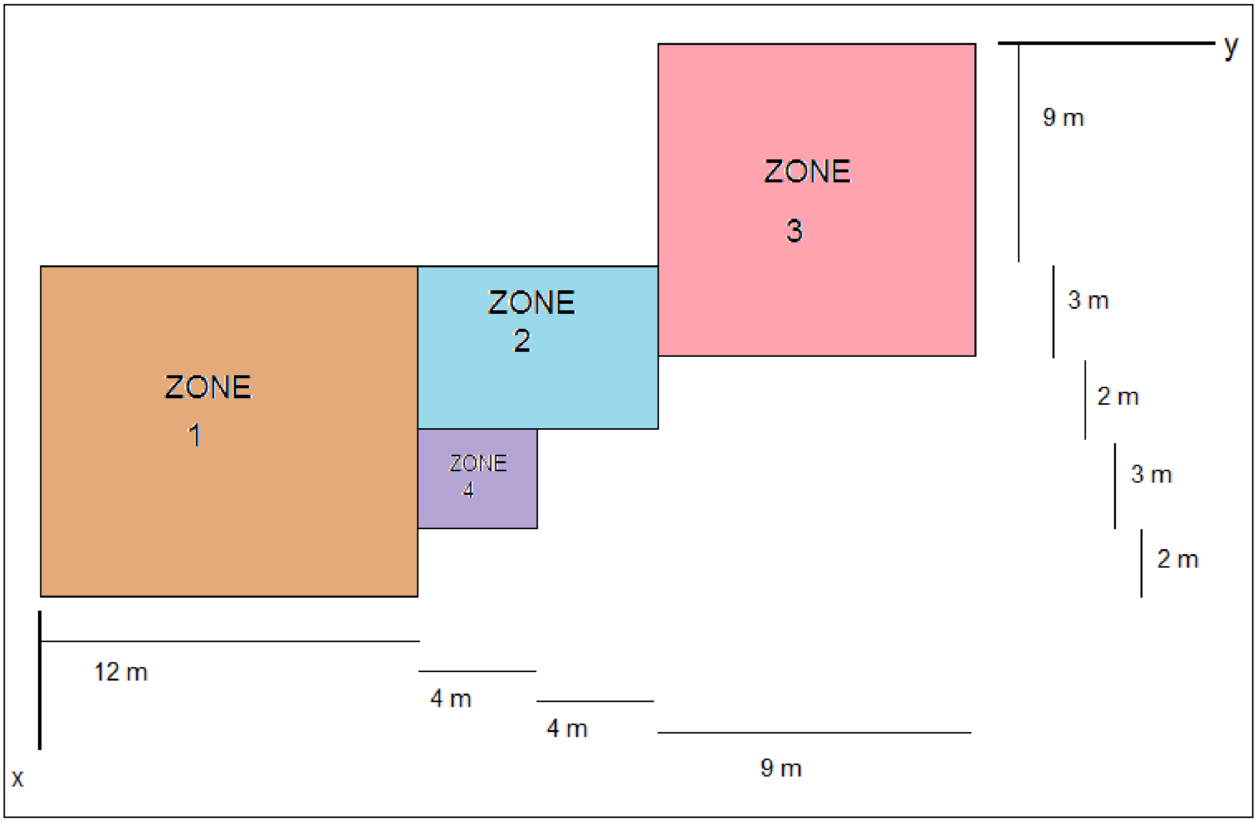


Figure 3: Dimensioning the Basement (Top View)

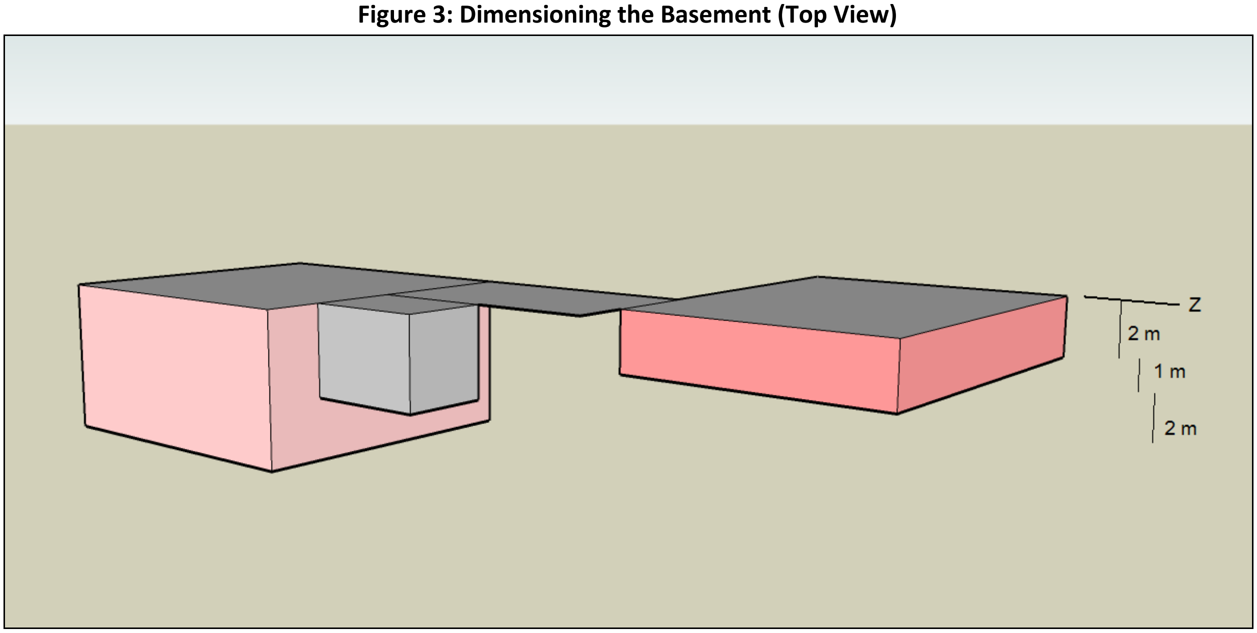


Figure 4: Dimensioning the Basement (Isometric View)

1.2 SoilNoding: Automatic Node Generator

The SoilNoding_1Dimension.exe application will need to be used for all three directions: x, y, and z.

1.2.1 Smallest Node Size

Opening *SoilNoding_1Dimension.exe* will yield the question, “Enter the size of the smallest node.” Please keep in mind that the smaller the size of the smallest node, the larger the input file will be; thus, the simulation time will be slower. For most purposes and for the example, a value of 0.1 was used.

1.2.2 Node Multiplier

A node multiplier of 2 is reasonable. The greater the multiplier, the more nodes there will be.

1.2.3 Lengths

The first length entered should be the distance to far-field if applicable for most cases for the x and y directions. For this example, the far-field distance is 10 m. Next, enter each subsequent, “small-to-small” distance that was determined for the respective direction. When done entering intermediate “small-to-small” distances, enter a 0 to prompt the far-field distance. Last, enter the far-field distance again. The application window should look like the following in Figure 5. Close the application and return to the directory.

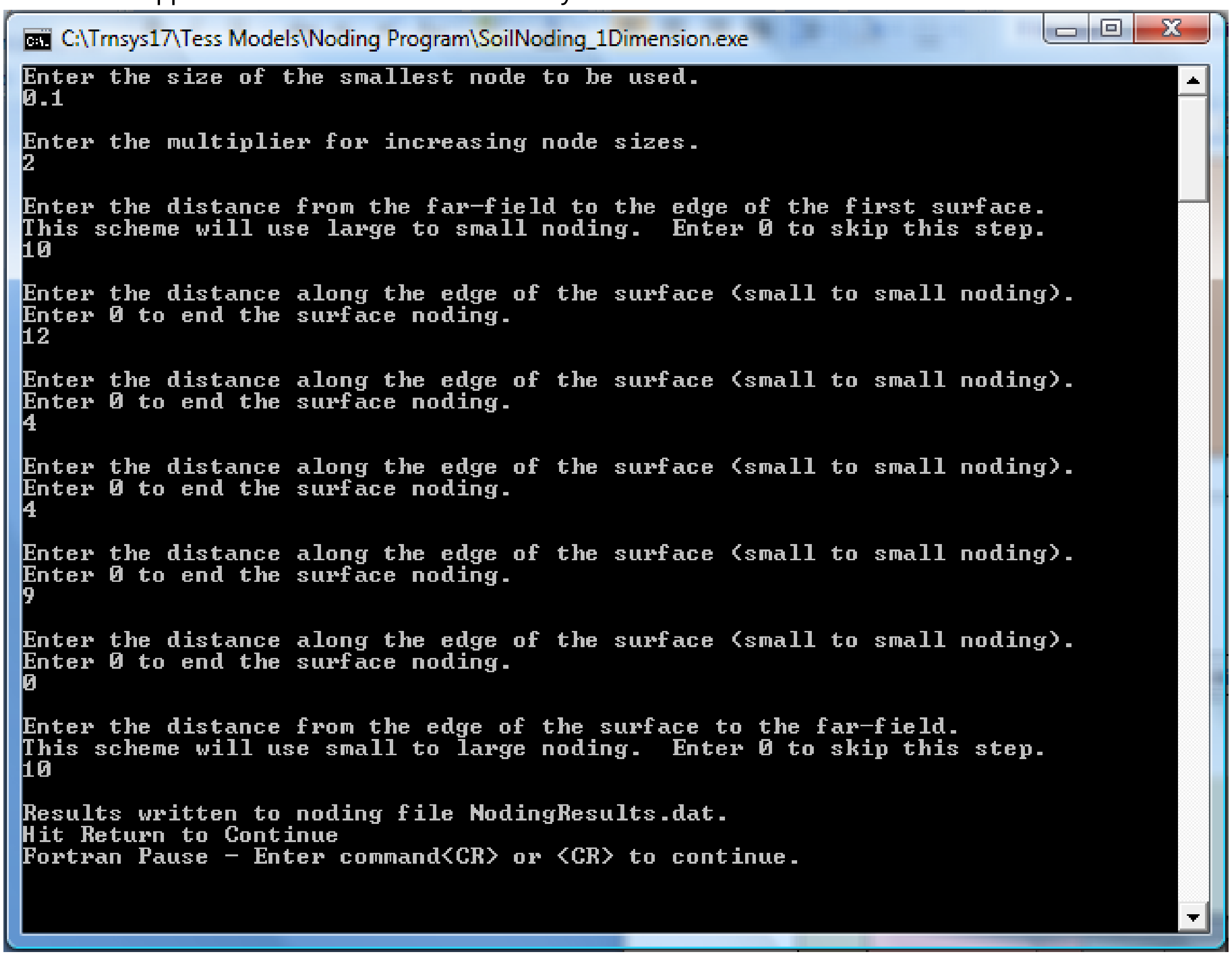


Figure 5: SmallNode for the X-Direction

1.2.4 NodingResults.dat

The node distances are generated in the *NodingResults.dat* file in the same directory as the *SoilNoding_1Dimension.exe* application. Simply rename the *NodingResults.dat* file something original such as "*x_nodes.out*", or open the *NodingResults.dat* file and save as a different name. The nodes for the other directions will be created.

1.2.5 Y and Z Directions

Open the *SoilNoding_1Dimension.exe* application again to compute the node distances for the y-direction as shown in Figure 6. Close the application and rename *NodingResults.dat* to "*y_nodes.out*".

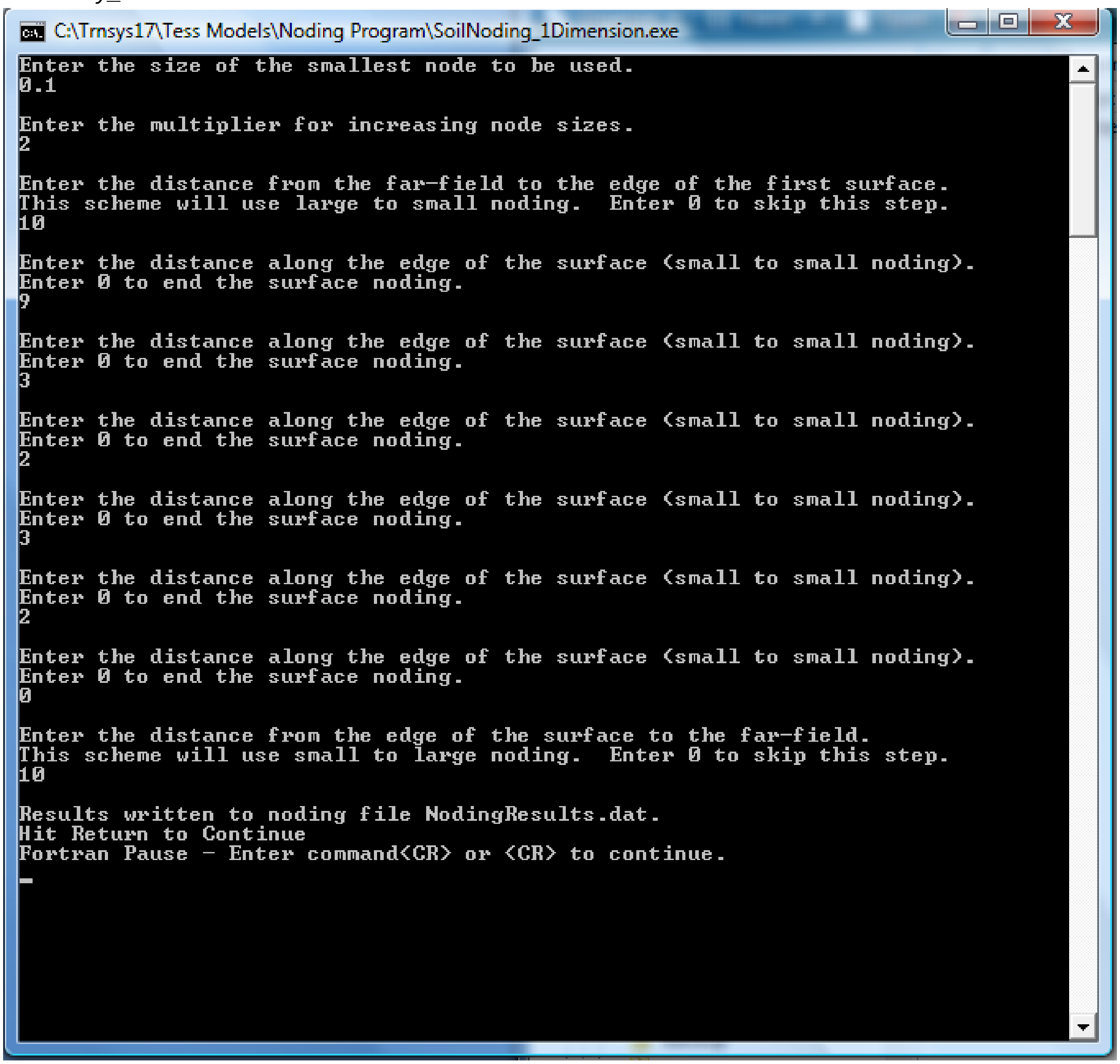


Figure 6: SmallNode for the Y-Direction

The z-direction will be entered in the application in the same fashion as the previous directions; however, it will not be necessary to first enter the far-field distance because it is exposed to the zone. Thus, enter the respective distances of the z-direction. For the last entry, enter twice the deep earth distance as shown in Figure 7. Again, rename the output file to "*z_nodes.out*".

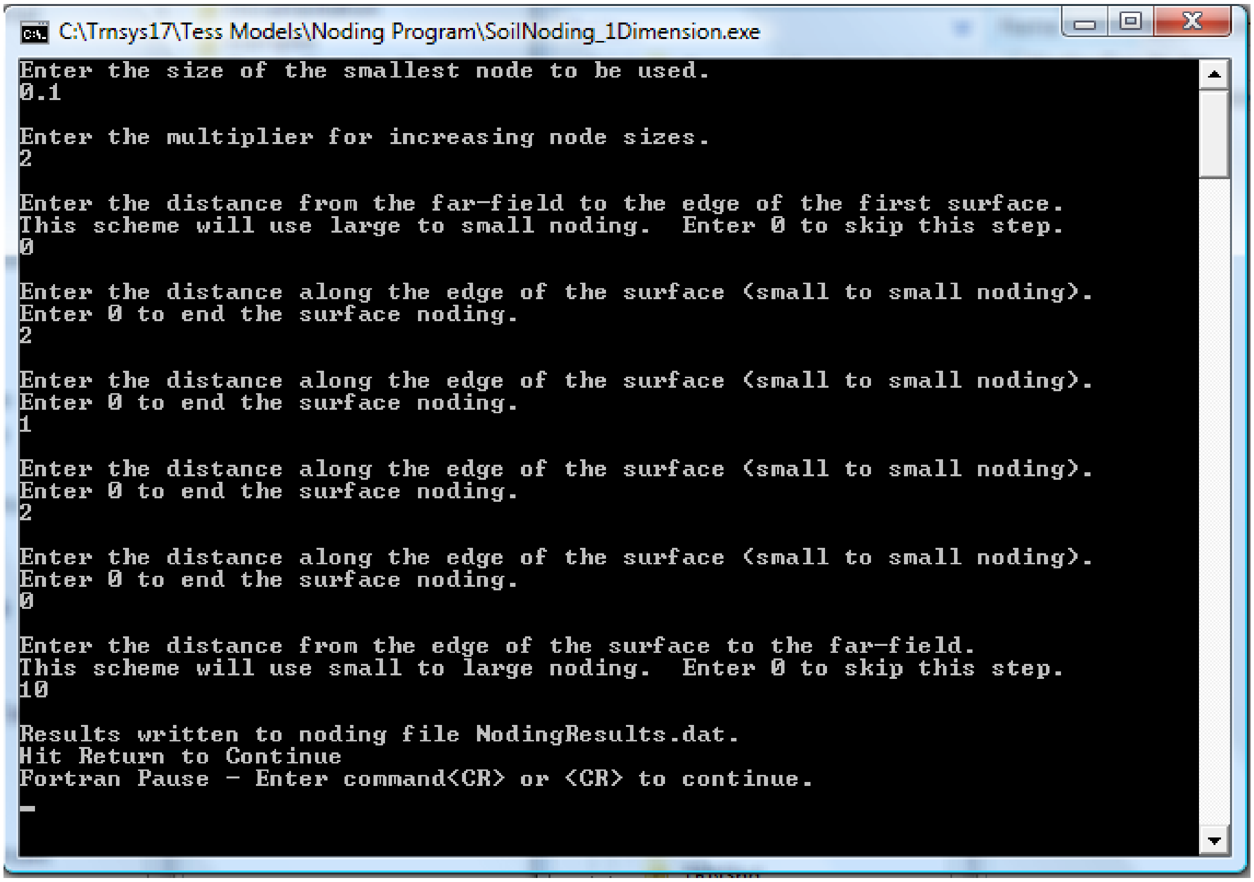


Figure 7: SmallNode for the Z-Direction

1.3 Surface Spreadsheet for the Data File

The surface and subsequent layers need to be laid out for the data file. Please refer to the provided spreadsheet, *Basement Processor.xls* for more detail. To do this, transpose the values of the edited *x_nodes.out* (Copy → Paste Special → Values, Transpose) across the top of the spreadsheet and the values of the edited *y_nodes.out* on the left of the spreadsheet as shown in Figure 10. Place a value of *1001* in each node (cell) that encompasses zone 1, place a value of the zone (1002, 1003, 1004, etc.) in each respective cell, and place a value of *-1* in each node (cell) that is not a zone. Again, refer the provided spreadsheet *Basement Processor.xls* to view how the example surface is identified.

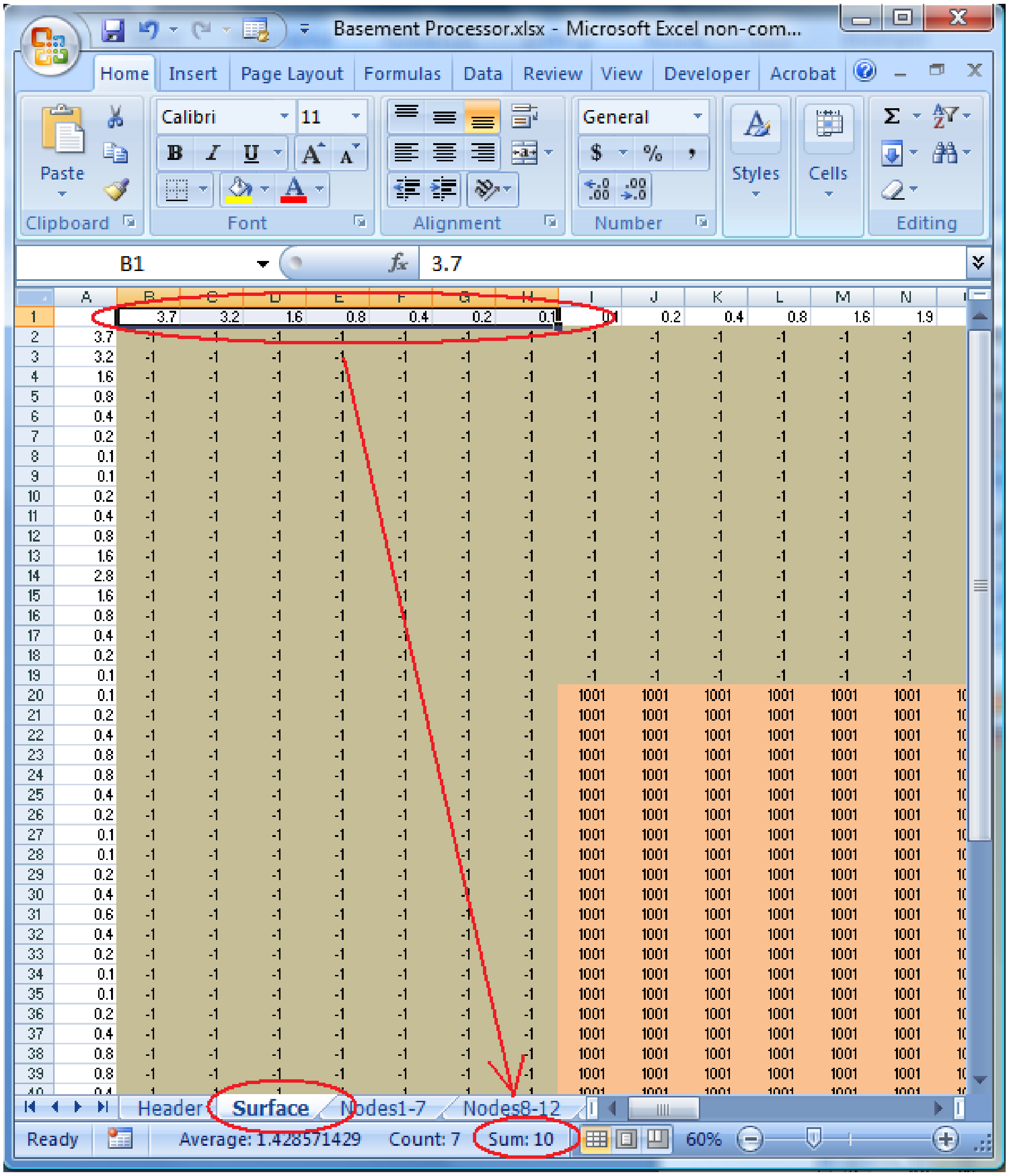


Figure 8: Creating the Surface Layer

1.4 Creating the Header for the Data File

The header of the data file is fairly straightforward expect for the list of values for the y-direction. Please refer to Figure 11. The first row is the number of x-values, the number of y-values, and the number of z-values. The second row are the x-values, the third row are the y-values in backwards order from the output file. **NOTE: To create the backwards row of y-values, simply take the column of y-values from the output file and in an adjacent column, and number the values in ascending order. Next, highlight that adjacent column of ascending numbers and sort the column largest to smallest as shown in Figure 12. Click "OK" to "Expand Selection". The column of y-values should now be in backwards order as shown in Figure 13. Copy the column of backwards y-values and transpose the column to a row.**

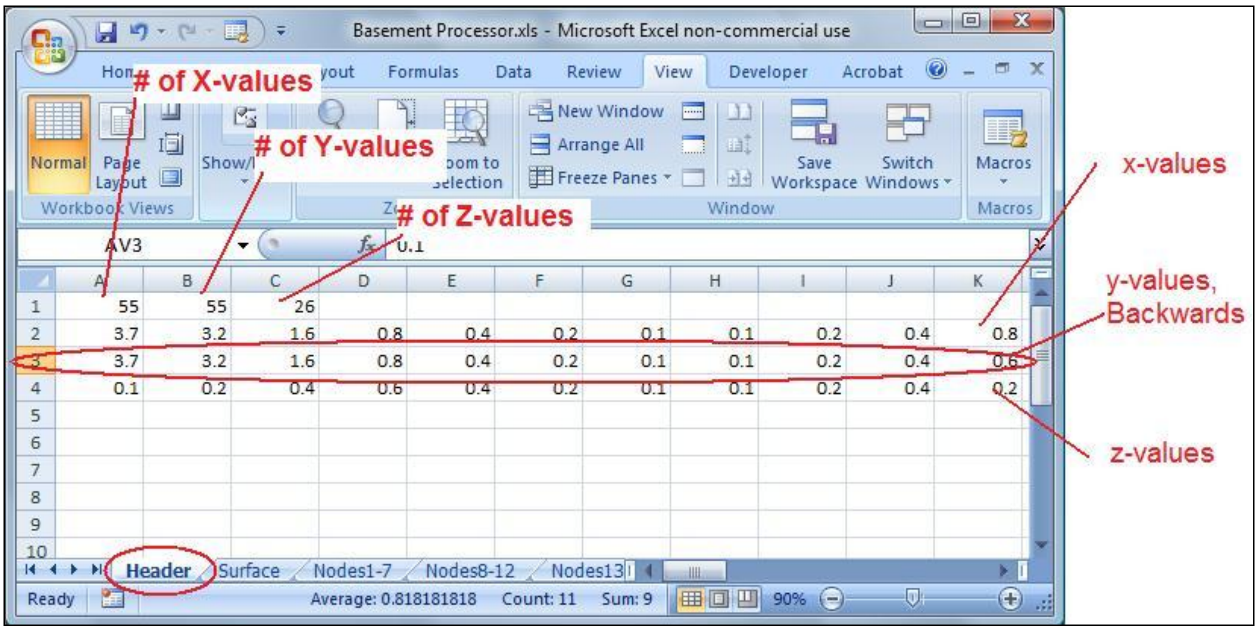


Figure 9: Header of Data File

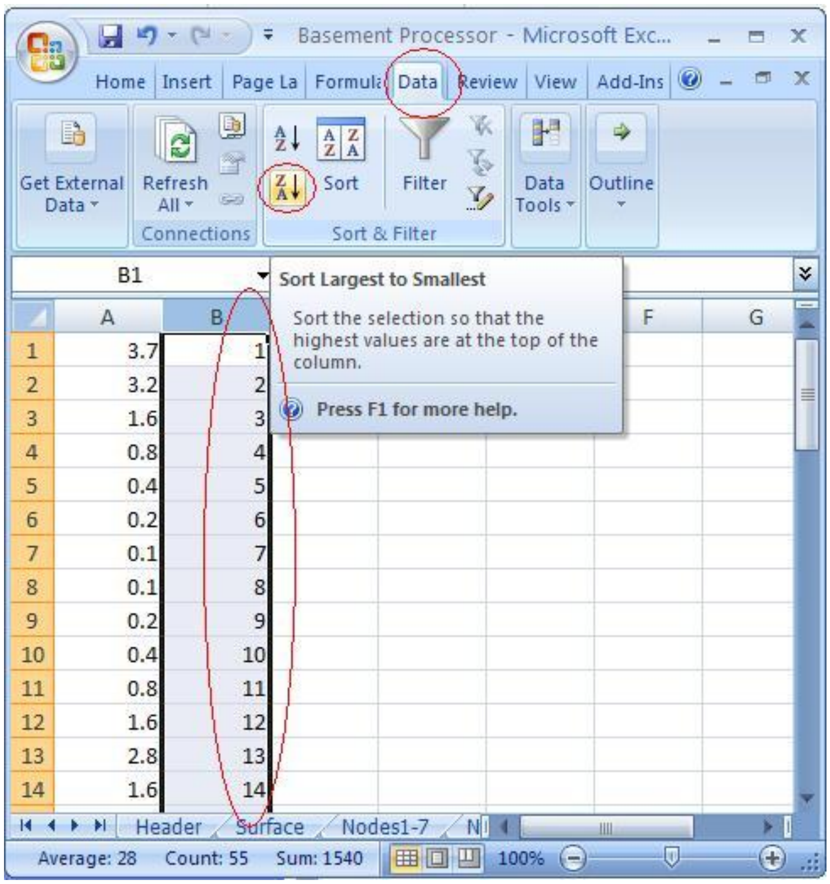


Figure 10: Creating the Row of Backwards Y-Values

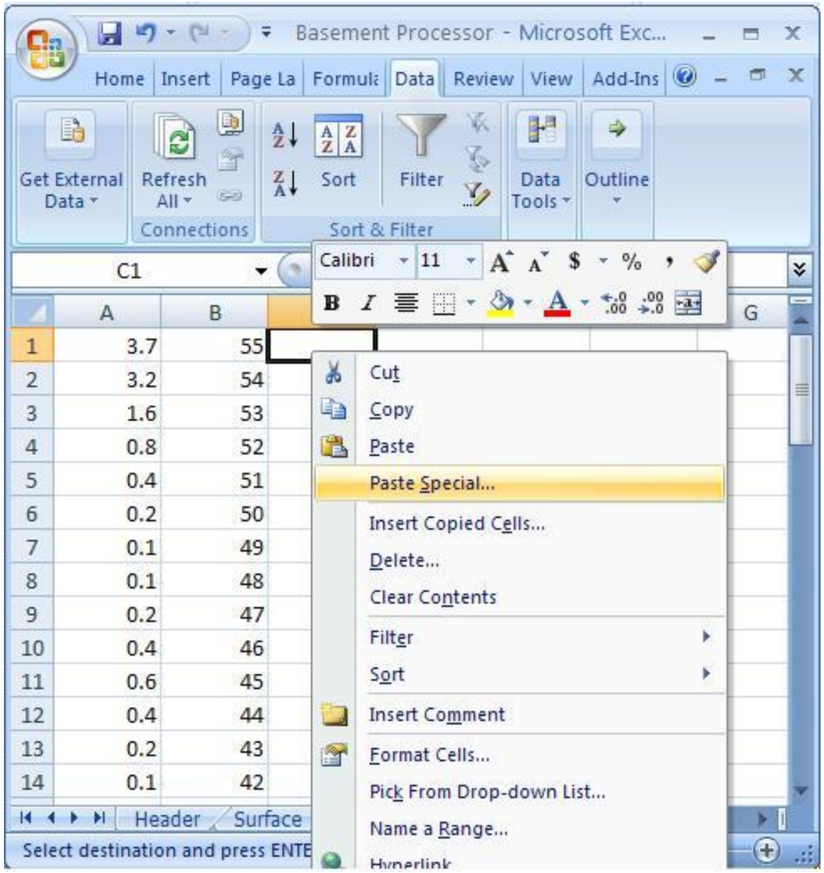
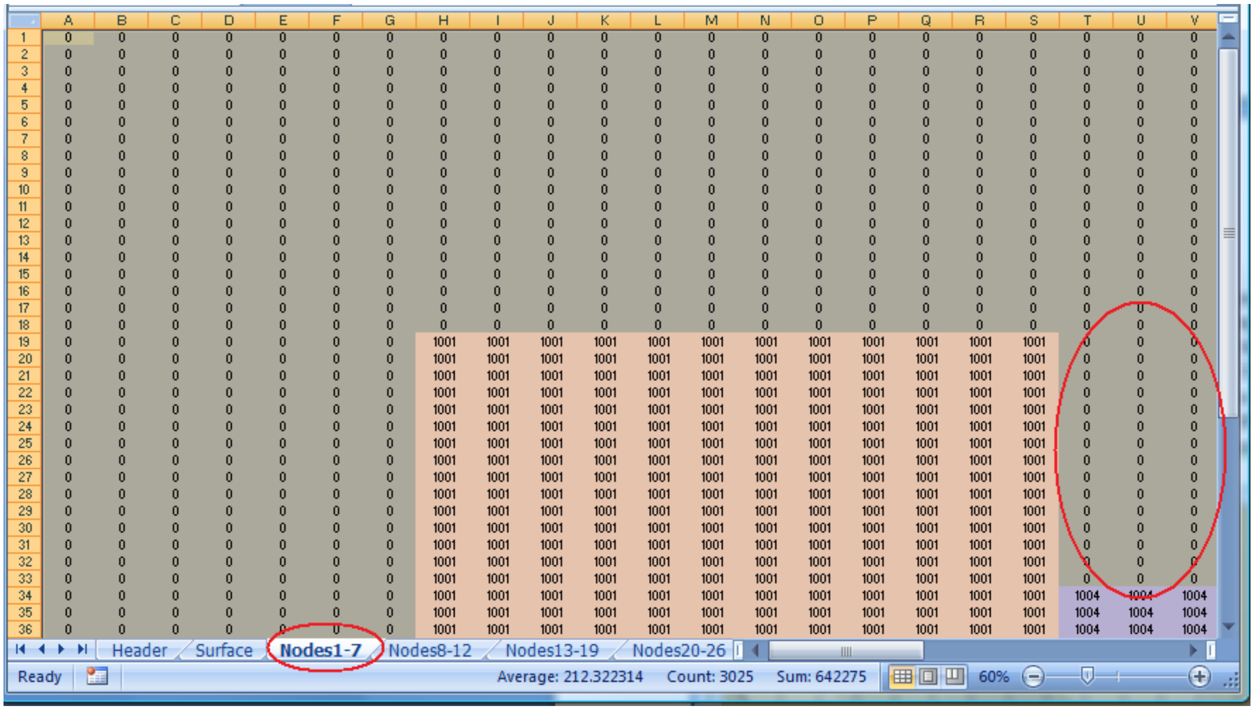


Figure 11: Column of Y-Values in Backwards Order

1.5 X-Y Slices for Each Z-Value

As the surface spreadsheet was created in section 1.4, a spreadsheet needs to be created for each of the z-values. Please note at the surface, four zones are represented, but just below the surface (the first seven z-values or nodes in the example) there are three zones represented because these depths do not encompass the slab on grade, zone 2. Oppose to the surface layer spreadsheet zeros are placed in cells that do not encompass zones. Likewise, for the 8-12th z-values (Nodes8-12), zone 3 is not included, and for the 13-19th z-values (Nodes13-19), zone 4 is not included. For the last z-values 20-26th (Nodes20-26), there are no zones encompassed, so the spreadsheet is entirely zeros.

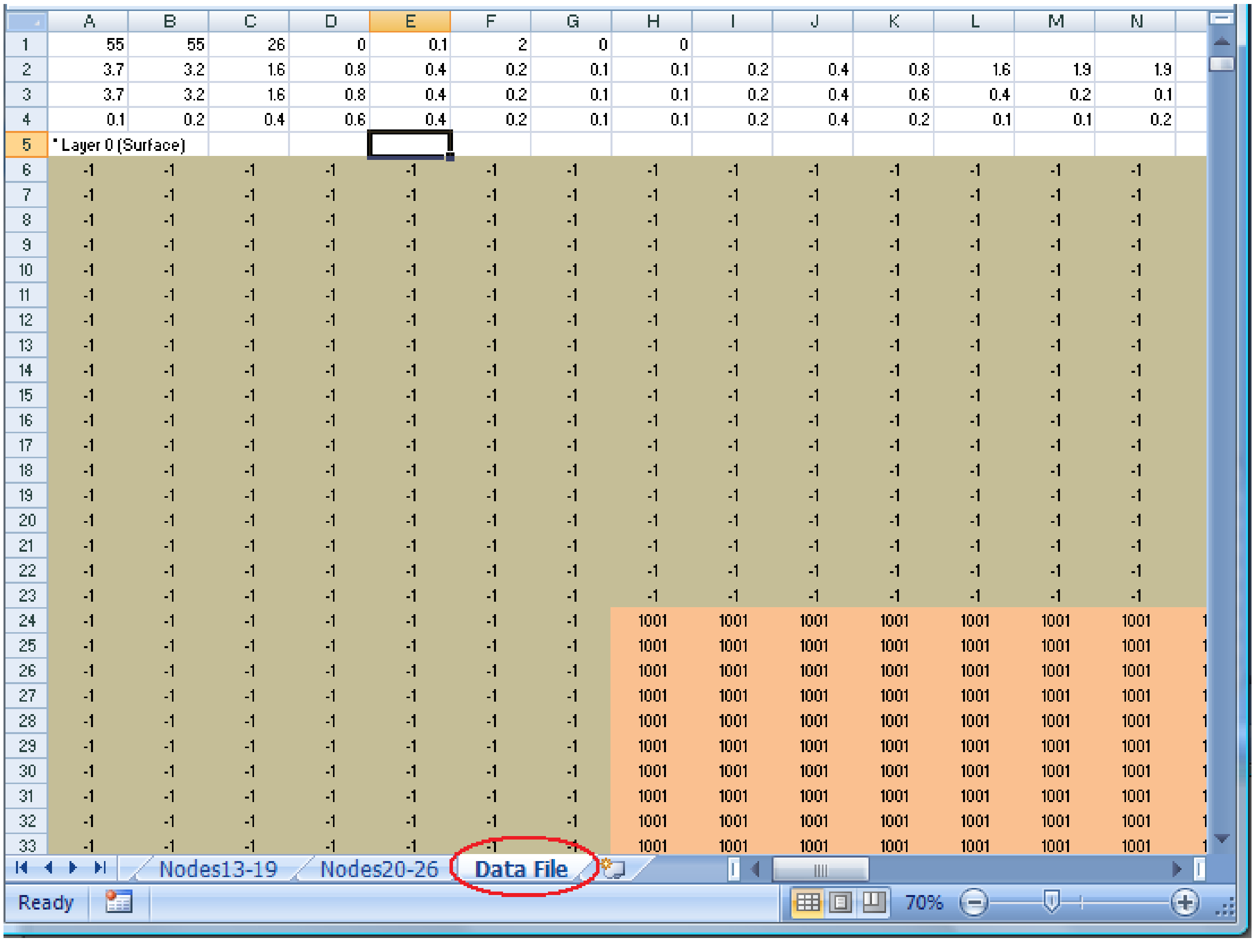


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	0	0	0
20	0	0	0	0	0	0	0	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	0	0	0
21	0	0	0	0	0	0	0	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	0	0	0
22	0	0	0	0	0	0	0	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	0	0	0
23	0	0	0	0	0	0	0	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	0	0	0
24	0	0	0	0	0	0	0	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	0	0	0
25	0	0	0	0	0	0	0	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	0	0	0
26	0	0	0	0	0	0	0	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	0	0	0
27	0	0	0	0	0	0	0	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	0	0	0
28	0	0	0	0	0	0	0	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	0	0	0
29	0	0	0	0	0	0	0	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	0	0	0
30	0	0	0	0	0	0	0	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	0	0	0
31	0	0	0	0	0	0	0	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	0	0	0
32	0	0	0	0	0	0	0	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	0	0	0
33	0	0	0	0	0	0	0	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	0	0	0
34	0	0	0	0	0	0	0	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1004	1004	1004
35	0	0	0	0	0	0	0	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1004	1004	1004
36	0	0	0	0	0	0	0	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1004	1004	1004

Figure 12: Spreadsheet for Nodes 1-7 (Z-Values 1-7)

1.6 Compiling the Data File

Open the “Data File” worksheet tab in the provided example *Basement Processor.xls*. Notice that below the header, in the 5th row is a comment (denoted by the “*” character) as in Figure 15. This zero represents the surface or the 0th slice. After the surface layer spreadsheet, each subsequent layer must be pasted into the worksheet. As shown in Figure 16, before each slice (z-value) layer the corresponding value must be entered.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	55	55	26	0	0.1	2	0	0						
2	3.7	3.2	1.6	0.8	0.4	0.2	0.1	0.1	0.2	0.4	0.8	1.6	1.9	1.9
3	3.7	3.2	1.6	0.8	0.4	0.2	0.1	0.1	0.2	0.4	0.6	0.4	0.2	0.1
4	0.1	0.2	0.4	0.6	0.4	0.2	0.1	0.1	0.2	0.4	0.2	0.1	0.1	0.2
5	* Layer 0 (Surface)													
6	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
7	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
8	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
9	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
10	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
11	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
12	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
13	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
14	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
15	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
16	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
17	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
18	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
19	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
20	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
21	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
22	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
23	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
24	-1	-1	-1	-1	-1	-1	-1	1001	1001	1001	1001	1001	1001	1001
25	-1	-1	-1	-1	-1	-1	-1	1001	1001	1001	1001	1001	1001	1001
26	-1	-1	-1	-1	-1	-1	-1	1001	1001	1001	1001	1001	1001	1001
27	-1	-1	-1	-1	-1	-1	-1	1001	1001	1001	1001	1001	1001	1001
28	-1	-1	-1	-1	-1	-1	-1	1001	1001	1001	1001	1001	1001	1001
29	-1	-1	-1	-1	-1	-1	-1	1001	1001	1001	1001	1001	1001	1001
30	-1	-1	-1	-1	-1	-1	-1	1001	1001	1001	1001	1001	1001	1001
31	-1	-1	-1	-1	-1	-1	-1	1001	1001	1001	1001	1001	1001	1001
32	-1	-1	-1	-1	-1	-1	-1	1001	1001	1001	1001	1001	1001	1001
33	-1	-1	-1	-1	-1	-1	-1	1001	1001	1001	1001	1001	1001	1001

Figure 13: Data File Spreadsheet

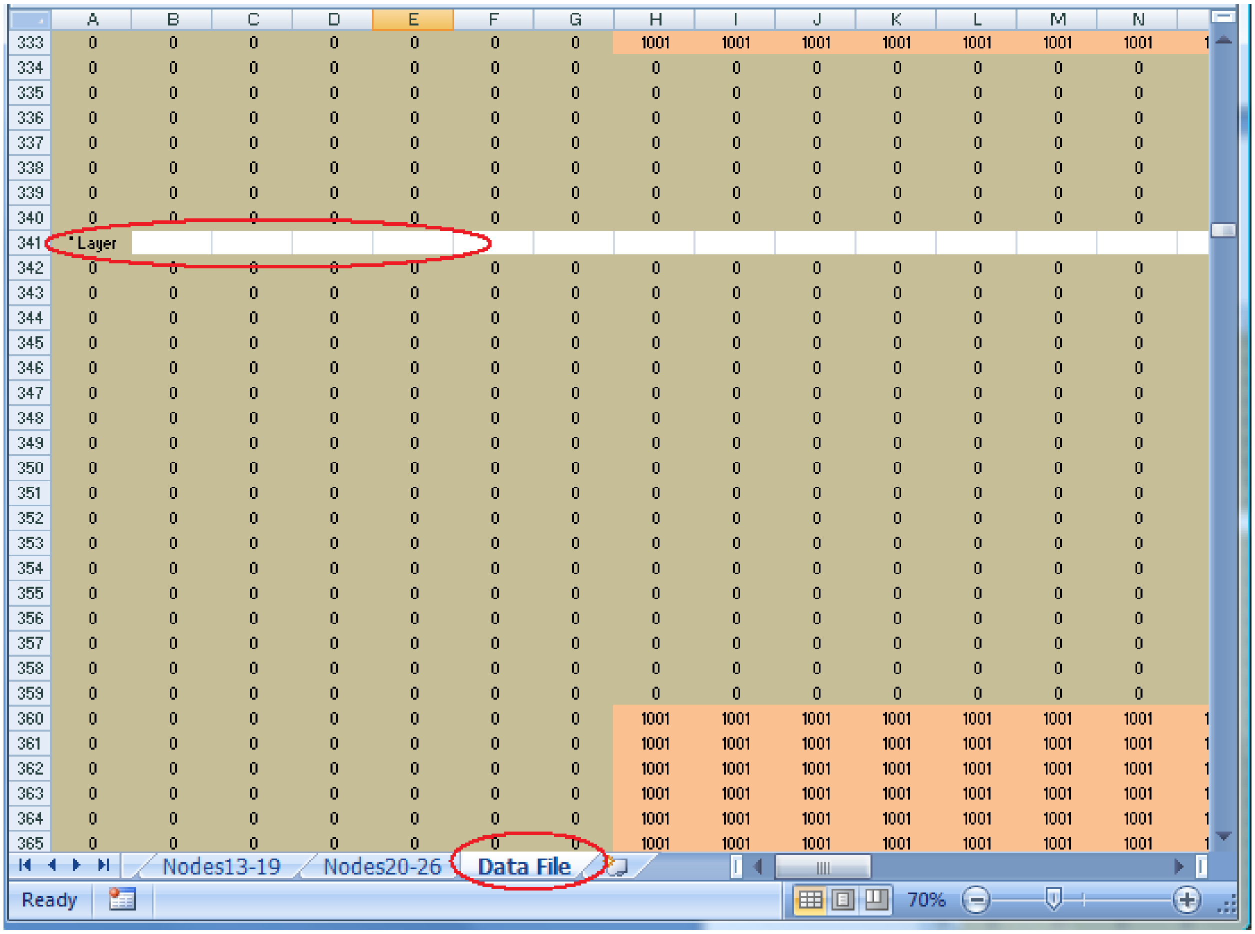


Figure 14: Data File (Between Surface and 1st Layer)

1.6.1 Exporting the Worksheet to Data File

There are two ways to export the worksheet with the data. You may save the worksheet as text (*.txt) tab-delimited, or simply copy and paste all of the data into a text editor.

2 Inputs and Outputs in Type56/TRNBUILD

In order to couple the TESS Basement Model with Type56/TRNBuild, the walls created in TRNBUILD have to be defined as boundary walls. When defining the wall type in the Wall Typemanager in TRNBUILD make sure to specify a back heat transfer coefficient of less than 0.001 as shown in Figure 17.

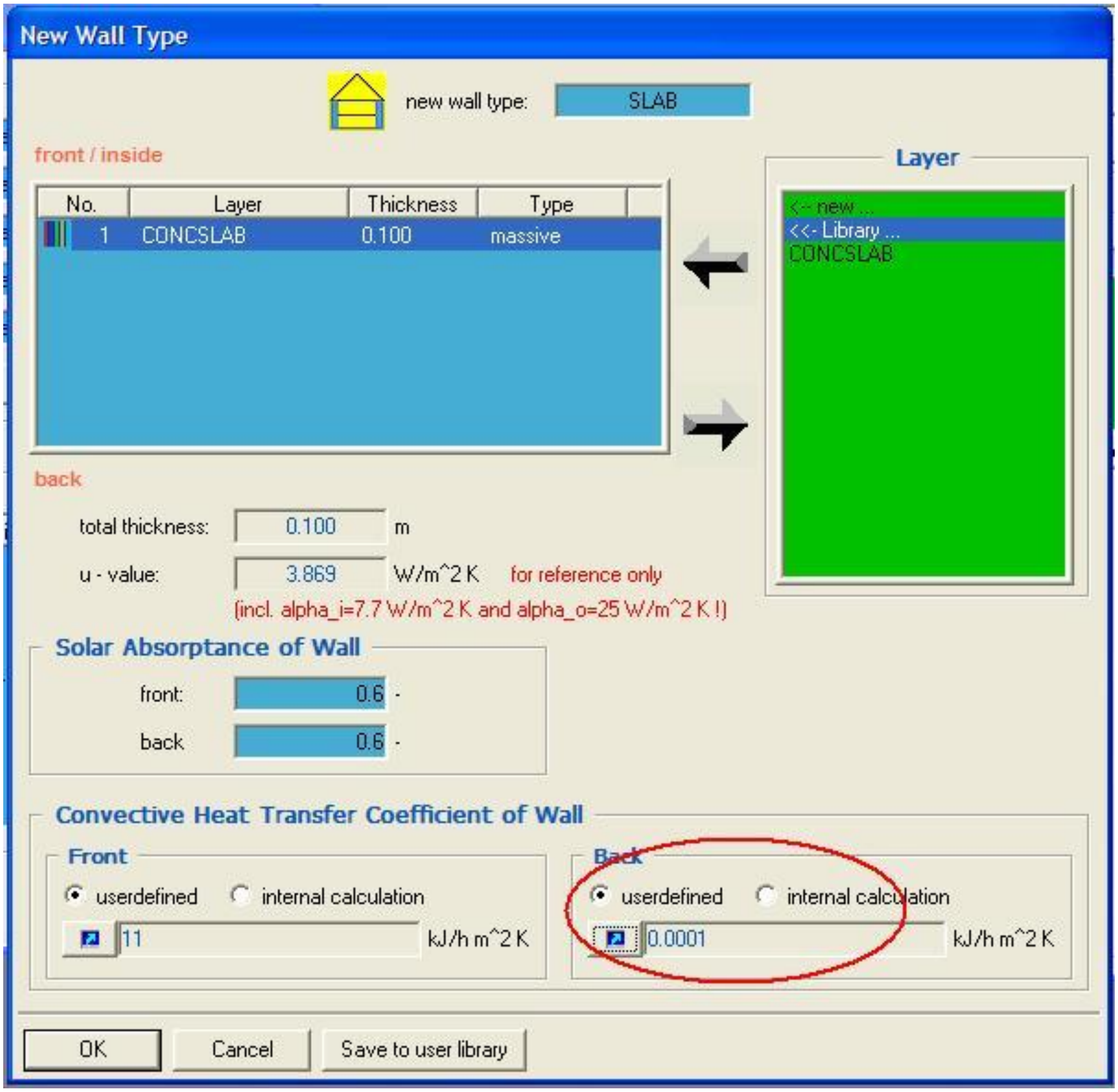


Figure 15

2.1 Temperature Inputs for Boundary Walls

Again, make sure to specify input temperatures for all of the boundary walls that are coupled to the basement model. **Note: Use the convention *Front, Back, Left, Right, Top, Bottom*** for ease. Creating the input temperature name is shown in Figure 19.

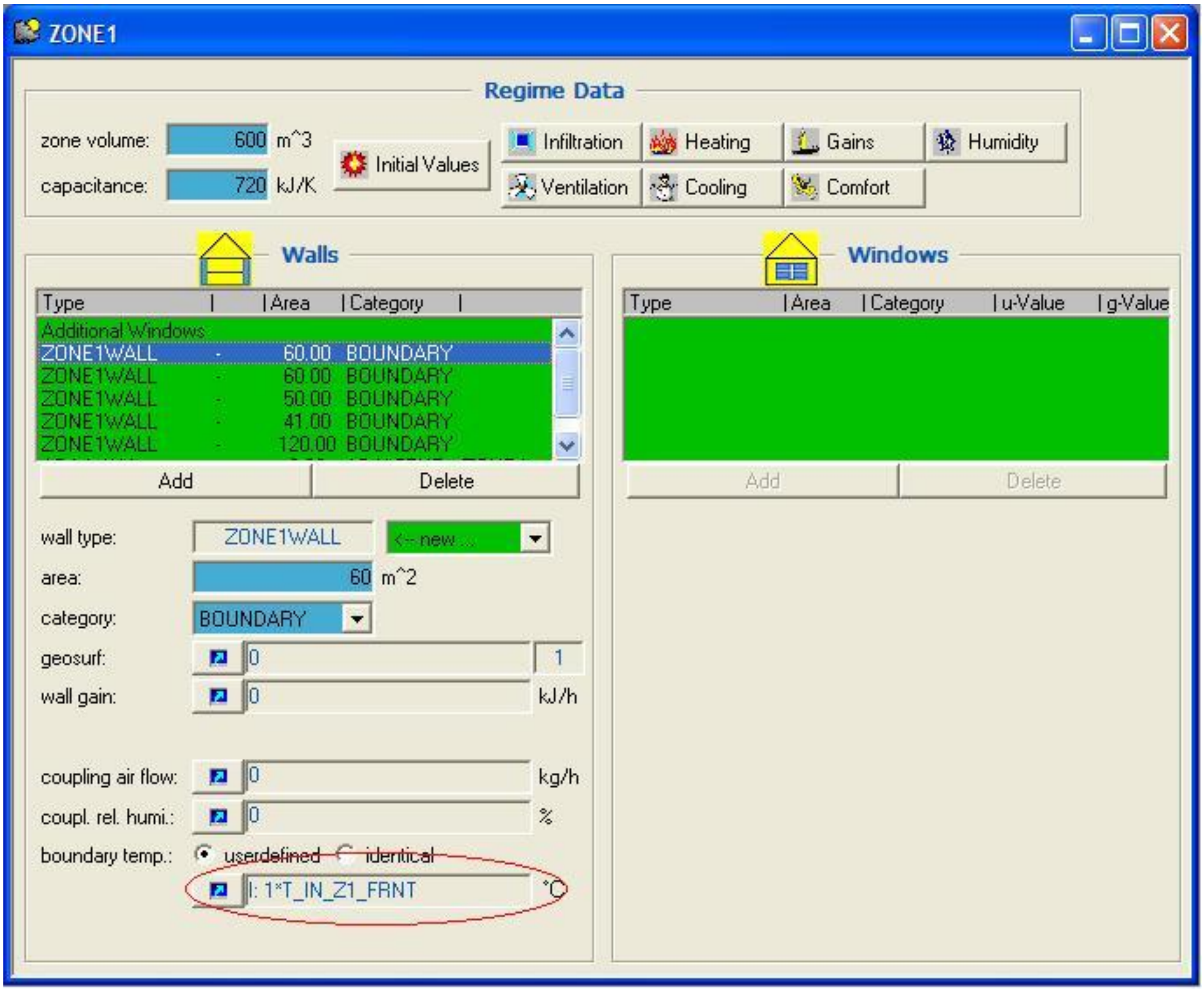


Figure 16

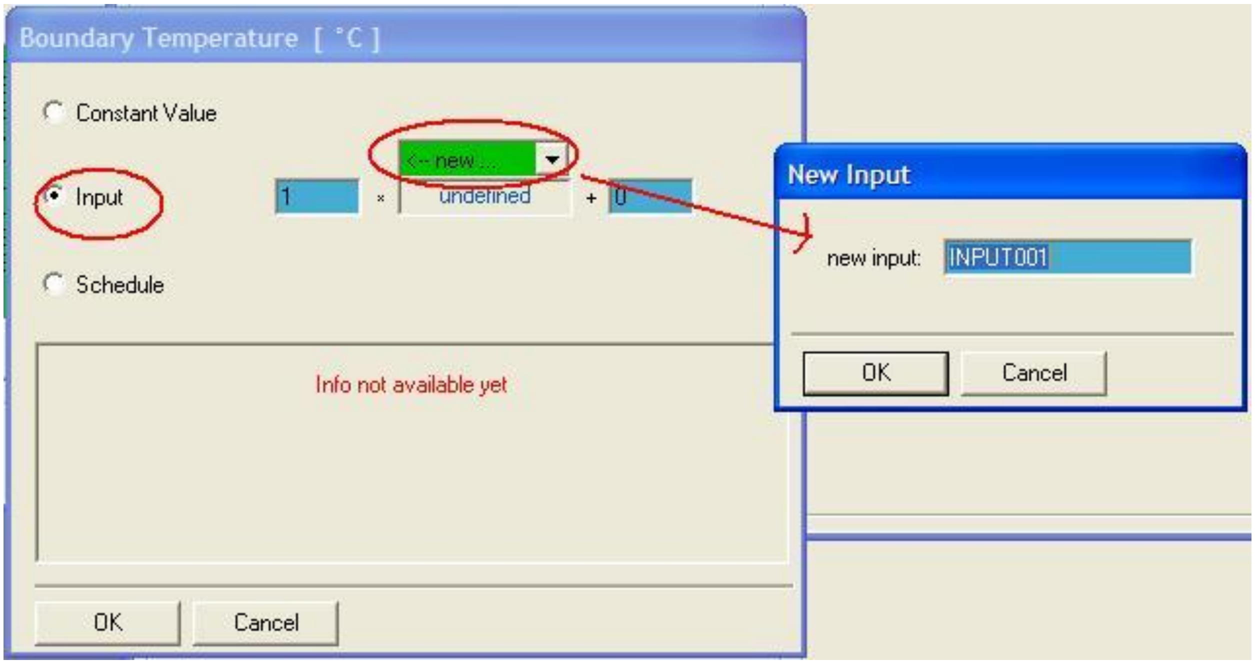


Figure 17

2.2 Outputs for Boundary Walls

TRNBUILD has numerous outputs for many different things. The output that is necessary for the TESS Basement Model is the surface output, NTYPE 20, *QCOMO*.

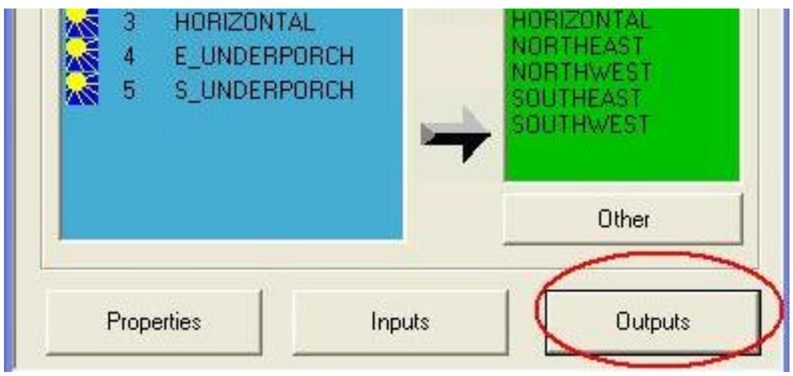


Figure 18

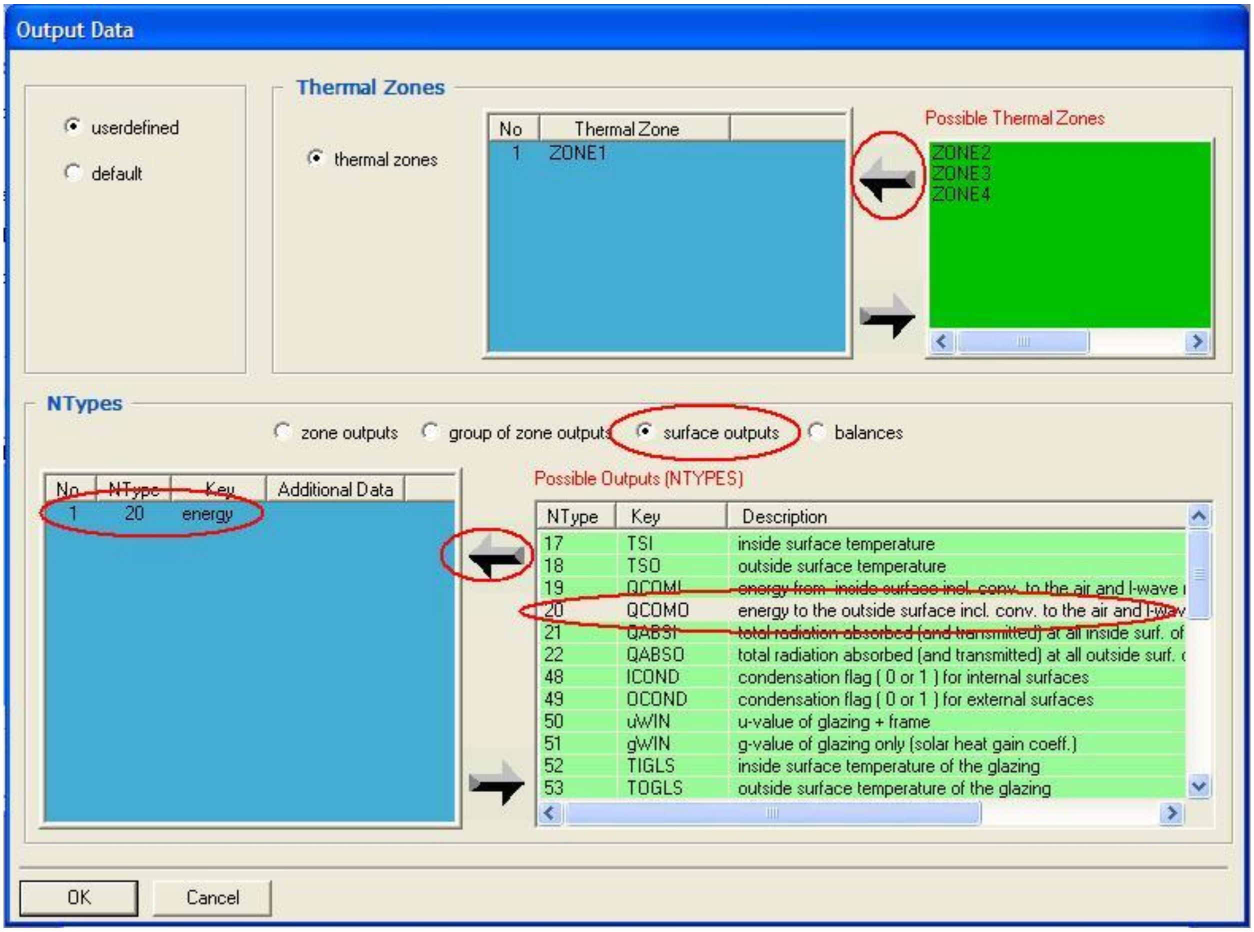


Figure 19

Figure 20

2.3 Surface ID Number

Take note of the surface identification number in TRNBUILD. This is necessary to connect the appropriate Type56 outputs to the TESS Basement Model component.

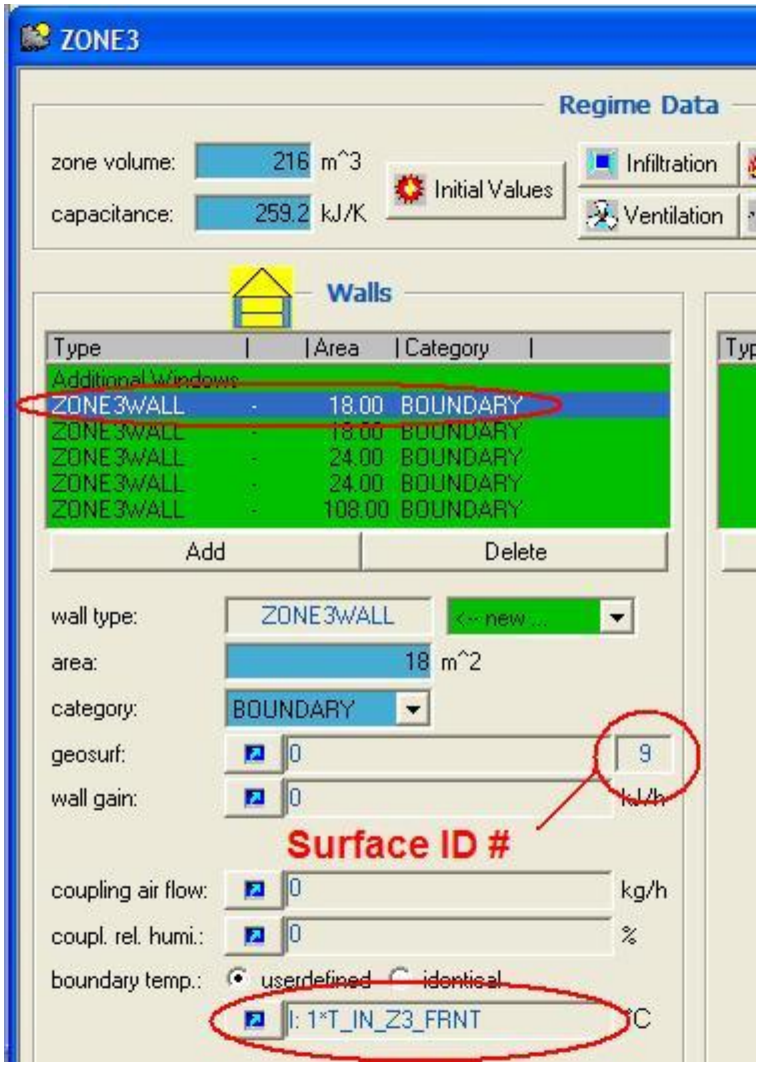


Figure 21

2.4 Connecting the Inputs of the Basement Component

The zone air temperatures (TAIR_ZONE#) and the boundary wall heat transfer rates(QCOMO_S#) need to be connected to the respective inputs of the basement component.

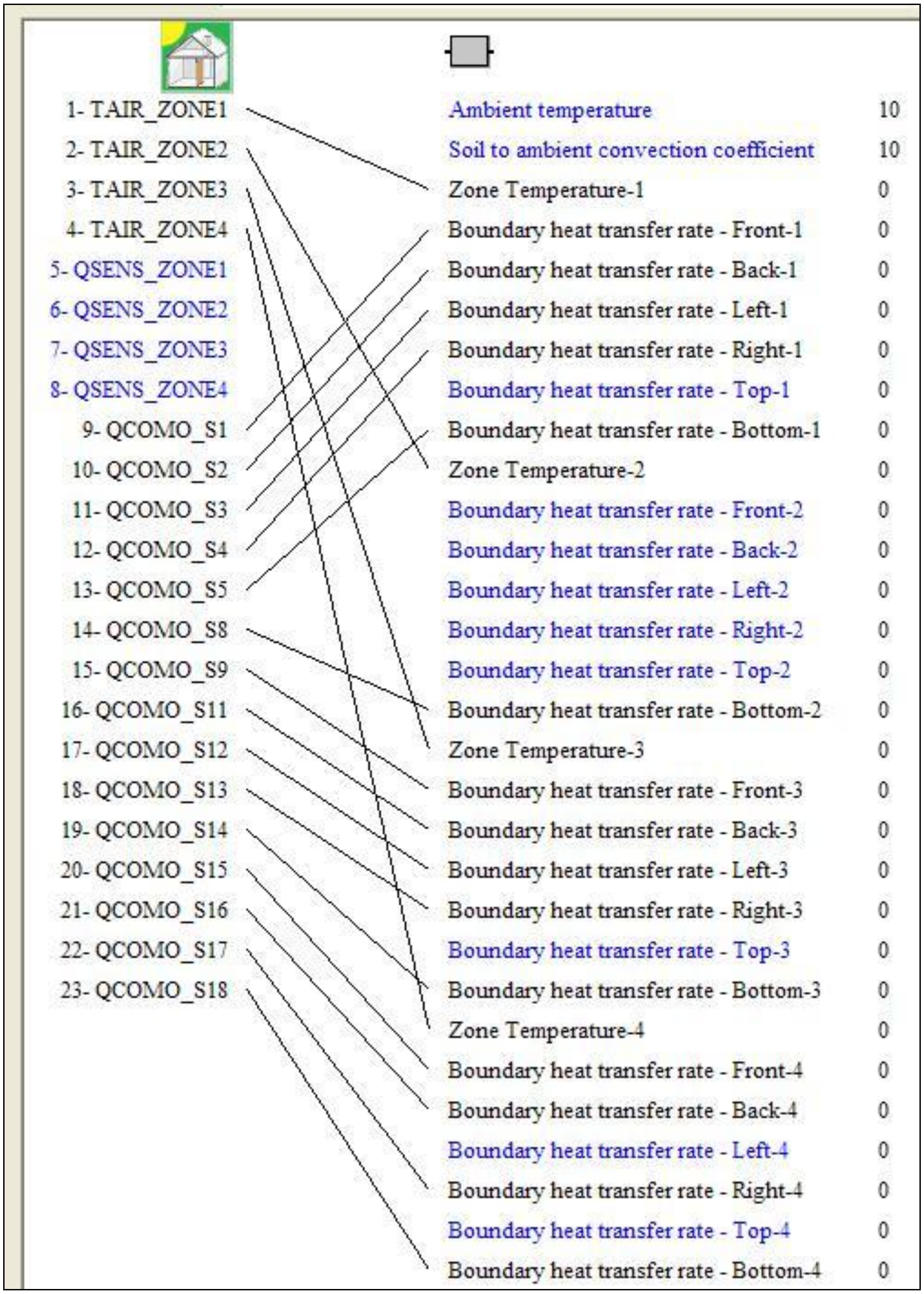


Figure 22

2.5 Connecting the Outputs of the Basement Component

The boundary temperatures of the basement model component are connected to the user-defined boundary wall temperatures of Type56.

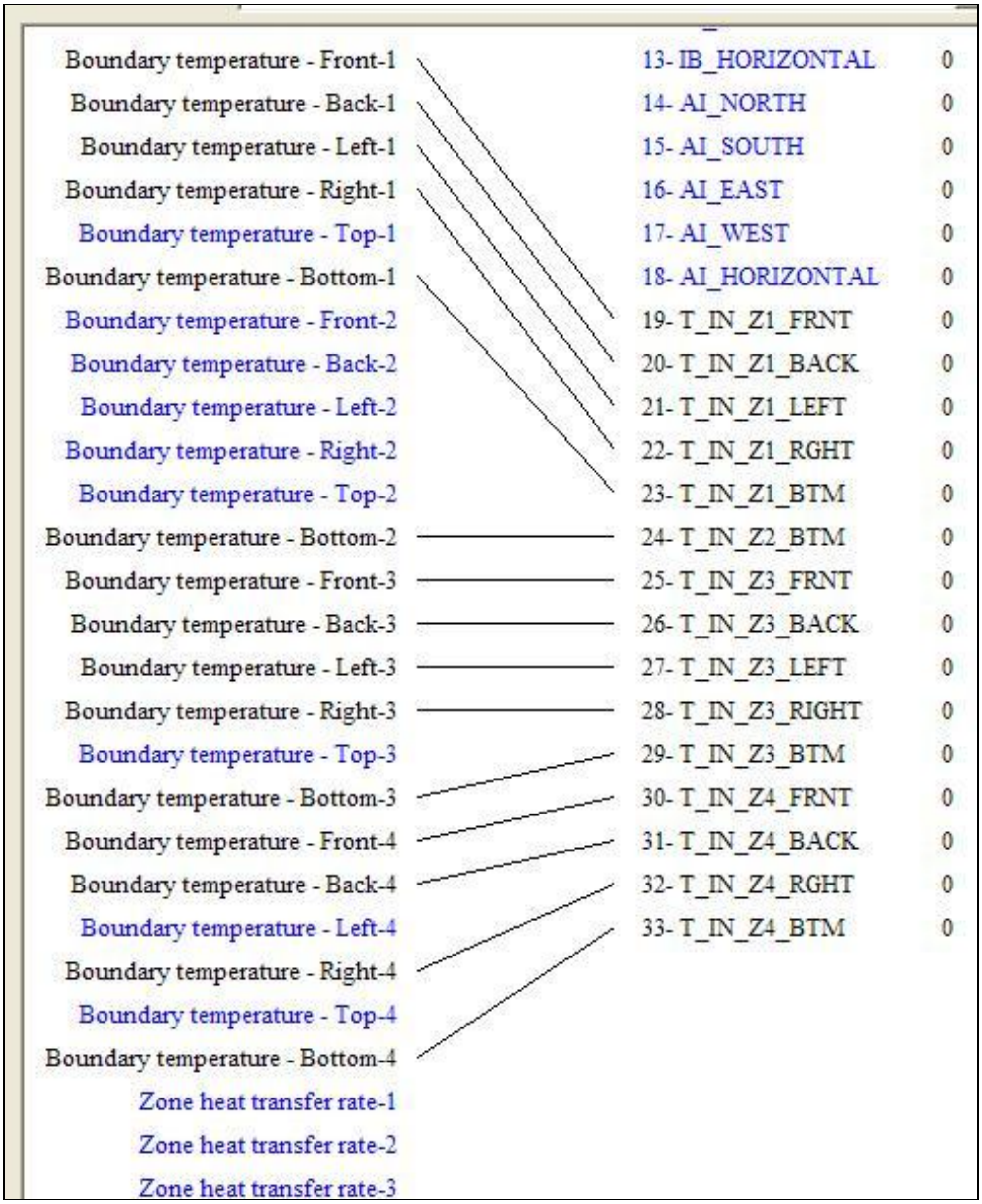


Figure 23

3 Post-Processing

The TESS Basement Model creates an output file (***.*Soil_out*) based on its parameters. It is usually desired to view the X-Y surface that is right below the basement. Thus it is important to know the "Depth node for X-Y surface-#".

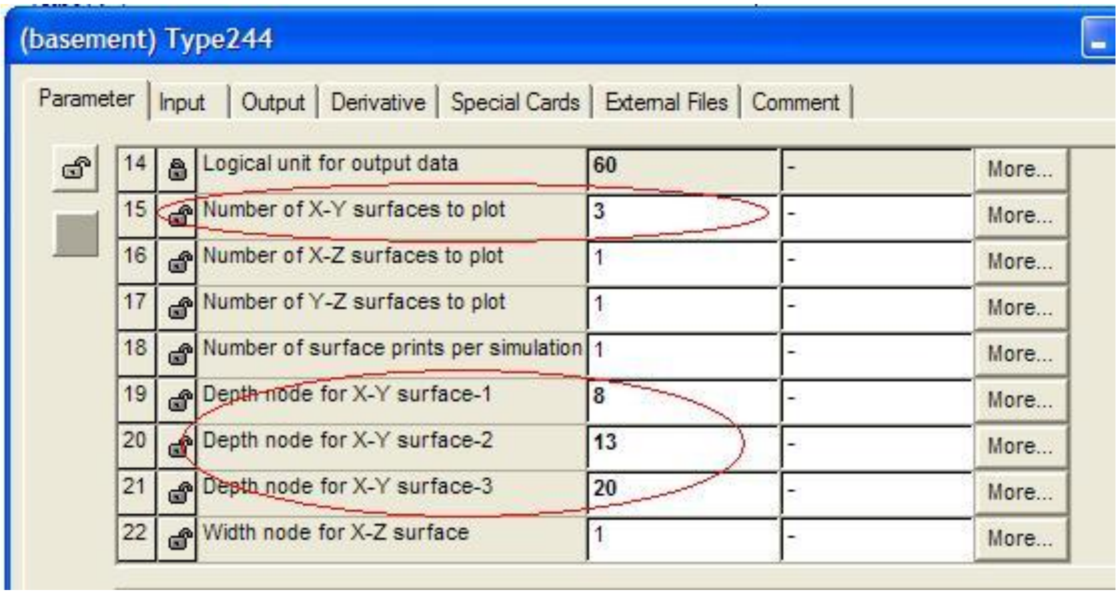


Figure 24

3.1 Viewing the Results

Open the output file (****.Soil_out*) in Excel as delimited, space. Scroll down until you can see the stop time of the simulation and "Horizontal Slices X-Y Plane" as shown in Figure 27. This is the output for the temperature at each node at the specified depth. Simply highlighting and graphing the temperatures is an excellent way to view the results.

	A	B	C	D	E	F	G	H	I
143									
144		Time=	168						
145									
146		Horizonta	Slices	X-Y	Plane				
147		17.161	17.161	17.161	17.161	17.161	17.161	17.161	17.161
148		17.161	17.161	17.161	17.161	17.161	17.161	17.161	17.161
149		17.161	17.161	17.161	17.16	17.16	17.16	17.16	17.16
150		17.161	17.161	17.16	17.157	17.156	17.156	17.157	17.157
151		17.161	17.161	17.16	17.156	17.163	17.178	17.188	17.196
152		17.161	17.161	17.16	17.156	17.178	17.218	17.248	17.269
153		17.161	17.161	17.16	17.157	17.188	17.248	17.296	17.327
154		17.161	17.161	17.16	17.157	17.195	17.269	17.327	18.739
155		17.161	17.161	17.16	17.158	17.206	17.299	17.376	18.739
156		17.161	17.161	17.159	17.16	17.225	17.347	17.442	18.739
157		17.161	17.161	17.159	17.162	17.246	17.39	17.497	18.739
158		17.161	17.161	17.159	17.164	17.255	17.406	17.515	18.739
159		17.161	17.161	17.16	17.173	17.274	17.427	17.538	18.739
160		17.161	17.161	17.162	17.193	17.319	17.482	17.594	18.739
161		17.161	17.161	17.164	17.208	17.355	17.532	17.648	18.739
162		17.161	17.161	17.165	17.215	17.375	17.564	17.688	18.739
163		17.161	17.161	17.165	17.22	17.389	17.587	17.727	20

Figure 25