Haack, Charles. Technical Assignment Three: Mechanical Systems Existing Conditions. November 21, 2008.

KTA Group, Inc. Mechanical Construction Documents. KTA Group, Herndon, VA. 2008.

Marley Update Cooling Tower Selection Software. www.marleyct.com. Visited March 2009.

Noritake Associates. Architectural Construction Documents. Noritake Associates, Alexandria, VA. 2008.

RS Means Online Cost Estimate Software. www.rsmeans.com. Visited March 2009.

Appendices

Appendix A – Breakdown of Monthly Energy Consumption & Costs

Table 32 – New Energy Consumption by Month

Energy Analysis						
Electric	Jan	Feb	Mar	Apr	May	Jun
On Peak Consumption (kWh)	222,030	206,577	231,893	212,386	241,873	192,257
Off Peak Consumption (kWh)	66,069	59,819	64,721	59,351	62,752	116,103
Natural Gas						
On Peak Consumption (Therms)	636	469	1,864	2,930	7,647	7,478
Off Peak Consumption (Therms)	228	175	25	41	646	2705

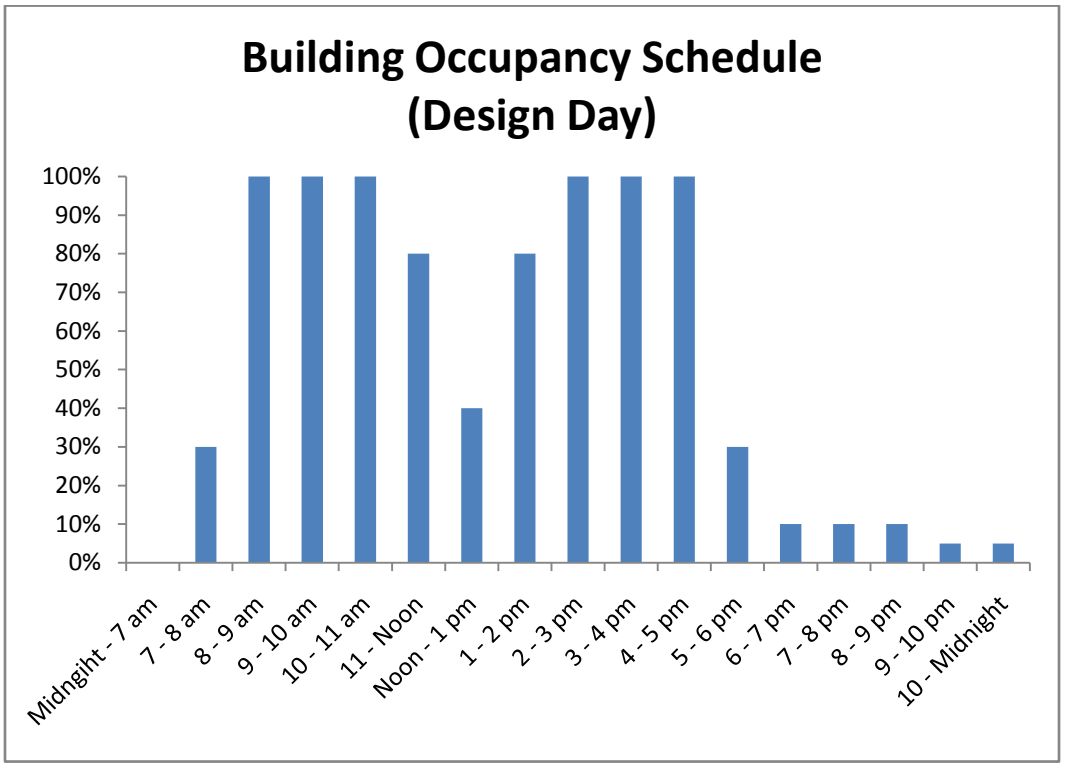
Energy Analysis							
Electric	Jul	Aug	Sep	Oct	Nov	Dec	Total
On Peak Consumption (kWh)	187,542	199,534	177,926	226,827	216,030	212,822	2,527,697
Off Peak Consumption (kWh)	117,413	119,598	108,422	61,485	59,258	66,874	961,864
Natural Gas							
On Peak Consumption (Therms)	7,877	7,951	5,828	3,824	2,879	482	49,866
Off Peak Consumption (Therms)	3065	2947	2017	4	16	164	12,032

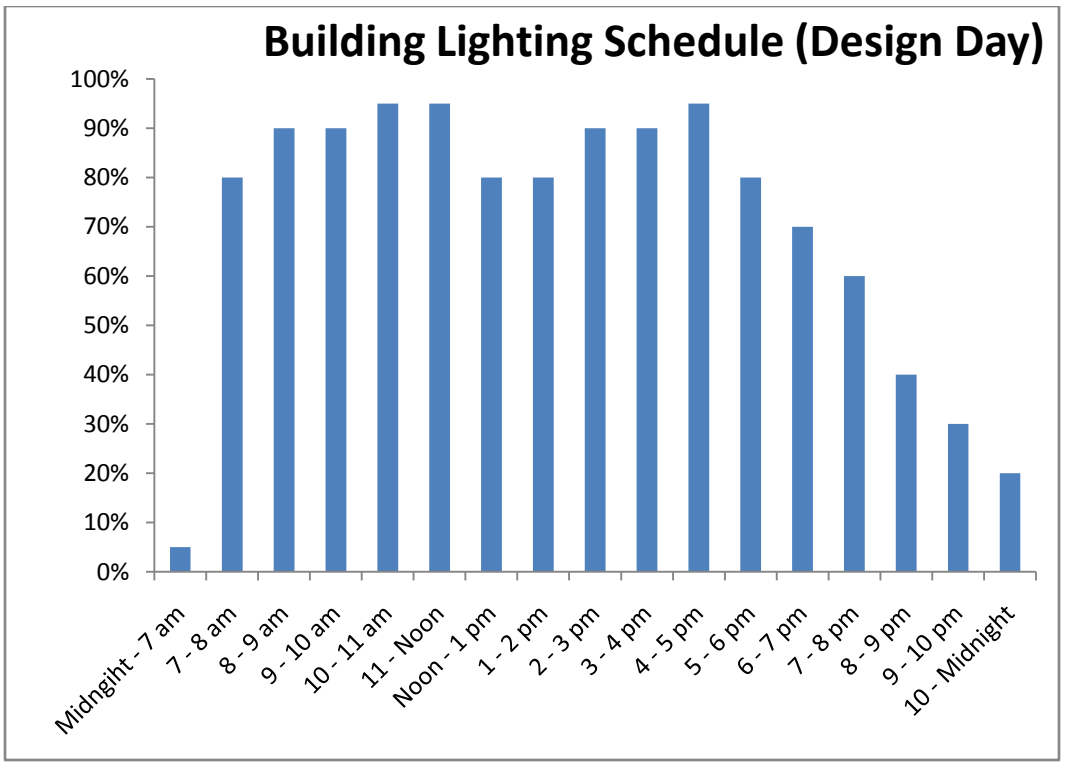
Tables 33 – New Energy Cost by Month

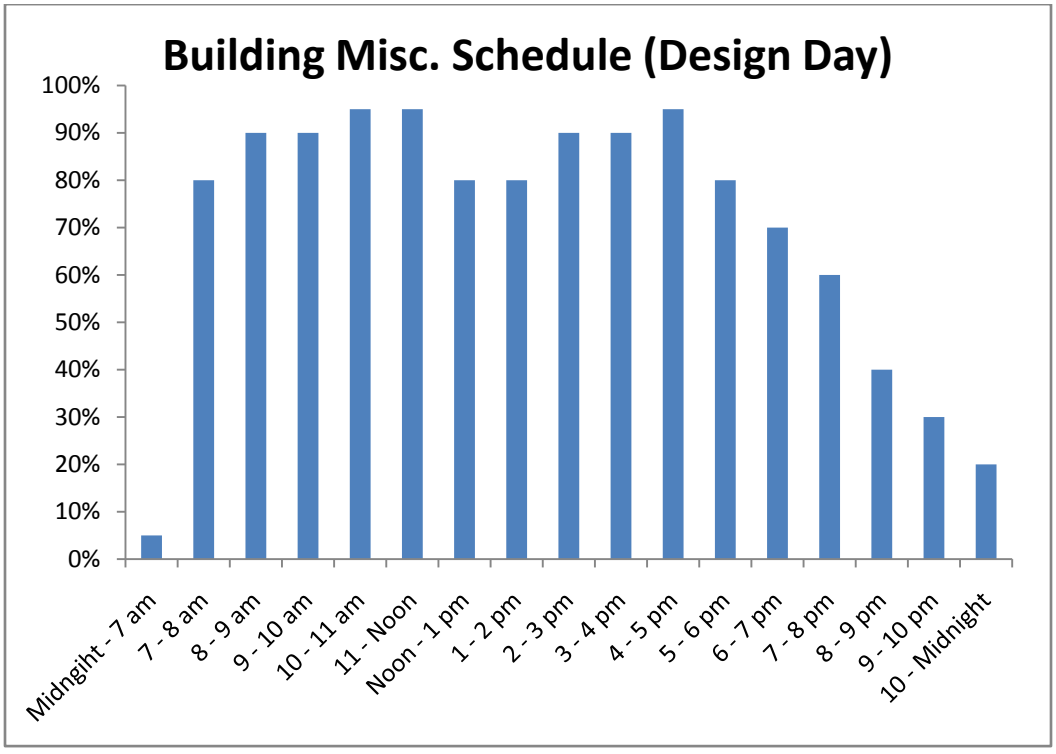
Monthly Energy Costs							
	Jan	Feb	Mar	Apr	May	Jun	Total
Natural Gas	$946.68	$705.63	$1,857.45	$2,921.38	$8,154.51	$10,245.12	$59,114.42
Electricity	$21,970.23	$21,335.30	$22,525.52	$21,915.96	$24,118.48	$25,236.26	$277,181.20
	Jul	Aug	Sep	Oct	Nov	Dec	**$336,295.62**
Natural Gas	$10,402.56	$9,349.39	$7,539.83	$3,470.85	$2,840.00	$681.01	
Electricity	$25,101.89	$25,526.54	$23,977.90	$22,441.52	$21,547.72	$21,483.88	

Appendix B – Building Usage Schedules

All schedules reflect a typical Monday to Friday schedule for the respective system. During weekends, the building is assumed to be unoccupied.




Building Lighting Schedule (Design Day)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Midnight - 7 am
7 - 8 am
8 - 9 am
9 - 10 am
10 - 11 am
11 - Noon
Noon - 1 pm
1 - 2 pm
2 - 3 pm
3 - 4 pm
4 - 5 pm
5 - 6 pm
6 - 7 pm
7 - 8 pm
8 - 9 pm
9 - 10 pm
10 - Midnight


Building Misc. Schedule (Design Day)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Midnight - 7 am
7 - 8 am
8 - 9 am
9 - 10 am
10 - 11 am
11 - Noon
Noon - 1 pm
1 - 2 pm
2 - 3 pm
3 - 4 pm
4 - 5 pm
5 - 6 pm
6 - 7 pm
7 - 8 pm
8 - 9 pm
9 - 10 pm
10 - Midnight

Appendix C – Cooling Tower Design Sheets

UPDATE™ Version 4.12.2
Product Data: 3/16/2009 (Current)

3/18/2009 10:20:03 AM

Job Information

Selected By

Penn State
104 Engineering Unit A
University Park, PA
wpb5@psu.edu

PSUAE
Tel 814-863-2076

SPX Cooling Technologies Contact

H & H Associates, Inc.
4510 Westport Drive
Mechanicsburg, PA 17055
frank@hhassociates.com

Tel 717-796-2401
Fax 717-796-9717

Cooling Tower Definition

Manufacturer	Marley	Fan Motor Speed	1800 rpm
Product	NC Class	Fan Motor Capacity per cell	7.500 BHp
Model	NC8401MAN1	Fan Motor Output per cell	7.376 BHp
Cells	1	Fan Motor Output total	7.376 BHp
CTI Certified	Yes	Air Flow per cell	55280 cfm
Fan	6.000 ft, 5 Blades	Air Flow total	55280 cfm
Fan Speed	370 rpm, 6974.3 fpm	Static Lift	10.425 ft
Fans per cell	1	Distribution Head Loss	0.000 ft
		ASHRAE 90.1 Performance	78.4 gpm/Hp

Model Group	Standard Low Sound (A)
Sound Pressure Level	73 dBA (Single Cell), 5.000 ft from Air Inlet Face. See sound report for details.

Conditions

Tower Water Flow	441.9 gpm	Air Density In	0.07094 lb/ft³
Hot Water Temperature	95.00 °F	Air Density Out	0.07141 lb/ft³
Range	10.00 °F	Humidity Ratio In	0.01712
Cold Water Temperature	85.00 °F	Humidity Ratio Out	0.02795
Approach	7.00 °F	Wet-Bulb Temp. Out	86.69 °F
Wet-Bulb Temperature	78.00 °F	Estimated Evaporation	5.0 gpm
Relative Humidity	50 %	Total Heat Rejection	2202000 Btu/h

- This selection satisfies your design conditions.

Weights & Dimensions

	Per Cell	Total
Shipping Weight	4275 lb	4275 lb
Heaviest Section	4057 lb	
Max Operating Weight	8678 lb	8678 lb
Width	12.833 ft	12.833 ft
Length	6.521 ft	6.521 ft
Height	10.250 ft	

Minimum Enclosure Clearance

Clearance required on air inlet sides of tower without altering performance. Assumes no air from below tower.

Solid Wall	3.757 ft
50 % Open Wall	3.000 ft

Weights and dimensions do not include options; refer to sales drawings.

Cold Weather Operation

Heater Sizing (to prevent freezing in the collection basin during periods of shutdown)

Heater kW/Cell	9.0	7.5	6.0	4.5	3.0
Ambient Temperature °F	-26.64	-14.92	-3.20	8.52	20.23

UPDATE™ Version 4.12.2
Product Data: 3/16/2009 (Current)

3/18/2009 10:22:12 AM

Job Information

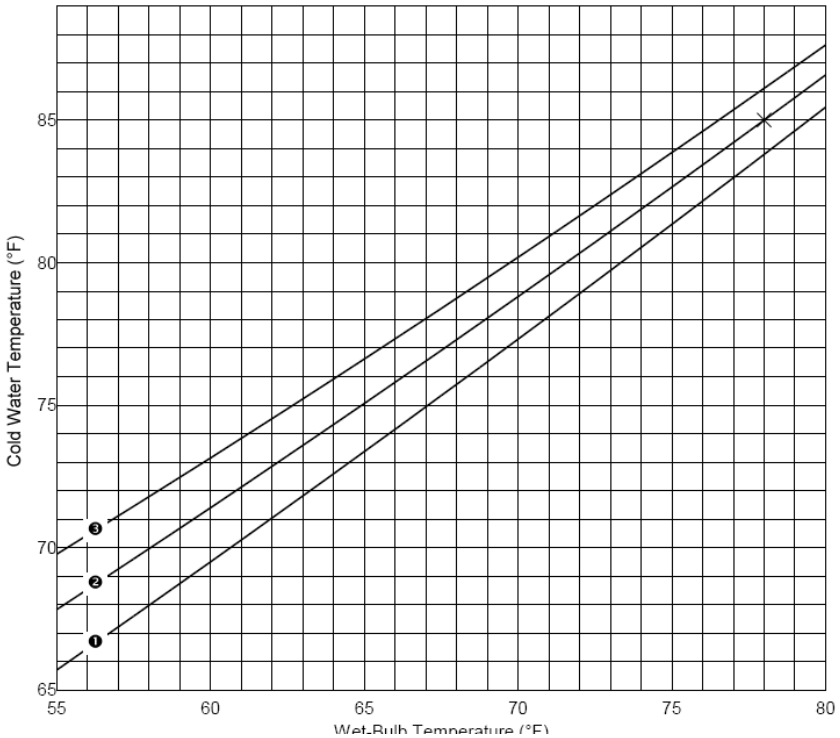
Selected by

Penn State
104 Engineering Unit A
University Park, PA
wpb5@psu.edu

PSUAE
Tel 814-863-2076
Fax

Cooling Tower Definition

Manufacturer	Marley
Product	NC Class
Model	NC8401MAN1
Cells	1
Fan	6.000 ft, 5 Blades
Fans per cell	1
Fan Motor Capacity per cell	7.500 BHp



Design Conditions

Tower Water Flow	441.9 gpm
Hot Water Temperature	95.00 °F
Cold Water Temperature	85.00 °F
Wet-Bulb Temperature	78.00 °F

Curve Conditions

Tower Water Flow (100.0 %)	441.9 gpm
Fan Speed (100.0 %)	370 rpm
Fan Motor Speed (100.0 %)	1800 rpm
Fan Motor Output per cell	7.376 BHp
Fan Motor Output total	7.376 BHp

Legend

❶ 8 °F Range
❷ 10 °F Range
❸ 12 °F Range
× Design Point

Appendix D – Rainwater Tank Sizing Calculations

Rainfall Storage Tank Calculation Region 2 - Mid Atlantic region					
Event	mm		11.53	Values Taken	
Mean	mm/hr		2.6235	from NOAA	
Mean duration	hr		4.4		
Mean interval	hr		70		
Area of roof	m^2	A	3902	42001	ft^2
Runoff Coefficient		ϕ	1		
Avg # of rainfall events	#	θ	86.96		
Depth Parameter	1/mm	ζ	0.086730269		
Duration Parameter	1/hr	λ	0.227272727		
Time Parameter	1/hr	ψ	0.014285714		
Designed first flush depth	mm	v_{ff}	0		
Annual total water collected	L	R_a	3912336	1033529.7	gallons
Reliability of supply of water		R_e	0.3		
Max reliability of supply of water		R_{emax}	0.35088		
Annual discharge time	hr	T_d	6087.2		
Maximum use per reliability R_e	L/day	G_{max}	1499.67	396.17055	gallons
Actual Water use	L/day	G	1189	314.10057	gallons
Required Storage Volume	L	B	60811	16064.675	gallons
Probabilty of Spillage	%	G(0)	0.3509		
Estimated Spill Volume	L	S	15786.18	4170.2687	gallons

Appendix E – Structural Calculations

The following appendix is a compilation of PCA Slab outputs and is divided into both the width and length column line calculations for a typical new air handling unit and a new cooling tower. Shear, Moment, and Deflection diagrams are shown along with a graphics showing the placement and size of the reinforcing steel for each of the cases.

Width Graphical Outputs

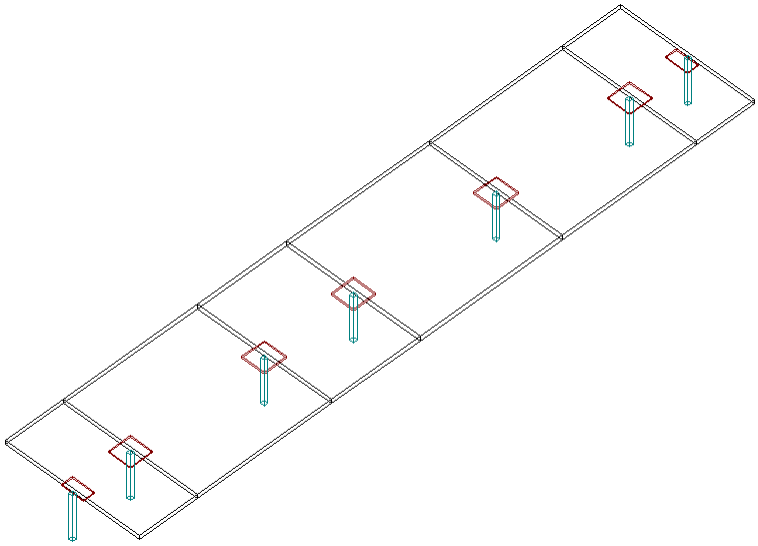


Figure XX - Isometric Displaying Tributary Areas for Width Calculation

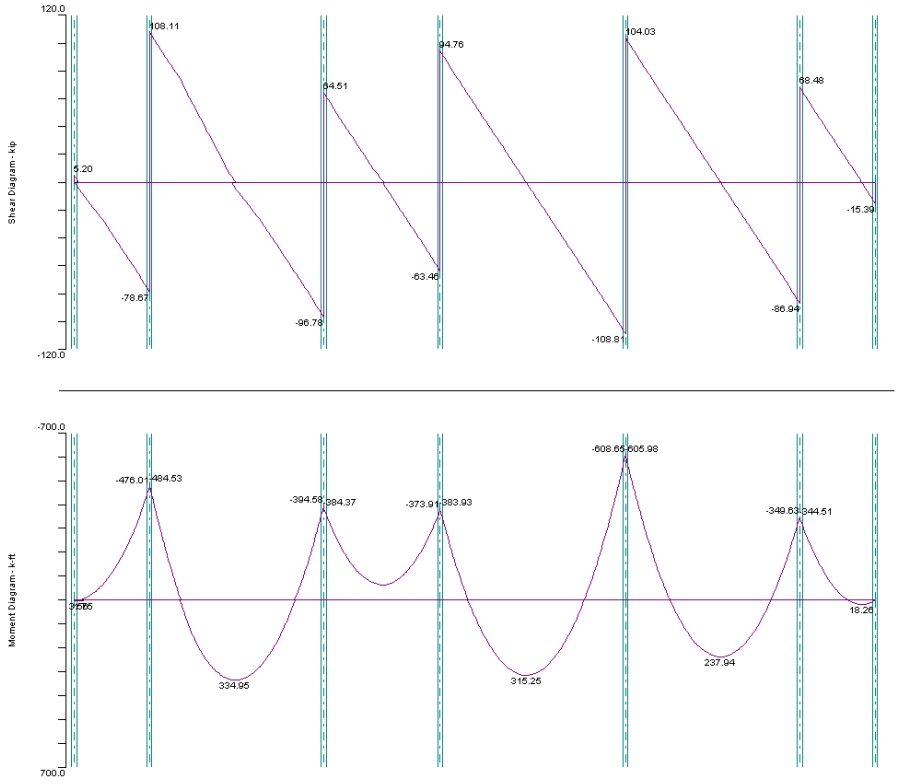


Figure 25 – Shear and Moment Diagrams for Typical AHU Width

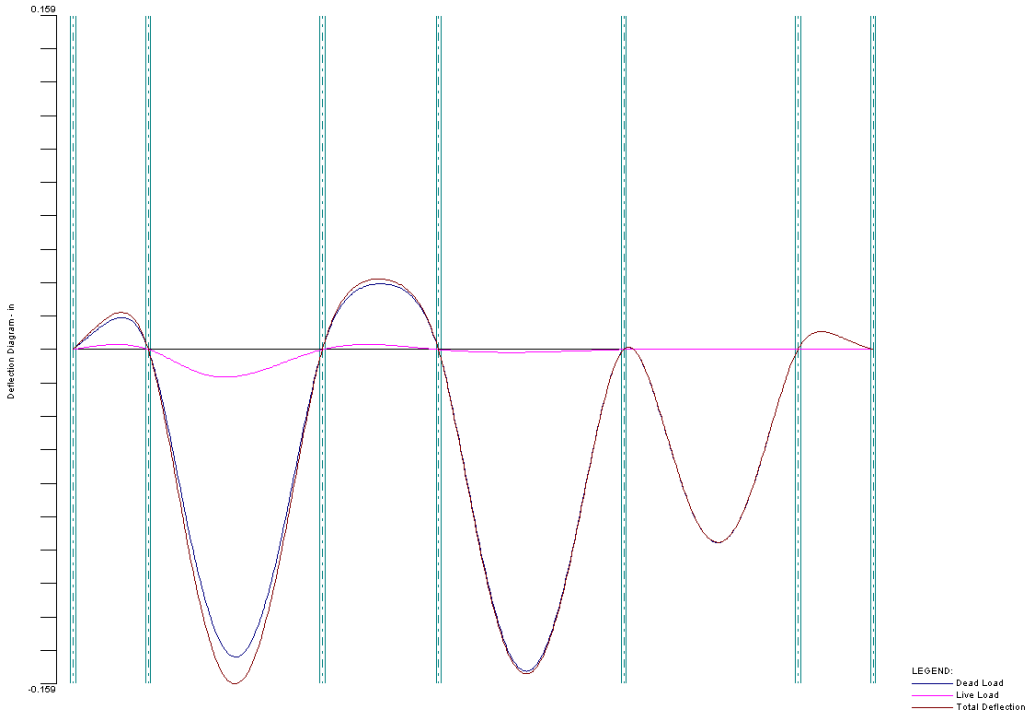


Figure 26 –Deflection Diagrams for Typical AHU Width

Figure 27 –Reinforcement for Typical AHU Width

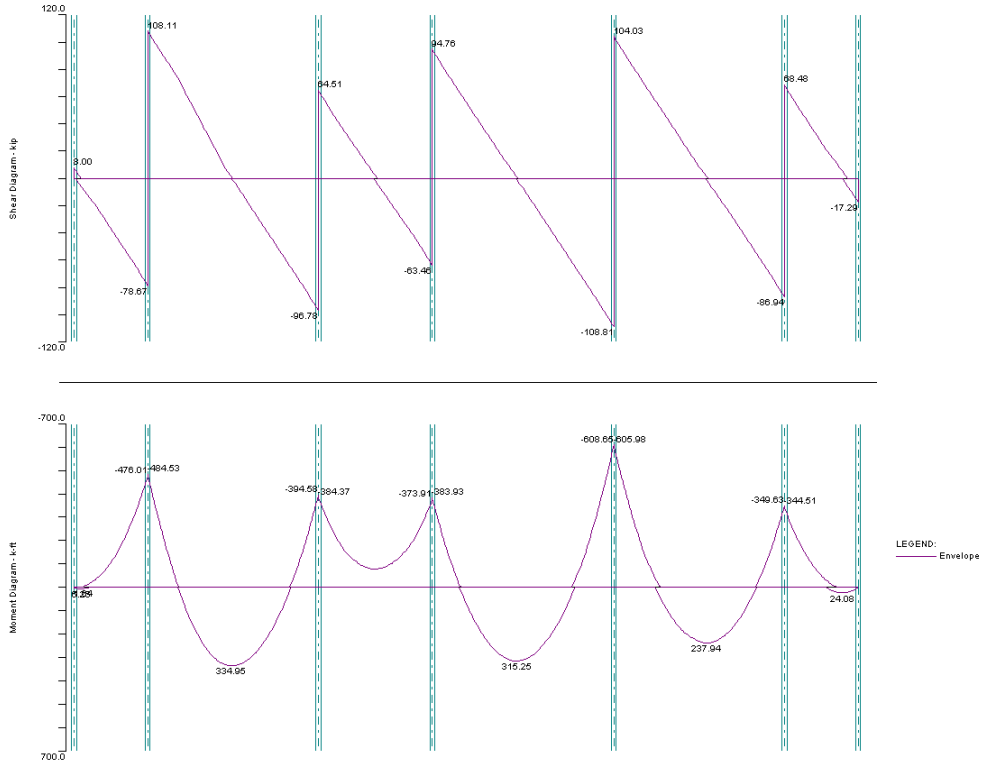


Figure 28 – Shear and Moment Diagrams for Typical Cooling Tower Width

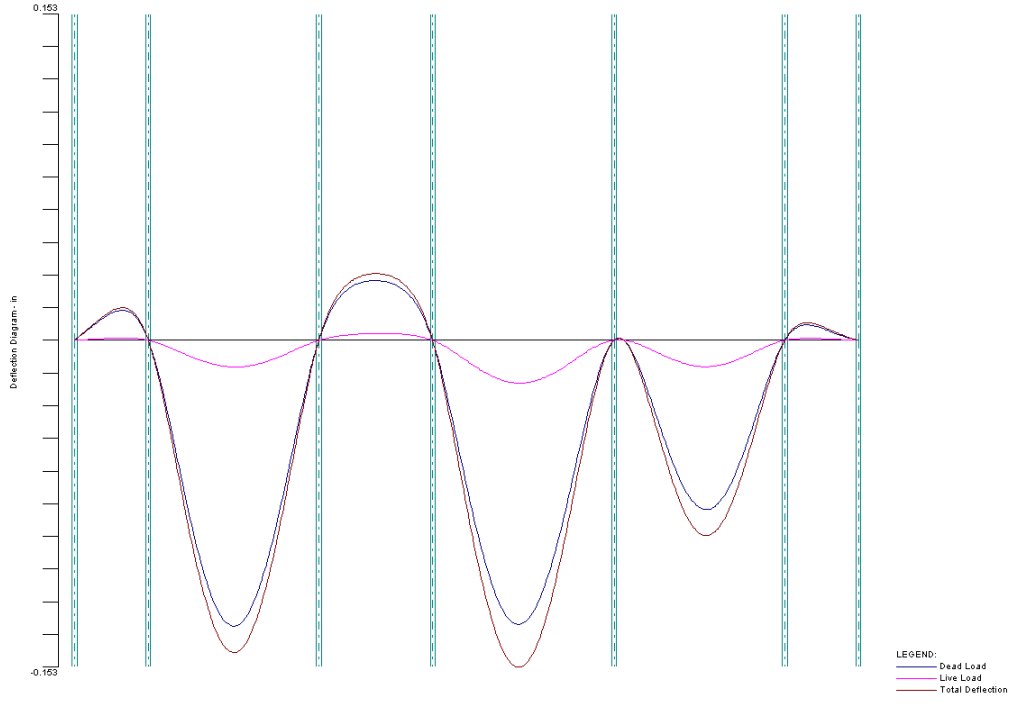


Figure 29 –Deflection Diagrams for Typical Cooling Tower Width

Figure 30 –Reinforcement for Typical Cooling Tower Width

Length Graphical Outputs

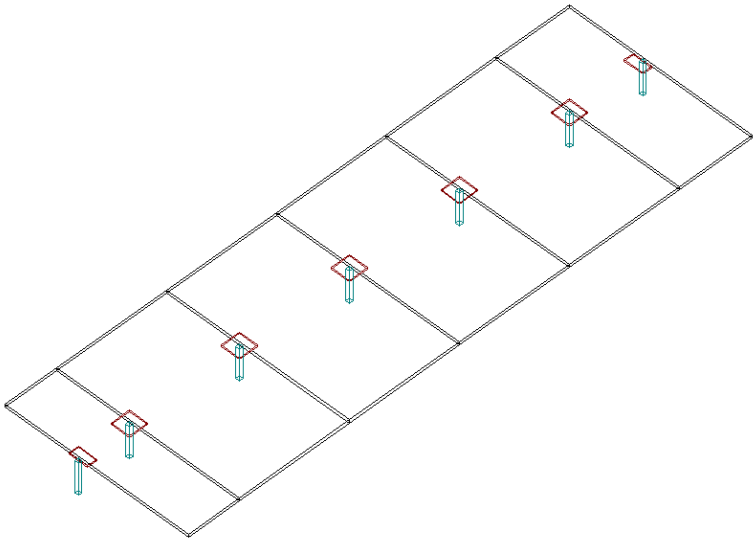


Figure 31 - Isometric Displaying Tributary Areas for Length Calculation