Cooling Load Calculation Validation

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SRP Thermal Mass Group

Contents

Introduction

The cooling load for the SRP peak hours was calculated during the previous individual analysis calculation. During this analysis, the max predicted cooling load was 16194 Btu/hr and the minimum cooling load was 11395 Btu/hr in Phoenix.

Based on common HVAC data, the typical cooling load for a home is 4 tons of refrigeration, or 48,000 Btu/hr. Our previous load was a lot smaller than it should be. It was determined that the factor that needed to change was the U values that change depending on the material used. Our value had previously been pulled from a video with a value for a specific wall, however, this analysis updates the previous calculations using U values from the ASHRAE handbook based on materials with the highest vs lowest insulation.

This assignment calculates the cooling load for the entire year to validate the calculations for the peak hours. After updating the U values, it was determined that the lowest cooling load is 4051 Btu/hr, and the highest is 106,511 Btu/hr. This translates to a range of 0.338-8.88 tons of refrigeration. This number appears to be much closer to the predicted tons of refrigerant, with the average being 4.6 tons of refrigeration. This matches the data given by the National Renewable Energy Lab and validates that the numbers calculated can be used to determine the mass and volume requirements for the material.

Assumptions

Current Assumptions

The cooling load is calculated for 1 year.

According to the National Renewable Energy Lab, a common reference HVAC companies use for sizing air conditioning systems is 400 square feet per ton of refrigeration for a home. [2] Our roof is 1700 feet squared. This means that our tons of refrigerant should be approximately 4 tons of refrigerant.

The cooling load is calculated in Excel. The initial data is given below with the values from the 1997 ASHRAE handbook based on the Phoenix Sky Harbor airport. The average area of the exterior walls on a home is from the Siding Authority estimator. [3] The average roof surface area is found from BFM roofing estimates. [4]

Table 1. ASHRAE Data

Initial Data		
Latitude	33.43	
Longitude	112.02	F
Outdoor Dry Bulb	110	F
Outdoor Wet Bulb	80	F
Daily Range	23	F

Area of Wall - North Facing	395	ft^2
Area of Wall - South Facing	395	ft^2
Area of Wall - East Facing	395	ft^2
Area of Wall - West Facing	395	ft^2
Area of Roof	1700	ft^2
Area of Windows	100	ft^2
U Walls Max	1	Btu/h*ft^2*F
U Roof Max	0.2	Btu/h*ft^2*F
U Walls Min	0.05	Btu/h*ft^2*F
U Roof Min	0.04	Btu/h*ft^2*F
U Windows	0.55	Btu/h*ft^2*F

The CLTD values for each wall, window, and roof are determined for different materials by the authors of the 1997 ASHRAE handbook. These values are copied into Excel for all 24 hours of the day. Because the quantity of values is so large, these tables are given in the Appendix.

Previous Assumptions

The main assumption that is changing between this calculation and the previous calculation is the period that the calculation is being done for. The SRP peak hours are between 2-8PM from their time of use plan. [5] This calculation incorporates data from a full year and focuses on validating that our calculations match generally accepted data.

Additionally, for the previous calculations, the U values were found from a video online explaining the calculations. [6] These were updated based on values in the ASHRAE handbook. Changing these values for the minimum and maximum U values gave an average that more closely matched the expected cooling load.

Equations

The following equation are from the 1997 ASHRAE handbook. [1] The cooling load for each part of the house (roof, windows, and walls) is calculated based on the coefficient of heat transfer, area, and a value devised by ASHRAE as the cooling load temperature difference. These values are then added together to determine the total cooling load.

$$Q_{roof} = U_{roof} * A_{roof} * CLTD_{corrected}$$ ***Equation 1***

$$Q_{windows} = U_{windows} * A_{windows} * CLTD_{corrected}$$ ***Equation 2***

$$Q_{walls} = U_{walls} * A_{walls} * CLTD_{corrected}$$ ***Equation 3***

$$Q_{total} = (Q_{roof} + Q_{windows} + Q_{walls})$$ ***Equation 4***

$$CLTD_{corrected} = CLTD + (78 - TR) + (TM - 85)$$ ***Equation 5***

$$TM = T_{max} - (\frac{DR}{2})$$ ***Equation 6***

Where

Q = cooling load (BTU/hr)

U = coefficient of heat transfer (Btu/hr*ft^2*F)

A = area (ft^2)

$CLTD$ = cooling load temperature difference (F)

$CLTD_{corrected}$ = CLTD adjusted for indoor and outdoor temperatures (F)

TR = indoor room temperature (F)

TM = mean outdoor temperature (F)

T_{max} = max outdoor temperature (F)

DR = daily range (F)

The mass and volume requirements for the material are based on previously developed MATLAB code, shown in the Appendix.

Results/Discussion

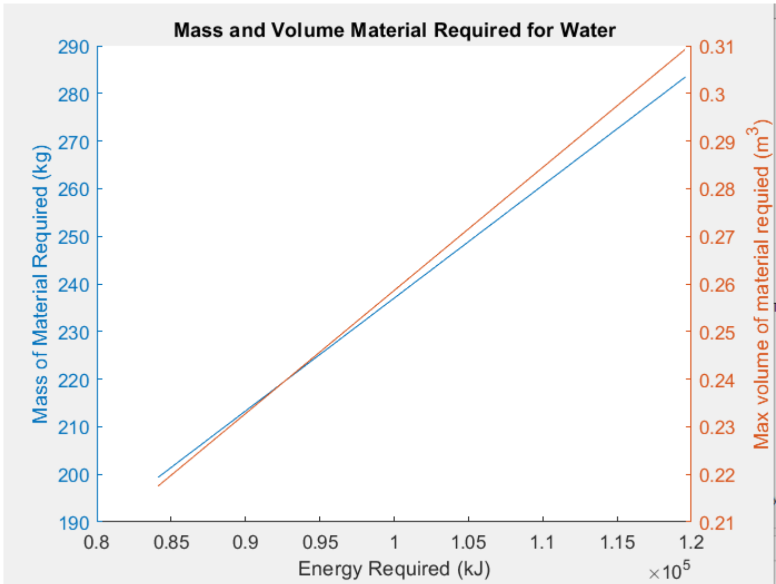
Previous Results

Table 2 shows the results for the cooling load calculations completed at the end of last semester. These results didn't match data from the National Renewable Energy Lab.

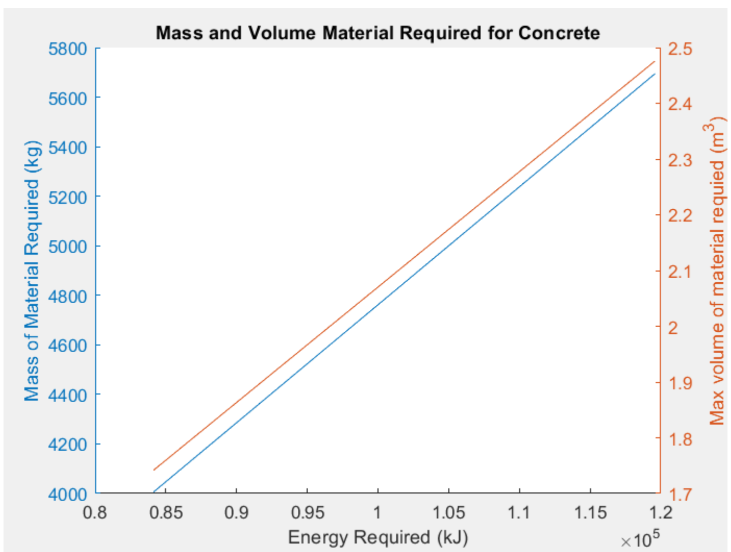
Table 2. Previous semester cooling load results for peak hours

Max Q Values (Btu)	**Max Q Values (kJ)**	**Max Q Values (kWh)**
113358.9	119593.64	33.22
Min Q Values (Btu)	**Min Q Values (kJ)**	**Min Q Values (kWh)**
79766.12	84153.257	23.38
Max Qdot Values (Btu/h)	**Max Qdot Values (kJ/h)**	**Max Qdot Values (kW)**
16194.12857	17084.80564	4.745646463
Min Qdot Values (Btu/h)	**Min Q Values (kJ/h)**	**Min Qdot Values (kW)**
11395.16	12021.8938	3.339321441

These values from last semester were used to find the mass and volume requirements for water and concrete to adequately store energy for peak hours. The graphs of these previous results are shown below.



Graph 1. Previous Mass and Volume Material Required for Water



Graph 2. Previous Mass and Volume Material Required for Concrete

Validation

Table 3 shows shows the cooling load results based on the minimum and maximum capacity through the year. The average value is then also calculated to compare to the data from NREL.

Table 3. Cooling load results for 1 full year

Min Qdot Values (Btu/h)	Min Qdot Values (kJ/h)	Min Qdot Values (kW)	Min Qdot Values (ton refrigerant)	Average Tons Required
4051.5	4274.3325	1.187281339	0.337625	4.60675
Max Qdot Values (Btu/h)	**Max Q Values (kJ/h)**	**Max Qdot Values (kW)**	**Max Qdot Values (ton refrigerant)**	
106510.5	112368.5775	31.21261977	8.875875	

Table 4. Percent difference between calculated cooling load and NREL data

	Cooling Load (tons of refrigeration)		
	Calculated	**NREL**	**% Difference**
Minimum	0.337625	4	92%
Maximum	8.875875	4	122%
Average	4.60675	4	15%

The percent difference is calculated between the cooling load from NREL and the maximum, minimum, and average cooling load. Because this data is meant to represent a variety of home cooling loads, the minimum and maximum have a large percent difference. However, the average is extremely similar to the expected cooling load with a percent difference of just 15%.

Determining the percent difference is a crucial step in this process because it demonstrates how closely our data matches the generally accepted data. Based on this evidence, our conclusion is that our data matches that of NREL if the minimum and maximum U values are used. Based on this information, the calculations from the previous semester are updated to match this change.

Updated Results

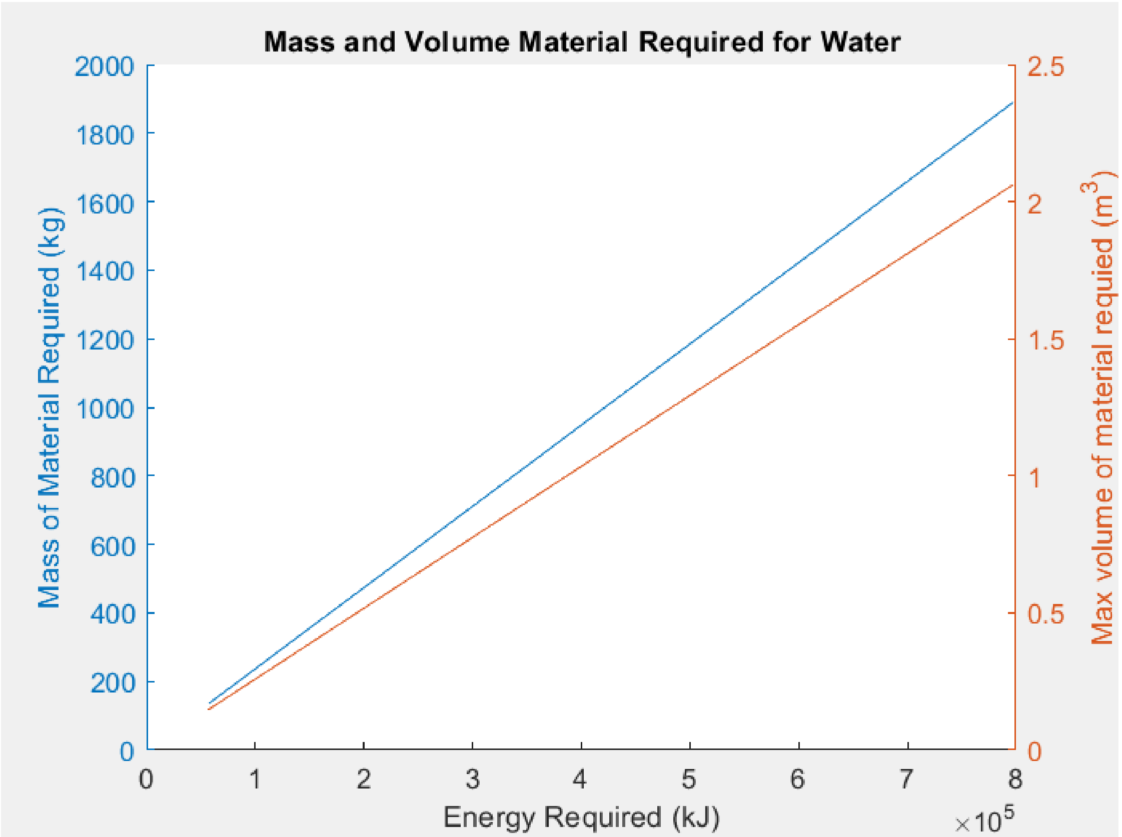
Table 4 shows the updated values for the peak hours based on the updated U values. Now that these values have been validated, the mass and volume requirements for the thermal mass can also be updated using the previously developed MATLAB code.

Table 4. Updated peak hour cooling load based on validation

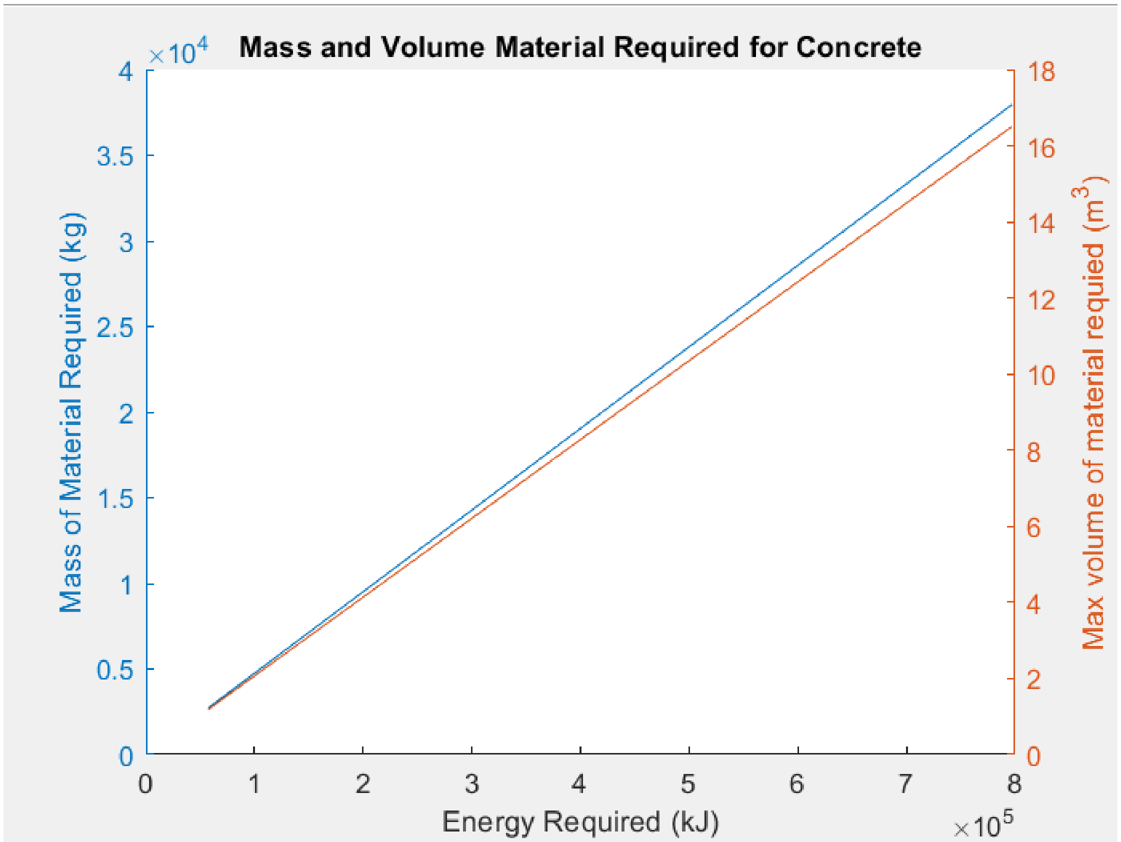
Max Q Values (Btu)		Max Q Values (kJ)		Max Q Values (kWh)	
Roof	188870	Roof	199257.85	Roof	55.35
Windows	9817.5	Windows	10357.463	Windows	2.88
Walls	556950	Walls	587582.25	Walls	163.21
Total	755637.5	Total	797197.56	Total	221.44

Min Q Values (Btu)		Min Q Values (kJ)		Min Q Values (kWh)	
Roof	25670	Roof	27081.85	Roof	7.52
Windows	9817.5	Windows	10357.463	Windows	2.88
Walls	18644	Walls	19669.42	Walls	5.46
Total	54131.5	Total	57108.733	Total	15.86
Max Qdot Values (Btu/h)		**Max Qdot Values (kJ/h)**		**Max Qdot Values (kW)**	
107948.2143		113885.3661		31.63393813	
Min Qdot Values (Btu/h)		**Min Q Values (kJ/h)**		**Min Qdot Values (kW)**	
7733.071429		8158.390357		2.26615609	

The following MATLAB graphs show the mass and volume requirements for water and concrete based on the updated Q values.



Graph 3. Mass and Volume Material Required for Water



Graph 4. Previous Mass and Volume Material Required for Concrete

Conclusion

Based on the validation, the U values had to be updated to reflect values in the ASHRAE handbook for materials with the highest and lowest thermal insulation. After making this update, the cooling load matched values predicted by the National Renewable Energy Lab.

Based on this information, the U values were updated for the peak hours, and new values were put into MATLAB from previously developed code that calculated the mass and volume requirements for the thermal mass.

Through this project, I was able to learn how to better validate results. Previously, the results were validated from a source with a graph that was difficult to understand. There was an exceptionally large percent difference without any real explanation. This calculation demonstrates a much more reasonable cooling load that is validated.

References

[1] R. Crawford, K. Herold, A. Jacobi, and T. Kuehn, *1997 ASHRAE Handbook*, I-P. 1997.
[2] M. Gestwick, “Strategy Guideline: Accurate Heating and Cooling Load Calculations.” Accessed: Sep. 13, 2024. [Online]. Available: https://www.nrel.gov/docs/fy11osti/51603.pdf
[3] “Siding Calculation & Exterior Sq. Ft. Estimation Methods,” Siding Authority. Accessed: Apr. 29, 2024. [Online]. Available: https://sidingauthority.com/estimation-calculator/
[4] B. Tarver, “How Much Does the Average Roof Replacement Cost,” B&M Roofing | Commercial & Residential Roofing in Colorado. Accessed: Apr. 29, 2024. [Online]. Available: https://bmroofing.com/how-much-does-the-average-roof-replacement-cost/
[5] “SRP Time-of-Use (TOU) Price Plan | SRP.” Accessed: Feb. 03, 2024. [Online]. Available: https://www.srpnet.com/price-plans/residential-electric/time-of-use
[6] AMJ Engineering, *Cooling Load | hand calculation example | HVAC 13*, (Dec. 30, 2021). Accessed: Apr. 22, 2024. [Online Video]. Available: https://www.youtube.com/watch?v=2sQ6ZxLMrps

Appendix

```
function MaterialProperties(Material,HeatofFusion, TempofFusion, SpecificHeat,
DensityMatrix, MinEnergyRequirement, MaxEnergyRequirement, LowestTemp, Costperkg)
% AUTHOR: Courtney Hiatt
% DATE: 3/26/2024
% INPUTS: Material Properties and Energy Requirements
% OUTPUTS: Graphs and Tables regarding mass and volume requirements

% This MATLAB code inputs the material properties and minimum to maximum
% energy requirements and outputs data and graphs on the required mass,
% volume, and price required to run the AC through the night.


%Initializing values
RoomTemp = 20; %C
dT = RoomTemp-LowestTemp; %C
T = linspace(LowestTemp,RoomTemp,20)'; %C
density = interp1(DensityMatrix(1,:),DensityMatrix(2,:),T); %kg/m^3
MinDensity = min(density); %kg/m^3
EnergyValues = linspace(MinEnergyRequirement, MaxEnergyRequirement, 20)'; %kJ
Mass = EnergyValues./(SpecificHeat*dT+HeatofFusion); %kg
Volume = Mass/MinDensity;
Latent = Mass*HeatofFusion;
Sensible = EnergyValues-Latent;
Cost = Mass*Costperkg;

% If the material does not go through phase change, the latent heat is 0,
% and this can be accounted for by changing the heat of fusion to 0.
if (LowestTemp > TempofFusion) || (TempofFusion > RoomTemp)
    HeatofFusion = 0;
end

%Plotting and creating a table of the mass and volume required for the
```

```
%minimum to maximum energy requirements
A = [EnergyValues, Mass, Volume, Latent, Sensible];
Table1 = array2table(A, 'VariableNames', {'Energy Requirmenets (kJ)', 'Mass Required
(kg)', 'Volume Required (m^3)', 'Latent Heat Storage (kJ)', 'Sensible Heat Storage
(kJ)'});
text = 'Mass and Volume Requirements for Energy Requirements ';
txt = append(text,Material);
Table1 = table(Table1, 'VariableNames', {txt})

figure
hold on
text = 'Mass and Volume Material Required for ';
txt = append(text,Material);
title(txt)
xlabel('Energy Required (kJ)')
yyaxis left
plot(EnergyValues,Mass)
ylabel('Mass of Material Required (kg)')
yyaxis right
plot(EnergyValues,Volume)
ylabel('Max volume of material requied (m^3)')
hold off

figure
hold on
text = 'Price and Mass Material Required for ';
txt = append(text,Material);
title(txt)
xlabel('Energy Required (kJ)')
yyaxis left
plot(EnergyValues,Mass)
ylabel('Mass of Material Required (kg)')
yyaxis right
plot(EnergyValues,Cost)
ylabel('Cost ($)')
hold off

%This creates a table and plot of the changes in volume for the max and min energy
%requirement
MaxMass = MaxEnergyRequirement./(SpecificHeat*dT+HeatofFusion); %kg
MaxVolumes = MaxMass./density; %m^3
MinMass = MinEnergyRequirement./(SpecificHeat*dT+HeatofFusion); %kg
MinVolumes = MinMass./density; %m^3

B = [T, MaxVolumes];
Table2 = array2table(B, 'VariableNames', {'Temperature (C)', 'Volume'});
text = 'Volume Requirements for Maximum Energy Requirements ';
txt = append(text,Material);
Table2 = table(Table2, 'VariableNames', {txt})
C = [T, MinVolumes];
Table3 = array2table(C, 'VariableNames', {'Temperature (C)', 'Volume (m^3)'});
text = 'Volume Requirements for Minimum Energy Requirements ';
txt = append(text,Material);
Table3 = table(Table3, 'VariableNames', {txt})
```

```
figure
hold on
plot(T,MaxVolumes)
plot(T,MinVolumes)
xlabel('Temperature (C)')
ylabel('Volume (m^3)')
text = 'Volume Requirements at Varying Temperatures for ';
txt = append(text,Material);
title(txt)
legend('Max Energy Requirements', 'Min Energy Requirements')
hold off

end
```

```
% AUTHOR: Courtney Hiatt
% DATE: 3/26/24
% This code is the driver for the material properties function and outputs
% mass, volume, and cost requirements for different materials.


clc
clear all

LowestTemp = -1; %deg C
MinEnergyRequirement = 84153; %kJ
MaxEnergyRequirement = 119593; %kJ

%Properties of water
Water = 'Water';
WaterHeatofFusion = 334; %kJ/kg
WaterSpecificHeat = 4.187; %kJ/kgC
TempofFusion = 0; %deg C
WaterDensityMatrix = [-50 -40 -35 -30 -25 -20 -15 -10 -5 0 1 4 10 15 20 25 30 35 40
45 50 55 60 65 70; 921.6 920.8 920.4 920 919.6 919.4 919.4 918.9 917.5 916.2 999.90
999.97 999.70 999.10 998.21 997.05 995.65 994.03 992.22 990.21 998.04 985.69 983.21
980.55 977.76]; %kg/m3
WaterCost = 0.0002189;
MaterialProperties(Water, WaterHeatofFusion, TempofFusion, WaterSpecificHeat,
WaterDensityMatrix, MinEnergyRequirement, MaxEnergyRequirement, LowestTemp,
WaterCost)


%Properties of concrete
Concrete = 'Concrete';
ConcreteHeatofFusion = 0; %kJ/kg
ConcreteSpecificHeat = 1; %kJ/kgC
ConcreteDensityMatrix = [-100,0, 80, 95, 180; 2300, 2300, 2300, 2300, 2254];
ConcreteTempofFusion = 1200; %deg C
```

```
ConcreteCost = 0.10;
MaterialProperties(Concrete, ConcreteHeatofFusion, ConcreteTempofFusion,
ConcreteSpecificHeat, ConcreteDensityMatrix, MinEnergyRequirement,
MaxEnergyRequirement, LowestTemp, ConcreteCost)
```

Table 5. CLTD values for the max Q roof

Max Roof - Assume Roof 1			
Hour	CLTD (F)	CLTD corrected (F)	Qdot (Btu/hr)
1	0	13.5	4590
2	-2	11.5	3910
3	-4	9.5	3230
4	-5	8.5	2890
5	-6	7.5	2550
6	-6	7.5	2550
7	0	13.5	4590
8	13	26.5	9010
9	29	42.5	14450
10	45	58.5	19890
11	60	73.5	24990
12	73	86.5	29410
13	83	96.5	32810
14	88	101.5	34510
15	88	101.5	34510
16	83	96.5	32810
17	73	86.5	29410
18	60	73.5	24990
19	43	56.5	19210
20	26	39.5	13430
21	15	28.5	9690
22	9	22.5	7650
23	5	18.5	6290
24	2	15.5	5270
Total			42330

Table 6. CLTD values for the max Q North wall

Max North Wall - Assume Wall 16			
Hour	CLTD (F)	CLTD corrected (F)	Qdot (Btu/hr)
1	18	31.5	12442.5

2	17	30.5	12047.5
3	16	29.5	11652.5
4	14	27.5	10862.5
5	13	26.5	10467.5
6	11	24.5	9677.5
7	10	23.5	9282.5
8	9	22.5	8887.5
9	8	21.5	8492.5
10	7	20.5	8097.5
11	7	20.5	8097.5
12	7	20.5	8097.5
13	8	21.5	8492.5
14	9	22.5	8887.5
15	10	23.5	9282.5
16	11	24.5	9677.5
17	13	26.5	10467.5
18	14	27.5	10862.5
19	16	29.5	11652.5
20	17	30.5	12047.5
21	18	31.5	12442.5
22	19	32.5	12837.5
23	19	32.5	12837.5
24	19	32.5	12837.5
Total			250430

Table 7. CLTD values for the max Q East wall

Max East Wall - Assume Wall 16			
Hour	CLTD (F)	CLTD corrected (F)	Qdot (Btu/hr)
1	25	38.5	15207.5
2	23	36.5	14417.5
3	21	34.5	13627.5
4	19	32.5	12837.5
5	17	30.5	12047.5
6	15	28.5	11257.5
7	13	26.5	10467.5
8	11	24.5	9677.5
9	11	24.5	9677.5
10	12	25.5	10072.5

11	15	28.5	11257.5
12	19	32.5	12837.5
13	22	35.5	14022.5
14	26	39.5	15602.5
15	28	41.5	16392.5
16	30	43.5	17182.5
17	31	44.5	17577.5
18	31	44.5	17577.5
19	32	45.5	17972.5
20	32	45.5	17972.5
21	31	44.5	17577.5
22	30	43.5	17182.5
23	29	42.5	16787.5
24	27	40.5	15997.5
Total			345230

Table 8. CLTD values for the max Q South wall

Max South Wall - Assume Wall 16			
Hour	CLTD (F)	CLTD corrected (F)	Qdot (Btu/hr)
1	24	37.5	14812.5
2	22	35.5	14022.5
3	20	33.5	13232.5
4	18	31.5	12442.5
5	16	29.5	11652.5
6	14	27.5	10862.5
7	12	25.5	10072.5
8	11	24.5	9677.5
9	9	22.5	8887.5
10	8	21.5	8492.5
11	8	21.5	8492.5
12	8	21.5	8492.5
13	9	22.5	8887.5
14	11	24.5	9677.5
15	14	27.5	10862.5
16	17	30.5	12047.5
17	20	33.5	13232.5
18	23	36.5	14417.5
19	25	38.5	15207.5

20	27	40.5	15997.5
21	27	40.5	15997.5
22	27	40.5	15997.5
23	27	40.5	15997.5
24	25	38.5	15207.5
Total			294670

Table 9. CLTD values for the max Q West wall

Max West Wall - Assume Wall 16			
Hour	CLTD (F)	CLTD corrected (F)	Qdot (Btu/hr)
1	36	49.5	19552.5
2	33	46.5	18367.5
3	31	44.5	17577.5
4	28	41.5	16392.5
5	25	38.5	15207.5
6	22	35.5	14022.5
7	20	33.5	13232.5
8	177	190.5	75247.5
9	15	28.5	11257.5
10	13	26.5	10467.5
11	12	25.5	10072.5
12	11	24.5	9677.5
13	11	24.5	9677.5
14	11	24.5	9677.5
15	12	25.5	10072.5
16	14	27.5	10862.5
17	17	30.5	12047.5
18	20	33.5	13232.5
19	25	38.5	15207.5
20	30	43.5	17182.5
21	34	47.5	18762.5
22	37	50.5	19947.5
23	38	51.5	20342.5
24	37	50.5	19947.5
Total			408035

Table 10. CLTD values for the max Q for windows

Max Windows (Conduction Load)			
Hour	CLTD (F)	CLTD corrected (F)	Q (Btu/hr)
1	1	14.5	797.5
2	0	13.5	742.5
3	-1	12.5	687.5
4	-2	11.5	632.5
5	-2	11.5	632.5
6	-2	11.5	632.5
7	-2	11.5	632.5
8	0	13.5	742.5
9	2	15.5	852.5
10	4	17.5	962.5
11	7	20.5	1127.5
12	9	22.5	1237.5
13	12	25.5	1402.5
14	13	26.5	1457.5
15	14	27.5	1512.5
16	14	27.5	1512.5
17	13	26.5	1457.5
18	12	25.5	1402.5
19	10	23.5	1292.5
20	8	21.5	1182.5
21	6	19.5	1072.5
22	4	17.5	962.5
23	3	16.5	907.5
24	2	15.5	852.5
Total			24695

Table 11. CLTD values for the min Q roof

Min Roof - Assume Roof 14			
Hour	CLTD (F)	CLTD corrected (F)	Qdot (Btu/hr)
1	35	48.5	3298
2	32	45.5	3094
3	30	43.5	2958
4	27	40.5	2754
5	25	38.5	2618

6	23	36.5	2482
7	21	34.5	2346
8	20	33.5	2278
9	19	32.5	2210
10	20	33.5	2278
11	22	35.5	2414
12	24	37.5	2550
13	28	41.5	2822
14	32	45.5	3094
15	36	49.5	3366
16	39	52.5	3570
17	42	55.5	3774
18	44	57.5	3910
19	45	58.5	3978
20	45	58.5	3978
21	44	57.5	3910
22	42	55.5	3774
23	40	53.5	3638
24	37	50.5	3434
Total			74528

Table 12. CLTD values for the min Q North wall

Min North Wall - Assume Wall 1			
Hour	CLTD (F)	CLTD corrected (F)	Qdot (Btu/hr)
1	1	14.5	286.375
2	0	13.5	266.625
3	-1	12.5	246.875
4	-2	11.5	227.125
5	-3	10.5	207.375
6	-1	12.5	246.875
7	7	20.5	404.875
8	11	24.5	483.875
9	11	24.5	483.875
10	13	26.5	523.375
11	17	30.5	602.375
12	21	34.5	681.375
13	25	38.5	760.375
14	27	40.5	799.875

15	29	42.5	839.375
16	29	42.5	839.375
17	28	41.5	819.625
18	29	42.5	839.375
19	27	40.5	799.875
20	17	30.5	602.375
21	11	24.5	483.875
22	7	20.5	404.875
23	5	18.5	365.375
24	3	16.5	325.875
Total			2182.375

Table 13. CLTD values for the min Q East wall

Min East Wall - Assume Wall 1			
Hour	CLTD (F)	CLTD corrected (F)	Qdot (Btu/hr)
1	1	14.5	286.375
2	0	13.5	266.625
3	-1	12.5	246.875
4	-2	11.5	227.125
5	-2	11.5	227.125
6	2	15.5	306.125
7	28	41.5	819.625
8	51	64.5	1273.875
9	62	75.5	1491.125
10	64	77.5	1530.625
11	59	72.5	1431.875
12	48	61.5	1214.625
13	36	49.5	977.625
14	31	44.5	878.875
15	30	43.5	859.125
16	30	43.5	859.125
17	28	41.5	819.625
18	25	38.5	760.375
19	20	33.5	661.625
20	14	27.5	543.125
21	10	23.5	464.125
22	7	20.5	404.875
23	5	18.5	365.375

24	3	16.5	325.875
Total			2103.375

Table 14. CLTD values for the min Q South wall

Min South Wall - Assume Wall 1			
Hour	CLTD (F)	CLTD corrected (F)	Qdot (Btu/hr)
1	1	14.5	286.375
2	0	13.5	266.625
3	-1	12.5	246.875
4	-2	11.5	227.125
5	-3	10.5	207.375
6	-2	11.5	227.125
7	0	13.5	266.625
8	4	17.5	345.625
9	11	24.5	483.875
10	21	34.5	681.375
11	33	46.5	918.375
12	43	56.5	1115.875
13	50	63.5	1254.125
14	52	65.5	1293.625
15	50	63.5	1254.125
16	44	57.5	1135.625
17	34	47.5	938.125
18	27	40.5	799.875
19	20	33.5	661.625
20	14	27.5	543.125
21	10	23.5	464.125
22	7	20.5	404.875
23	5	18.5	365.375
24	3	16.5	325.875
Total			2103.375

Table 15. CLTD values for the min Q West wall

Min West Wall - Assume Wall 1			
Hour	CLTD (F)	CLTD corrected (F)	Qdot (Btu/hr)
1	2	15.5	306.125

2	1	14.5	286.375
3	-1	12.5	246.875
4	-2	11.5	227.125
5	-2	11.5	227.125
6	-2	11.5	227.125
7	1	14.5	286.375
8	4	17.5	345.625
9	8	21.5	424.625
10	13	26.5	523.375
11	17	30.5	602.375
12	21	34.5	681.375
13	27	40.5	799.875
14	42	55.5	1096.125
15	59	72.5	1431.875
16	73	86.5	1708.375
17	80	93.5	1846.625
18	79	92.5	1826.875
19	62	75.5	1491.125
20	32	45.5	898.625
21	16	29.5	582.625
22	9	22.5	444.375
23	6	19.5	385.125
24	3	16.5	325.875
Total			2636.625

Table 16. CLTD values for the min Q windows

Min Windows (Conduction Load)			
Hour	CLTD (F)	CLTD corrected (F)	Q (Btu/hr)
1	1	14.5	797.5
2	0	13.5	742.5
3	-1	12.5	687.5
4	-2	11.5	632.5
5	-2	11.5	632.5
6	-2	11.5	632.5
7	-2	11.5	632.5
8	0	13.5	742.5
9	2	15.5	852.5
10	4	17.5	962.5

11	7	20.5	1127.5
12	9	22.5	1237.5
13	12	25.5	1402.5
14	13	26.5	1457.5
15	14	27.5	1512.5
16	14	27.5	1512.5
17	13	26.5	1457.5
18	12	25.5	1402.5
19	10	23.5	1292.5
20	8	21.5	1182.5
21	6	19.5	1072.5
22	4	17.5	962.5
23	3	16.5	907.5
24	2	15.5	852.5
Total			4977.5