



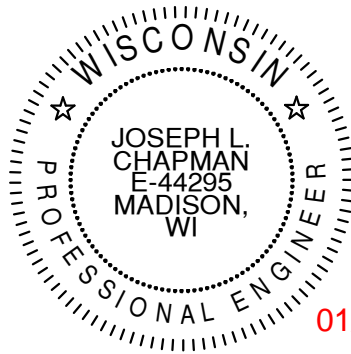
DC ENGINEERING

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STRUCTURAL CALCULATIONS

Fire Station 2 Solar Panel Addition

Madison, WI



PREPARED FOR:
City of Madison

DCE JOB #:
21COMD04



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ROOF ANALYSIS



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Careful listening. Dynamic solutions.

JOB _____
SHEET NO. _____ OF _____
CALCULATED BY _____ DATE _____
CHECKED BY _____ DATE _____
SCALE _____

Project Summary

Adding (2) solar arrays to roof of existing structure. Mounting equipment does not require direct attachment to deck and is secured using ballast blocks. Additional load to deck and framing is 4 PSF.

Fire Station 2 Existing Roof Analysis

Original Design Loads

Snow load

Ground snow load = 30 PSF

Roof snow load = 30 PSF per original plans

Drift at each array:

Height of each array = 1.1', no additional drift at each array

Dead load

3" Tectum + 1-1/4" urethane = 5.5 PSF + 1 PSF = 6.5 PSF

EPDM membrane + roof ballast = 5.5 PSF

MEP = 1.5 PSF

DL = 13.5 PSF

Compare applied loads to allowable loads using H-series joist tables.

Array 1 and 2:

28H9 joist @ 5' O.C.

Span = 49'

Max. allowable loads from H-series table

Total load = 278 PLF

Live load (for L/360 deflection) = 144 PLF

No ceiling attached to H-joists, can use live load for L/240 deflection: $(144 \text{ PLF})(1.5) = 216 \text{ PLF}$

Max. applied loads

DL = $15.2 \text{ PLF} + (17.5 \text{ PSF})(5 \text{ FT}) = 102.7 \text{ PLF}$

LL = $(30 \text{ PSF})(5 \text{ FT}) = 150 \text{ PLF}$

Total load = $150 \text{ PLF} + 102.7 \text{ PLF} = 252.7 \text{ PLF} < 278 \text{ PLF OK}$

Live load = $150 \text{ PLF} < 216 \text{ PLF OK}$

28H10 and 28H11 acceptable by inspection.

W16x31 Beams:

Longest span = 19.5'

Roof tributary = 3.6'

Beams acceptable as shown.

Steel Beam

Lic. #: KW-06015046

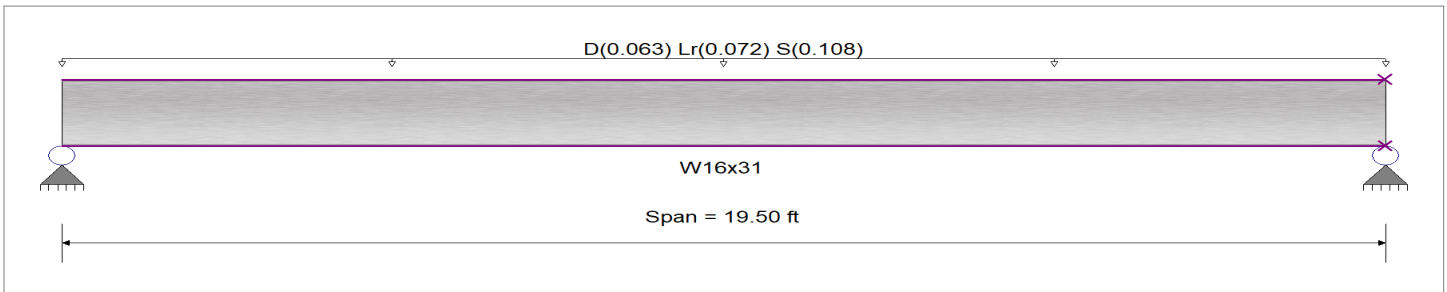
DESCRIPTION: EXISTING W16x31

CODE REFERENCES

Calculations per AISC 360-16, IBC 2018, CBC 2019, ASCE 7-16
 Load Combination Set : ASCE 7-16

Material Properties

Analysis Method : Allowable Strength Design
 Beam Bracing : Beam is Fully Braced against lateral-torsional buckling
 Bending Axis : Major Axis Bending
 Fy : Steel Yield : 36.0 ksi
 E: Modulus : 29,000.0 ksi



Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Beam self weight calculated and added to loading
 Uniform Load : D = 0.01750, Lr = 0.020, S = 0.030 ksf, Tributary Width = 3.60 ft, (ROOF + ARRAYS)

DESIGN SUMMARY

Design OK

Maximum Bending Stress Ratio =	0.099 : 1	Maximum Shear Stress Ratio =	0.031 : 1
Section used for this span	W16x31	Section used for this span	W16x31
Ma : Applied	9.601 k-ft	Va : Applied	1.970 k
Mn / Omega : Allowable	97.006 k-ft	Vn/Omega : Allowable	62.964 k
Load Combination	+D+S	Load Combination	+D+S
Location of maximum on span	9.750ft	Location of maximum on span	0.000 ft
Span # where maximum occurs	Span # 1	Span # where maximum occurs	Span # 1
Maximum Deflection			
Max Downward Transient Deflection	0.032 in	Ratio =	7,209 >=360
Max Upward Transient Deflection	0.000 in	Ratio =	0 <360
Max Downward Total Deflection	0.061 in	Ratio =	3855 >=240.
Max Upward Total Deflection	0.000 in	Ratio =	0 <240.0

Maximum Forces & Stresses for Load Combinations

Load Combination	Segment Length	Span #	Max Stress Ratios		Summary of Moment Values						Summary of Shear Values			
			M	V	Mmax +	Mmax -	Ma Max	Mnx	Mnx/Omega	Cb	Rm	Va Max	Vnx	Vnx/Omega
D Only	Dsgn. L = 19.50 ft	1	0.046	0.015	4.47		4.47	162.00	97.01	1.00	1.00	0.92	94.45	62.96
+D+Lr	Dsgn. L = 19.50 ft	1	0.081	0.026	7.89		7.89	162.00	97.01	1.00	1.00	1.62	94.45	62.96
+D+S	Dsgn. L = 19.50 ft	1	0.099	0.031	9.60		9.60	162.00	97.01	1.00	1.00	1.97	94.45	62.96
+D+0.750Lr	Dsgn. L = 19.50 ft	1	0.073	0.023	7.03		7.03	162.00	97.01	1.00	1.00	1.44	94.45	62.96
+D+0.750S	Dsgn. L = 19.50 ft	1	0.086	0.027	8.32		8.32	162.00	97.01	1.00	1.00	1.71	94.45	62.96
+0.60D	Dsgn. L = 19.50 ft	1	0.028	0.009	2.68		2.68	162.00	97.01	1.00	1.00	0.55	94.45	62.96

Overall Maximum Deflections

Load Combination	Span	Max. "-" Defl	Location in Span	Load Combination	Max. "+" Defl	Location in Span
+D+S	1	0.0607	9.806		0.0000	0.000

Vertical Reactions

Support notation : Far left is #1

Values in KIPS

Load Combination	Support 1	Support 2
Overall MAXimum	1.970	1.970
Overall MINimum	0.550	0.550
D Only	0.917	0.917
+D+Lr	1.619	1.619

Project Title:
Engineer:
Project ID:
Project Descr:

Steel Beam

File: Fire_Station2_Existing_Beams.ec6
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Lic. # : KW-06015046

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DESCRIPTION: EXISTING W16x31

Vertical Reactions

Support notation : Far left is #1

Values in KIPS

Load Combination	Support 1	Support 2
+D+S	1.970	1.970
+D+0.750Lr	1.443	1.443
+D+0.750S	1.706	1.706
+0.60D	0.550	0.550
Lr Only	0.702	0.702
S Only	1.053	1.053

Existing Tectum Roof Deck Analysis:

Maximum applied load = DL + SL = 17.5 PSF + 30 PSF = 47.5 PSF

See below for deck capacity

ARMSTRONG

LOCATION DEPENDENT

TECTUM® I ROOF DECK DESIGN LOAD DATA

System	Thickness ¹	Wt. (PFS) ¹	24"	30"	36"	38"	40"	42"	44"	48"	50"	52"	54"	60"	66"	72"
Plank	2"	3.5	130	75	50	45	40	35								
	2-1/2"	4.5	150	120	80	70	60	50	45	35						
	3"	5.3	200	125	102	91	82	74	65	50	45	40	35			
Long Span Plank	2"	3.8	130	75	75	75	70	64	57	50	45	40	35			
	2-1/2"	4.7	150	120	120	120	114	103	93	77	70	65	60	50	35	
	3"	5.5	200	125	125	125	125	120	115	110	104	96	88	71	58	50

For loads greater than 200 lbs., contact Armstrong TechLine.

¹ Thickness and weight are nominal.

STANDARD LOAD TABLE

OPEN WEB STEEL JOISTS, H- SERIES

Based on Allowable Stress of 30,000 PSI

Adopted by the Steel Joist Institute and American Institute of Steel Construction Inc., October 1, 1974

The black figures in the following table give the TOTAL safe uniformly distributed load-carrying capacities, in pounds per linear foot, of H-Series Steel Joists. The weight of DEAD loads, including the joists, must be deducted to determine the LIVE load-carrying capacities of the joists. The load table may be used for parallel chord joists installed to a maximum slope of 1/2 inch per foot.

The figures shown in blue in this load table are the LIVE loads per linear foot of joist which will produce an approximate deflection of 1/360 of the span. LIVE loads which will produce a deflection of 1/240 of the span may be

obtained by multiplying the figures in blue by 1.5. In no case shall the total load capacity of the joists be exceeded.**

Tests on steel joists designed in accordance with the Standard Specifications have demonstrated that the Standard Load Tables are applicable for concentrated top chord loadings (such as are developed in bulb-tee roof construction) when the sum of the equal concentrated top chord loadings does not exceed the allowable uniform loading for the joist type and span and the loads are placed at spacings not exceeding 33" along the top chord.

LOADS ABOVE THE COLORED LINES ARE GOVERNED BY SHEAR.

Joist Designation	8H3	10H3	10H4	12H3	12H4	12H5	12H6	14H3	14H4	14H5	14H6	14H7	16H4	16H5	16H6	16H7	16H8
Nominal *Depth (in.)	8	10	10	12	12	12	12	14	14	14	14	14	16	16	16	16	16
Resist. Moment (in.-lbs.)	91,000	116,000	148,000	140,000	180,000	222,000	260,000	165,000	212,000	259,000	307,000	369,000	221,000	289,000	344,000	413,000	478,000
Max. End React. (lbs.)	2400	2500	2800	2800	3200	3600	3900	3200	3500	3800	4200	4600	3800	4300	4600	4900	5200
†Approx. Wt. (lbs./ft.)	5.0	5.0	6.1	5.2	6.2	7.1	8.2	5.5	6.5	7.4	8.6	10.0	6.6	7.8	8.6	10.3	11.4
Span in Feet	600																
8	600																
9	533																
10	480 460	500	560														
11	436 345	455	509														
12	400 266	417	467	467	533	600	650										
13	359 209	385 337	431 417	431	492	554	600										
14	310 167	357 270	400 334	400 393	457	514	557	457	500	543	600	657					
15	270 136	333 219	373 271	373 320	427 418	480	520	427	467	507	560	613					
16	232 112	302 181	350 223	350 264	400 345	450 404	488 480	400 366	438	475	525	575	475	538	575	613	650
17		268 151	329 186	323 220	376 287	424 337	459 400	376 305	412 398	447	494	541	447	506	541	576	612
18		239 127	305 157	288 185	356 242	400 284	433 337	340 257	389 336	422 393	467	511	422 413	478	511	544	578
19		214 108	273 133	259 157	332 206	379 241	411 286	305 218	368 285	400 334	442 399	484 470	400 351	453 432	484	516	547
20		193 92	247 114	233 135	300 177	360 207	390 246	275 187	350 245	380 287	420 342	460 403	368 301	430 370	460 437	490	520
21				212 117	272 152	336 179	371 212	249 162	320 212	362 248	400 295	438 348	334 260	391 320	438 377	467 454	495
22				193 101	248 133	306 155	355 185	227 141	292 184	345 215	382 257	418 302	304 226	391 278	418 328	445 395	473 454
23				176 89	227 116	280 136	328 162	208 123	267 161	326 189	365 225	400 265	279 198	364 243	400 287	426 346	452 398
24				162 78	208 102	257 120	301 142	191 108	245 142	300 166	350 198	383 233	256 174	334 214	383 253	408 304	433 350
25								176 96	226 125	276 147	327 175	368 206	236 154	308 190	367 224	392 269	416 310
26								163 85	209 111	255 131	303 156	354 183	218 137	285 169	339 199	377 239	400 275
27								151 76	194 99	237 117	281 139	337 164	202 122	264 151	315 177	363 214	385 246
28								140 68	180 89	220 104	261 125	314 147	188 110	246 135	293 159	350 192	371 220
29													175 99	229 121	273 143	327 172	359 198
30													164 89	214 110	255 129	306 156	347 179
31													153 81	200 99	239 141	287 141	332 162
32													144 74	188 90	224 107	269 128	311 148

See page LT-48 for notes

For Joist Depths 18" to 22" inclusive

Joist Designation	18H5	18H6	18H7	18H8	18H9	18H10	18H11	20H5	20H6	20H7	20H8	20H9	20H10	20H11	22H6	22H7	22H8	22H9	22H10	22H11
Nominal *Depth (in.)	18	18	18	18	18	18	18	20	20	20	20	20	20	20	22	22	22	22	22	22
Resist. Moment (in.-lbs.)	325,000	383,000	466,000	540,000	627,000	705,000	814,000	365,000	406,000	499,000	602,000	701,000	789,000	912,000	422,000	526,000	653,000	776,000	873,000	1,009,000
Max. End React. (lbs.)	4500	4800	5200	5400	5900	6600	7600	4800	5100	5400	5600	6400	7000	7900	5400	5600	5800	6700	7200	8100
†Approx. Wt. (lbs./ft.)	8.0	9.2	10.4	11.6	12.6	14.0	15.8	8.4	9.6	10.7	12.2	13.2	14.6	16.4	9.7	10.7	12.0	13.8	15.2	16.9
Span in Feet	18	18	18	18	18	18	18	20	20	20	20	20	20	20	22	22	22	22	22	22
19	474	505	547	568	621															
20	450	480	520	540	590			480	510	540	560	640								
21	429 409	457	495	514	562	629		457	486	514	533	610								
22	409 356	436 420	473	491	536	600		436	464	491	509	582	636		491	509	527	609		
23	391 312	417 368	452 441	470	513	574		417 380	443 434	470	487	557	609		470	487	504	583	626	
24	375 274	400 324	433 388	450 444	492 484	550 546	633 619	400 335	425 382	450	467	533	583		450 446	467	483	558	600	
25	347 243	384 286	416 343	432 393	472 428	528 483	608 548	384 296	408 338	432 411	448	512	560	632	432 395	448	464	536	576	648
26	321 216	369 255	400 305	415 349	454 380	508 429	585 487	360 263	392 300	415 365	431	492 476	538	608	415 351	431 426	446	515	554	623
27	297 193	350 227	385 272	400 312	437 340	489 383	563 435	334 235	371 268	400 326	415 392	474 425	519 480	585 545	386 313	415 380	430	496	533	600
28	276 173	326 204	371 244	386 280	421 305	471 344	543 390	310 211	345 240	386 292	400 352	457 381	500 431	564 488	359 281	400 341	414	479 468	514	579
29	258 155	304 184	359 220	372 252	407 274	455 309	524 351	289 190	322 216	372 263	386 317	441 343	483 388	545 440	335 253	386 307	400 379	462 421	497 473	559 539
30	241 140	284 166	345 199	360 227	393 248	440 280	507 317	270 171	301 195	360 238	373 286	427 310	467 350	527 397	313 228	373 277	387 343	447 381	480 428	540 487
31	225 127	266 150	323 180	348 206	381 224	426 253	490 287	253 155	282 177	346 215	361 259	413 281	452 317	510 360	293 207	361 251	374 311	432 345	465 387	523 441
32	212 116	249 137	303 164	338 187	369 204	413 230	475 261	238 141	264 161	325 196	350 236	400 255	438 288	494 327	275 188	342 228	363 282	419 314	450 352	506 401
33	199 106	234 125	285 149	327 171	358 186	400 210	461 238	223 129	249 147	305 178	339 215	388 233	424 263	479 298	258 172	322 208	352 257	406 286	436 321	491 366
34	187 96	221 114	269 136	311 156	347 170	388 192	447 218	210 118	234 134	288 163	329 196	376 213	412 240	465 273	243 157	303 190	341 235	394 261	424 294	476 335
35	177 88	208 104	254 125	294 143	337 156	377 176	434 200	199 108	221 123	272 150	320 180	366 195	400 220	451 250	230 144	286 175	331 216	383 240	411 269	463 307
36	167 81	197 96	240 115	278 132	323 143	363 162	419 183	188 99	209 113	257 137	310 166	356 179	389 203	439 230	217 132	271 160	322 198	372 220	400 247	450 282
37								178 91	198 104	243 127	293 152	341 165	378 187	427 212	206 122	256 148	314 183	362 203	389 228	438 260
38								169 84	187 96	230 117	278 141	324 153	364 172	416 195	195 112	243 136	301 169	353 187	379 210	426 240
39								160 78	178 89	219 108	264 130	307 141	346 159	400 181	185 104	231 126	286 156	340 173	369 195	415 222
40								152 72	169 82	208 100	251 121	292 131	329 148	380 168	176 96	219 117	272 145	323 161	360 180	405 205
41														167 89	209 109	259 134	308 149	346 167	395 191	
42														159 83	199 101	247 125	293 139	330 156	381 177	
43														152 78	190 94	235 116	280 129	315 145	364 165	
44														145 72	181 88	225 109	267 121	301 136	347 154	

*Indicates Nominal Depth of steel joists only.

†Approximate Weights per Linear Foot of steel joists only. Accessories and nailer strip not included.

*†See manufacturers' catalog for detailed information on specific joist types.

**Section 5.9 of the "Standard Specifications for Open Web Steel Joists, J- and H-Series" limits the design LIVE load deflection as follows:

FLOORS, 1/360 span. ROOFS, 1/360 of span where a plaster ceiling is attached or suspended; 1/240 of span for all other cases.



For Joist Depths 24" to 30" inclusive

Joist Designation	24H6	24H7	24H8	24H9	24H10	24H11	26H8	26H9	26H10	26H11	28H8	28H9	28H10	28H11	30H8	30H9	30H10	30H11
Nominal *Depth (in.)	24	24	24	24	24	24	26	26	26	26	28	28	28	28	30	30	30	30
Resist. Moment (in.-lbs.)	462,000	576,000	716,000	851,000	957,000	1,106,000	784,000	925,000	1,040,000	1,203,000	846,000	1,000,000	1,124,000	1,300,000	909,000	1,075,000	1,207,000	1,397,000
Max. End React. (lbs.)	5600	5800	6000	7000	7500	8200	6700	7200	7600	8300	6700	7200	7700	8400	6800	7500	8100	8700
†Approx. Wt. (lbs./ft.)	10.3	11.5	12.7	14.0	15.5	17.5	12.8	14.8	16.2	17.9	13.5	15.2	16.8	18.3	14.2	15.4	17.3	18.8
Span in Feet																		
24	467	483	500	583	625													
25	448	464	480	560	600													
26	431	446	462	538	577	631	515	554	585	638								
27	415 375	430	444	519	556	607	496	533	563	615								
28	393 336	414 406	429	500	536	586	479	514	543	593	479	514	550	600				
29	366 303	400 365	414	483	517	566	462	497	524	572	462	497	531	579				
30	342 273	387 330	400	467 457	500	547	447	480	507	553	447	480	513	560	453	500	540	580
31	320 248	374 299	387 373	452 414	484 465	529	432 418	465	490	535	432	465	497	542	439	484	523	561
32	301 225	363 272	375 339	438 376	469 423	513	419 380	450 445	475	519	419	450	481	525	425	469	506	544
33	283 205	352 248	364 309	424 343	455 386	497	406 440	436 405	461	503	406 404	436	467	509	412	455	491	527
34	266 188	332 227	353 283	412 314	441 353	482	394 317	424 371	447	488	394 370	424	453	494	400	441	476	512
35	251 172	313 208	343 259	400 288	429 323	469	383 290	411 340	434	474	383 339	411 396	440	480	389	429	463	497
36	238 158	296 191	333 238	389 264	417 297	456	372 339	400 312	422	461	372 311	400 364	428	467	378 359	417	450	483
37	225 146	280 176	324 219	378 243	405 274	443	362 246	389	411	449	362 287	389 336	416	454	368 330	405 387	438 436	470
38	213 135	266 162	316 202	368 225	395 253	432	353 227	379	400	437	353 341	379	405	442	358 305	395 357	426 402	458
39	202 124	252 150	308 187	359 208	385 234	421	344 210	369	390	426	344 245	369 287	395	431	349 282	385 331	415 372	446
40	193 115	240 139	298 174	350 193	375 217	410	327 194	360	380	415	335 227	360	385	420	340 262	375 306	405 345	435
41	183 107	228 129	284 161	337 179	366 201	400	311 211	351	371	405	327 272	351	376	410	332 243	366 285	395 320	424
42	175 100	218 120	271 150	322 166	357 187	390	296 168	343	362	395	319 253	343	367	400	324 226	357 265	386 298	414
43	167 93	208 112	258 140	307 155	345 174	381	283 156	334	353	386	305 183	335	358	391	316 211	349 247	377 278	405
44	159 87	198 105	247 130	293 145	330 163	373	270 146	319	345	377	291 171	327	350	382	309 196	341 230	368 259	395
45	152 81	190 98	236 122	280 135	315 152	364	258 137	305	338	369	279 159	320	342	373	299 184	333 215	360 242	387
46	146 76	181 92	226 114	268 127	302 142	348	247 128	291	328	361	267 149	313	335	365	286 172	326 202	352 227	378
47	139 71	174 86	216 107	257 119	289 133	334	237 120	279	314	353	255 140	302	328	357	274 161	319 189	345 213	370
48	134 67	167 81	207 100	246 111	277 125	320	227 112	268	301	346	245 148	289	321	350	263 151	311 177	338 200	363
49							218	257	289	334	235	278	312	343	252	298	331	355
50							209	247	277	321	226	267	300	336	242	287	322	348
51							100	117	131	150	116	136	153	175	134	157	177	202
52							201	237	267	308	217	256	288	329	233	276	309	341
53							94	110	124	141	110	128	144	165	126	148	166	191
54							193	228	256	297	209	247	277	321	224	265	298	335
55							88	104	117	133	103	121	136	156	119	139	157	180
56											201	237	267	309	216	255	286	328
57											98	114	128	147	112	132	148	170
58											193	229	257	297	208	246	276	319
59											92	108	121	139	106	125	140	161
60											186	220	248	287	200	237	266	308
											87	102	115	132	101	118	133	152
											180	213	239	276	193	229	257	297
											83	97	109	125	95	112	126	144
															187	221	248	287
															90	106	119	137
															180	213	239	277
															86	101	113	130
															174	206	231	268
															81	95	108	123
															168	199	224	259
															77	91	102	117

*Indicates Nominal Depth of steel joists only.

†Approximate Weights per Linear Foot of steel joists only. Accessories and nailer strip not included.

*†See manufacturers' catalog for detailed information on specific joist types.

**Section 5.9 of the "Standard Specifications for Open Web Steel Joists, J- and H-Series" limits the design LIVE load deflection as follows:

FLOORS, 1/360 span. ROOFS, 1/360 of span where a plaster ceiling is attached or suspended; 1/240 of span for all other cases.





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SOLAR PANEL AND MOUNTING INFORMATION

PROJECT TITLE	PROJECT ID	CREATED
ROOFMOUNT RM10	EF551222	Sept. 28, 2021, 1:46 p.m.

NAME	Fire 2 Draft	Designed by wcmahon@cityofmadison.com
ADDRESS	Monona, WI 53713, USA	ROOFMOUNT RM10
CITY, STATE	Madison, WI	Hanwha/Q-Cells
MODULE	Hanwha/Q-Cells Q-PEAK DUO L-G5.2 380	38 - Q-PEAK DUO L-G5.2 380
		824.50 ft ²
		14.44 KW

BILL OF MATERIALS

LEGEND: ■ Base System Part ■ Accessory

PART NUMBER	PART TYPE	DESCRIPTION	QUANTITY	SUGGESTED QUANTITY	UNIT PRICE (USD)	TOTAL LIST PRICE (USD)
UserSupplied	Ballast Block	Ballast Block	75	75	0.00	0.00
310710	Ballast Bay	RM Ballast Bay 10 Degree	59	59	42.63	2515.17
310760	RM Roof Pad	RM Roof Pad	118	118	2.23	263.14
310750	Module Clip	RM Module Clip	180	180	1.58	284.40
310751	RM Hex Bolt	RM Hex Bolt (Module Clip)	180	180	0.94	169.20

BASE SYSTEM PRICE	\$2968.77	ACCESSORIES PRICE	\$263.14	TOTAL PRICE	\$3231.91
	\$0.206 PER WATT		\$0.018 PER WATT		\$0.224 PER WATT

This design is to be evaluated to the product appropriate Unirac Code Compliant Installation Manual which references International Building Code 2009, 2012, 2015, 2018 and ASCE 7-05, ASCE 7-10, ASCE 7-16 and California Building Code 2010, 2016. The installation of products related to this design is subject to requirements in the above mentioned installation manual.

DETAILED PARTS DESCRIPTION

QTY



Ballast Block UserSupplied Ballast Block

75

Standard 4x8x16 inch cap blocks. Nationwide availability. Please confirm the weight of your ballast block as this will affect the total blocks required for your installation.



Ballast Bay 310710 RM Ballast Bay 10 Degree

59

Aluminum ballast bay attaches to north and south module edges (for 10 degree tilt installations) and provides ballast placement location.



RM Roof Pad 310760 RM Roof Pad

118

TPE 201-73 BK Santoprene Roof Pad. PLEASE NOTE: Depending on your roof type and seismic conditions, some quantity of roof pads may be required. These will be listed separately on your bill of materials.



Module Clip 310750 RM Module Clip

180

Aluminum clip fastens module frame to ballast bay and provides bonding path from module to bay to module.



RM Hex Bolt 310751 RM Hex Bolt (Module Clip)

180

Hex bolt with integrated locking patch.

ENGINEERING REPORT

Plan review

AVERAGE PSF	3.84 psf
TOTAL NUMBER OF MODULES	38
TOTAL KW	14.44 KW
TOTAL MODULE AREA	~1349 ft ²
TOTAL WEIGHT ON ROOF	5180 lbs
RACKING WEIGHT	207 lbs
MODULE WEIGHT	1968 lbs
BALLAST WEIGHT	2888 lbs
MAX BAY LOAD (DEAD)	132 lbs

Loads Used for Design

BUILDING CODE	ASCE 7-10
BASIC WIND SPEED	115.00 mph
GROUND SNOW LOAD	30.00 psf
SEISMIC (SS)	0.08
ELEVATION	871.00 ft
WIND EXPOSURE	B
MRI	25
RISK CATEGORY	II
VELOCITY PRESSURE, QZ	15.4 psf

Loads Determined by Zip

53713

CITY, STATE	Madison, WI
BASIC WIND SPEED	115.00 mph
GROUND SNOW LOAD	30.00 psf

Inspection

PRODUCT	ROOFMOUNT RM10
MODULE MANUFACTURER	Hanwha/Q-Cells
MODEL	Q-PEAK DUO L-G5.2 380
MODULE WATTS	380 watts
MODULE LENGTH	79.30"
MODULE WIDTH	39.40"
MODULE THICKNESS	1.38"
MODULE WEIGHT	51.80 lbs
BALLAST BLOCK (CMU) WEIGHT	38.5 lbs
MAX BLOCKS PER BAY	4
BUILDING HEIGHT	20.00 ft
ROOF TYPE	MINERAL_CAP
PARAPET HEIGHT	<= 1/2 Array Height (<= 6 inches)

Roof Area 1 - Array 1

AVERAGE PSF	3.91 psf
TOTAL NUMBER OF MODULES:	18
TOTAL KW:	6.84 KW
TOTAL AREA:	642 ft ²
TOTAL WEIGHT ON ROOF:	2511 lbs
RACKING WEIGHT:	98 lbs
MODULE WEIGHT:	932 lbs
BALLAST WEIGHT:	1425 lbs
ATTACHMENT COUNT	

MINIMUM SEISMIC SEPARATION (UNATTACHED ARRAYS) *	
ARRAY TO ARRAY:	3.0"
TO FIXED OBJECT ON ROOF:	6.0"
TO ROOF EDGE WITH QUALIFYING PARAPET:	6.0"
TO ROOF EDGE WITHOUT QUALIFYING PARAPET:	9.0"
MAX ARRAY (SEISMIC) (FOR UNATTACHED ARRAYS) *	
MAX NUMBER OF NORTH-SOUTH ROWS:	26
MAX NUMBER OF EAST-WEST COLUMNS:	115
*In jurisdictions that follow SEAOC PV-1 methodology.	

Roof Area 1 - Array 2

AVERAGE PSF	3.78 psf
TOTAL NUMBER OF MODULES:	20
TOTAL KW:	7.60 KW
TOTAL AREA:	707 ft ²
TOTAL WEIGHT ON ROOF:	2670 lbs
RACKING WEIGHT:	109 lbs
MODULE WEIGHT:	1036 lbs
BALLAST WEIGHT:	1463 lbs
ATTACHMENT COUNT	

MINIMUM SEISMIC SEPARATION (UNATTACHED ARRAYS) *	
ARRAY TO ARRAY:	3.0"
TO FIXED OBJECT ON ROOF:	6.0"
TO ROOF EDGE WITH QUALIFYING PARAPET:	6.0"
TO ROOF EDGE WITHOUT QUALIFYING PARAPET:	9.0"
MAX ARRAY (SEISMIC) (FOR UNATTACHED ARRAYS) *	
MAX NUMBER OF NORTH-SOUTH ROWS:	26
MAX NUMBER OF EAST-WEST COLUMNS:	115
*In jurisdictions that follow SEAOC PV-1 methodology.	

RM10 U-BUILDER PRODUCT ASSUMPTIONS

RM10 – Ballasted Flat Roof Systems

Limitations of Responsibility: It is the user's responsibility to ensure that inputs are correct for your specific project.

Unirac is not the solar, electrical, or building engineer of record and is not responsible for the solar, electrical, or building design for this project.

Building Assumptions

1. Risk Category III
2. Building Height \leq 50 ft
3. Building Height > 50 ft: only where (longest length of building x building height)^{0.5} \leq 100 ft
4. Roof Slope \geq 0° (0:12) and \leq 3° (5/8:12) for Seismic Design Category C, D, E and F. For low seismic regions Seismic Design Category A and B (provided Array Importance factor = 1.0), Roof Slope \geq 0° (0:12) and \leq 7° (1 1/2:12).
5. Roofing Material Types: EDPM, PVC, TPO, or Mineral Cap
6. Surrounding Building Grade: Level

Ballast Blocks

The installer is responsible for procuring the ballast blocks (Concrete Masonry Units – CMU) and verifying the required minimum weight needed for this design. CMU should comply with ASM standard specification for concrete roof pavers designation (C1491 or C90 with an integral water repellant suitable for the climate it is placed). It is recommended that the blocks are inspected periodically for any signs of degradation. If degradation of the block is observed, the block should immediately be replaced.

The CMU ballast block should have nominal dimensions of 4"x8"x16". The actual block dimensions are 3/8" less than the nominal dimensions. Ballast blocks should have a weight as specified for the project in the "Inspection" section of this report.

Design Parameters

1. Risk Category I to III
2. Wind Design
 - a. Basic Wind Speed: 85-120 mph (ASCE 7-05)/110-150 mph (ASCE 7-10)/90-180 mph (ASCE 7-16)
 - b. Exposure: B, C or D (ASCE 7-05/ASCE 7-10)
 - c. 25 year Design Life/50 year Design Life for ASCE 7-16
 - d. Elevation: Insertion of the project at - grade elevation can result in a reduction of wind pressure. If your project is in a special case study region or in an area where wind studies have been performed, please verify with your jurisdiction to ensure that elevation effects have not already been factored into the wind speed. If elevation effects have been included in your wind speed, please select 0 ft as the project site elevation.
 - e. Wind Tunnel Testing: Wind tunnel testing coefficients have been utilized for design of the system.
3. Snow Design
 - a. Ground Snow Load: 0-80 psf (ASCE 7-10/ASCE 7-16)
 - b. Exposure Factor: 0.9
 - c. Thermal Factor: 1.2
 - d. Roof Snow Load: Calculation per Section 7.3 (ASCE 7-05/ASCE 7-10/ASCE 7-16)
 - e. Unbalanced/Drifting/Sliding: Results are based on the uniform snow loading and do not consider unbalanced, drifting, and sliding conditions
4. Seismic Design
 - a. Report *SEAOC PV1-2012/ASCE 7-16 SECTION 13.6.12 – Structural Seismic Requirements and Commentary for Rooftop Solar Photovoltaic Arrays*
 - b. Seismic Site Class: A, B, C, or D (ASCE 7-05/ASCE 7-10/ASCE 7-16)
 - c. Importance Factor Array (Ip): 1.0
 - d. Importance Factor Building (Ie): 1.0
 - e. Site Class: D

Properties

1. Bay Weight: ~3.5 lbs
2. Module Gaps (E/W) = 0.25 in
3. Bays: North row bays overhang the module by ~19.5 inches.

Module Properties

1. Module return flange: Minimum of 0.9in (when using 1-3/4 in. clip bolts) is required.
2. Module return flange: Minimum of 0.65in (when using 2 in. clip bolts) is required.

Testing

1. Coefficient of Friction
2. Wind Tunnel
3. UL 2703
4. Component Testing (Bay and Clamp)

Setbacks

For the wind tunnel recommendations in U-Builder to apply, the following setbacks should be observed/followed for U-Builder wind design:

1. Modules should be placed a minimum of 3 feet from the edge of the building in any direction.
2. If the array is located near an obstruction that is 3.5 feet wide and 3.5 feet high or larger, the nearest module of the array must be located a distance from the obstruction that is greater than or equal to the height of the obstruction.
Exception: When using ASCE 7-16 Building Code and using the obstruction feature in the module editor to accurately model the size and location of obstruction.
3. Installations within the setbacks listed above require site specific engineering²
4. The setbacks above are for wind. High seismic areas, fire access isles, mechanical equipment, etc., may require larger setbacks than listed above for wind.

Site Specific Engineering

Conditions listed below are beyond the current capabilities of U-Builder. Site specific engineering is required.

1. Wind designs for a project design life exceeding 25 years^{1/ASCE 7-16}
2. Building assumptions and design parameters outside of U-Builder assumptions²
3. Attachments²
4. Risk Category III or IV projects (U-Builder can be adjusted for the correct wind, but not the seismic or snow design)²
5. Wind tunnel testing reduction factors are not permitted by the Authority Having Jurisdiction (AHJ)³
6. Seismic designs that fall outside SEAOC PV1-2012/ASCE 7-16 SECTION 13.6.12 recommendations (>3% roof slope, or AHJ's that require shake table testing or non-linear site-specific response history analysis)³
7. Signed and sealed site-specific calculations, layouts, and drawings³

Notes:

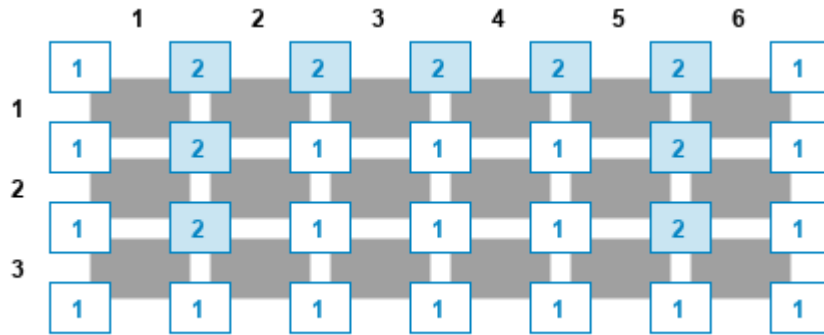
¹Please contact info@unirac.com.

²Please contact EngineeringServices@unirac.com for more information.




³Please contact Theresa Allen with PZSE Structural Engineers at theresa@pzse.com. These items will require direct coordination with PZSE to complete the requested services.

INSTALLATION AND DESIGN PLAN

Roof Area 1 / Roof Area 1 - Array 1



LEGEND

-  Module
-  Standard corner bay with CMU block count
-  Supplemental bay with CMU block count

NOTE

Blocks above with values greater than 4 require extra ballast bays, except north-most bays which require extra bays for values greater than 6. The proper number of bays are provided in the Bill of Materials. The installer must install these extra bays as near to the indicated location as possible.

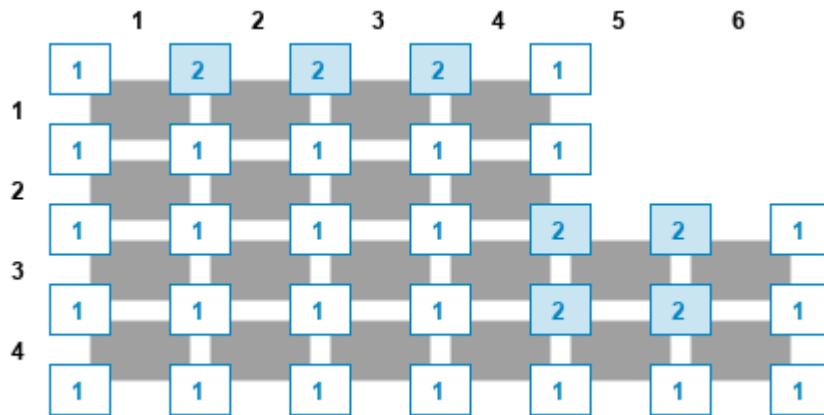
Install roof pads to every bay.

Layout Dimensions




NS DIMENSION	~ 16.20 ft
EW DIMENSION	~ 39.78 ft

ROW	MODULES	BAYS	BALLAST BLOCKS (CMU)	BALLAST WEIGHT (LBS)
1	6	7	12	462
2	6	7	9	347
3	6	7	9	347
4	0	7	7	270

Roof Area 1 / Roof Area 1 - Array 2



LEGEND

-  Module
-  Standard corner bay with CMU block count
-  Supplemental bay with CMU block count

NOTE

Blocks above with values greater than 4 require extra ballast bays, except north-most bays which require extra bays for values greater than 6. The proper number of bays are provided in the Bill of Materials. The installer must install these extra bays as near to the indicated location as possible.

Install roof pads to every bay.

Layout Dimensions

NS DIMENSION ~ 21.06 ft

EW DIMENSION ~ 39.78 ft

ROW	MODULES	BAYS	BALLAST BLOCKS (CMU)	BALLAST WEIGHT (LBS)
1	4	5	8	308
2	4	5	5	193
3	6	7	9	347
4	6	7	9	347
5	0	7	7	270