

Structural Engineering

SCADA

Electrical Engineering

Instrumentation

Controls

October 3, 2012

Unirac, Inc.
1411 Broadway Boulevard NE
Albuquerque, NM 97102-1545

Subject: Engineering for SolarMount™ Evolution – ICC-ES ESR 3083

To Whom It May Concern:

TJC and Associates, Inc. (TJCAA) has worked with Unirac, Inc. to obtain an ICC-ES ESR for its SolarMount™ Evolution product. Terrapin Testing, a division of TJCAA and an IAS accredited laboratory, conducted the qualification testing for the SolarMount™ Evolution product. Terence Cavanagh, S.E., a Principal with TJCAA, is the Engineer of Record (EOR) for the engineering submitted to ICC-ES in support of ESR 3083. Therefore, where a specific EOR must be identified in association with ESR 3083, this letter may be used for that purpose. For the user's convenience, a copy of ESR 3083 has been attached to this letter.

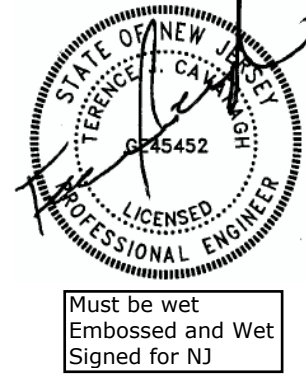
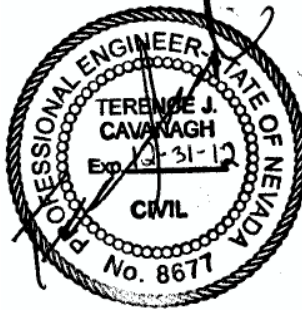
Sincerely,

Terence J. Cavanagh
TJC and Associates, Inc.

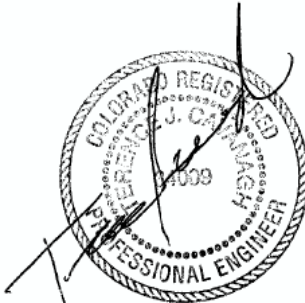
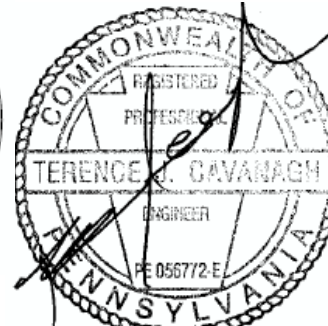
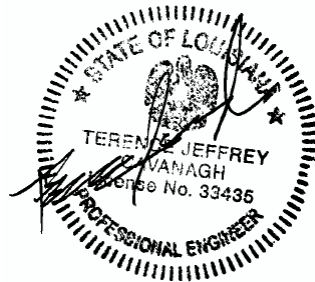
TJC:ns

Enclosures: ESR 3083

file: 310003TG.100.100



Must be wet
Embossed and Wet
Signed for NJ



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ICC-ES Evaluation Report

ESR-3083

Issued February 1, 2012

This report is subject to renewal February 1, 2013.

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A Subsidiary of the International Code Council®

DIVISION: 05 00 00—METALS
Section: 05 05 23—Metal Fastenings
Section: 05 10 00—Structural Metal Framing

REPORT HOLDER:

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EVALUATION SUBJECT:

**UNIRAC SOLARMOUNT™ (E)VOLUTION FLUSH MOUNT
 MODULAR FRAMING SYSTEM**

1.0 EVALUATION SCOPE
Compliance with the following codes:

- 2009 and 2006 *International Building Code (IBC)*
- 2009 and 2006 *International Residential Code (IRC)*

Property evaluated:

Structural

2.0 USES

The Unirac SolarMount™ (E)volution Flush Mount Modular Framing System is intended for use as a means to support and secure photovoltaic modules to a roof under code-prescribed loading conditions. The flush mount system will be oriented so that the modules are parallel to, and elevated above, the roof surface on which they are mounted. The flush mount modular framing system is designed to be installed with a photovoltaic module that is composed of a 6063-T5 or better type aluminum frame, having a depth of 0.95 to 2.0 inches (24.13 to 51 mm), and a minimum thickness of 0.060 inch (1.52 mm).

3.0 DESCRIPTION
3.1 General:

The Unirac SolarMount™ (E)volution Flush Mount Modular Framing System is composed of extruded aluminum beams, clips, clamps, attachments, and fasteners which are used to attach an array of photovoltaic panels to a roof structure.

3.2 Materials:

3.2.1 Beams: Beams are used to support the PV modules and are provided in lengths of up to 20 feet

(6.1 m) and may be cut to other lengths based on the limitations provided in this report. Beams are formed from either 6005A-T61, 6351-T5, or 6061-T6 extruded aluminum. See the figure within Table 3 for a description of the beam.

3.2.2 Flange Attachment: The flange attachment, shown in Figure 1 of this report, is a bracket used to connect the beam to the roof structure. The flange attachment is composed of the flange bracket and the seismic clip. Both of the flange attachment components are made from 6005A-T61, 6351-T5, or 6061-T6 extruded aluminum.

3.2.3 Retainer: The retainer, shown in Figure 1, is used to secure the beam to the flange attachment and is also used at beam splices. The retainer is made from 5052-H32 aluminum. Four stainless steel self-drilling screws having a 1/4-inch (6.35 mm) diameter are used to connect each retainer to the web of the beam.

3.2.4 End Clamp: The end clamp, shown in Figure 1, is a two-component clamp used to connect the end PV module of an array of PV modules to the beam. The top component of the clamp is made from 300 series stainless steel. The bottom component of the clamp is made from either 6005A-T61, 6351-T5, or 6061-T6 extruded aluminum. A 5/16-inch-diameter (7.94 mm) stainless steel bolt is used with each end clamp to fasten the top component of the clamp to the bottom component.

3.2.5 Mid Clamp: The mid clamp, shown in Figure 1, is used to connect two adjacent PV modules to the beam. The top component of the clamp is made from 300 series stainless steel. The bottom component of the clamp is made from either 6005A-T61, 6351-T5, or 6061-T6 extruded aluminum. A 5/16-inch-diameter (7.94 mm) stainless steel bolt is used with each mid clamp to fasten the top component of the clamp to the bottom component.

3.2.6 Beam End Stop: The beam end stop, shown in Figure 1, is used to limit the movement of the PV module along the beam length. The beam end stop is made from either 6005A-T61, 6351-T5, or 6061-T6 extruded aluminum. Each beam end stop is attached to the top flange of the beam by using two 1/4-inch-diameter (6.35 mm) stainless steel self-drilling screws.

3.2.7 Bolts and nuts: Stainless steel nuts and bolts used with the end and mid clamps are 5/16-inch diameter 300 series stainless steel with a minimum tensile strength of 85 ksi (586 MPa), and have serrations on the underside of the bolt head and on the face of the nuts to provide resistance to loosening.

3.2.8 Self-tapping Screws: Self-tapping screws are $\frac{1}{4}$ -inch (6.35 mm), 20-thread-per-inch, austenitic stainless steel screws, and have minimum ultimate tensile and shear strengths of 4124 pounds and 2860 pounds (18.3 and 12.7 kN), respectively.

4.0 DESIGN AND INSTALLATION

4.1 Design:

The attachment of the flush mount modular framing system to the supporting roof structure must be designed in accordance with the applicable code to resist the applied forces. The design of the flush mount modular framing system may be based on one of the design methods shown in Sections 4.1.1 and 4.1.2, below, both of which are based on Allowable Stress Design. Regardless of which method is selected, the installation conditions shown in Figure 1 must be followed.

4.1.1 Design Method 1, Analytical: Allowable load capacity for connectors and beam section properties are provided in Tables 2 and 3. Allowable load capacities shown in Table 2 are based on a PV module with an aluminum frame, as described in Section 2.0 of this report, being installed with the components described in Table 2. The design forces determined in accordance with the applicable code must not exceed the allowable load capacities of the connectors and beam. The section properties indicated in Table 3 of this report must be used in the design of the beam in accordance with the 2005 Aluminum Design Manual (ADM). Design of the beam must consider axial forces, which in turn are caused by loads acting parallel to the beam and bending forces, which are caused by loads acting perpendicular to the beam. The allowable axial load must be determined using Section 3.4.7 of the ADM. Unbraced length of the beam must be considered as the spacing between points of attachment. Consideration must be given to both X-axis and Y-axis buckling of the beam due to axial forces. Design of the beam must also consider bending forces applied to the beam in both the X-axis direction (loads perpendicular to the surface of the PV module) and Y-axis direction (loads parallel to the surface of the PV module). Allowable bending stresses must be determined using Section 3.4.14 of the ADM. Unbraced length of the beam must be considered as the spacing between the attachment points. Shear stresses in the beam due to forces applied to the beam in both the X-axis (loads perpendicular to the surface of the PV module) and Y-axis (loads parallel to the surface of the PV module) directions must be considered. The allowable shear stress is 12 ksi (82.7 MPa). Consideration must also be given to torsional forces caused by loads parallel to the surface of the PV module and perpendicular to the beam. The maximum load applied to the beam must not exceed the web crippling reactions shown in Table 3. Combined stresses must be considered in the determination of the beam capacity in accordance with Section 4 of the ADM. Applied loads must be determined in accordance with the applicable code and the ICC-ES Acceptance Criteria for Modular Framing Systems Used to Support Photovoltaic (PV) Modules (AC428). Where code applied design loads are modified and/or clarified by AC428, the more stringent design load must be used. Applied loads must be considered as loads acting parallel to the surface of the PV modules and perpendicular to the surface of the PV modules.

4.1.2 Design Method 2, Prescriptive: Allowable spacing of flange attachments, retainer spacing and reaction loads at attachment points for use in designing the roof and connection of the system to the roof are provided in Tables 4 through 16, subject to the conditions listed in this section.

For alternate installation conditions, the allowable spacing shown in Tables 4 through 15 may be adjusted in accordance with the provisions shown in Table 17 of this report.

The allowable spacings shown in Tables 4 to 16 are based on the following conditions:

1. The building has either a monoslope roof with a slope less than 3 degrees, a gable roof with a slope less than or equal to 45 degrees, or a hip roof with a slope less than or equal to 27 degrees.
2. The roof has a minimum slope of 1.2 degrees.
3. Installations are limited to site conditions where the topographic factor, K_{zt} , is equal to one.
4. Values in Tables 4 through 16 are for installations in Wind Exposure Category B or C.
5. Values in Tables 4 through 16 are valid for building heights less than or equal to 30 feet (9.1 m).
6. Values in Tables 4 through 16 are for a PV module array located in roof zone 1, as indicated in Figures 11-B through 11-D of ASCE 7-05.
7. The maximum allowable cantilever of the beam is 40 percent of the adjacent span of the beam flange attachment spacings shown in Tables 4 through 16.
8. Values in the tables are for roof installations only with PV modules parallel to and less than 10 inches above the roof surface.
9. In regions with ground snow loads less than 20 psf but not zero, the roof angle in degrees must be greater than the horizontal distance from eave to ridge in feet divided by 50 (horizontal distance from eave to ridge in meters divided by 15.2).
10. System dead load, including PV modules and mounting hardware, must be between 1.6 and 6.2 psf (7.8 and 30.3 kg/m²).
11. Importance factors are equal to 1.0 in Tables 4 through 16.
12. The values shown in Tables 4 through 17 are based on uniform loading conditions. Unbalanced, drifting, and sliding snow load conditions have not been considered.
13. Installations must be in seismic site class A, B, C, or D, as defined in ASCE 7-05.
14. Spectral response acceleration, S_s , is less than or equal to 1.2 in Tables 4 through 16.
15. Reaction forces shown in Tables 4 through 16 may be reduced linearly if the installed distance between attachments is less than the distance between attachments shown in the Tables 4 through 15. For example, if the spacing is half the amount shown in the tables, then the reaction force may also be reduced by half.
16. The force on the retainer is 160 pounds (711 N) at the maximum retainer spacing specified in Table 16. The force on the retainer may be reduced linearly if the distance between attachments is less than shown in Tables 4 through 15. For example, if the distance between attachments is half the value shown in the tables, then the force on the retainer will be 80 pounds (356 N).
17. The longest continuous run of spliced beams is 20 feet (6.1 m). A beam positive stop must be installed at the lowest end of any run of beams installed perpendicular to the roof ridgeline.

18. The maximum width of the PV module, which is the PV module dimension parallel to the beam, must be equal to or less than the module length along beam shown in Table 16.
19. Adjustment factors provided in Table 17 must be applied to the allowable spacing values shown in Tables 4 through 15. Adjustment factors for a specific condition must not be combined with an adjustment factor for another condition. The most conservative adjustment factor must be considered when multiple conditions exist.

4.2 Installation:

Installation procedures must be in accordance with Unirac published installation instructions and as noted in Figure 1 and applicable provisions shown in Section 5.0 of this report. Locations must be in accordance with the approved plans and specifications.

4.3 Special Inspection:

Periodic special inspections as indicated in Item 2 of IBC Section 1707.7 must be required during installation of mid clamps and end-clamps in Seismic Design Categories E and F. The role of the special inspector is to verify that the connectors and connecting material and installation are in accordance with this evaluation report and Unirac's published installation instructions.

5.0 CONDITIONS OF USE

The Unirac SolarMount™ (E)volution Flush Mount Modular Framing Systems described in this report comply with, or are suitable alternatives to what is specified in, those codes listed in Section 1.0 of this report, subject to the following conditions:

- 5.1 The methods of securing the modular framing system to the roof structure must be designed by a registered design professional where required by the statutes of the local jurisdiction.
- 5.2 The capacity of the PV module to resist the structural loads cited in this report must be demonstrated to the satisfaction of the code official. The PV module must be compatible for support and restraint with the flush mount modular framing system.
- 5.3 Modular framing systems subject to vibratory loading are outside the scope of this report.
- 5.4 Electrical safety, grounding provisions and grounding continuity are outside the scope of this report.
- 5.5 Roof penetrations must be flashed in accordance with accepted flashing practices to the satisfaction of the code official.

- 5.6 The location of the PV modules and support framing on a roof must be established by the local jurisdiction, based on consideration of access by fire personnel, roof vents, and other roof features.
- 5.7 The roof live load must be determined by the local jurisdiction.
- 5.8 The framing system must be installed in accordance with the installation instructions of the PV module manufacturer, Unirac's published installation instructions and as described in this report. A copy of the applicable installation instructions must be available for review at the jobsite. Where a conflict between this report and the installation instructions occurs, the more restrictive governs.
- 5.9 For the analytical design approach described in Section 4.1.1 of this report, the design forces calculated in accordance with the code must not exceed the allowable connector capacities shown in Table 2 and the allowable beam capacity calculated in accordance with the provisions of Section 4.1.1 and Table 3.
- 5.10 For the prescriptive design approach described in Section 4.1.2, the design assumptions shown in Section 4.1.2 must be considered for prescriptive installation of the modular framing system, as shown in Tables 4 through 17.
- 5.11 The distance between the bottom of the PV module and the roof must be between 2 and 10 inches (51 and 254 mm).
- 5.12 A registered design professional must verify that the structure supporting the PV array will adequately support the anticipated applied loads.
- 5.13 Special inspections must be conducted in accordance with Section 4.3.

6.0 EVIDENCE SUBMITTED

Data in accordance with the ICC-ES Acceptance Criteria for Modular Framing Systems Used to Support Photovoltaic (PV) Modules (AC428) dated November 2010.

7.0 IDENTIFICATION

The beams and connector components are identified on the packaging by a label with the manufacturer's name (Unirac), the words "SolarMount (E)volution" and the evaluation report number (ICC-ES ESR-3083). The clamps have the name "Unirac" embossed in a location visible after installation.

Table 1: Bolt lengths for mid and end clamps

Bolt Length (inches)	Module Height Range (Inches)
1.25	0.95 TO 1.60
1.75	1.45 TO 2.00

For St: 1 pound = 4.48 New tons
 1 inch = 25.4 millimeters
 1 psf = 0.0478 kiloPascals
 1 mph = 1.61 kilometers/hr

Table 2: Allowable loads for components (Allowable Stress Design, ASD)

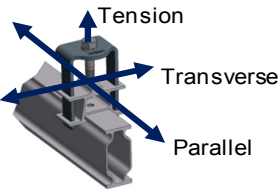
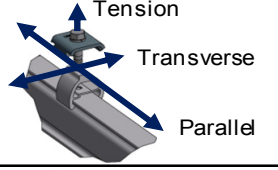
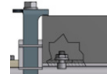
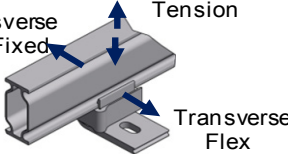
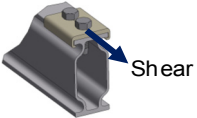
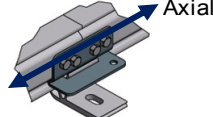
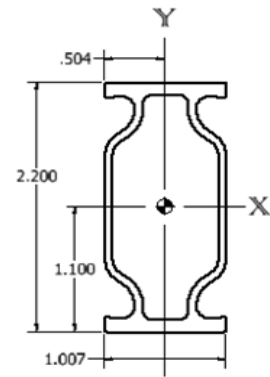
Component	Load Direction	Allowable Load (pounds)	
End Clamp to beam	Tension	958	
	Transverse to beam (as friction clip)	315	
	Parallel to beam	204	
Note - Forces applied to the clamps shall be orthogonal to the beam			
Mid Clamp to beam	Tension	1061	
	Transverse to beam (as friction clip)	636	
	Parallel to beam	244	
Note - Forces applied to the clamps shall be orthogonal to the beam			
Module Positive Stop (2 per module)	Transverse to beam	711	
Beam to flange attachment	Tension	744	
	Compression	1183	
	Transverse, fixed side	243	
	Transverse, flex side	134	
Beam end stop	Shear	1071	
Retainer	Axial to beam	429	

Table 3: Beam section properties

Properties	Units	Value
Gross area	in ²	0.537
Section Modulus, X-axis	in ³	0.3359
Section Modulus, Y-axis	in ³	0.1309
Moment of inertia, X-axis	in ⁴	0.3695
Moment of inertia, Y-axis	in ⁴	0.0659
Radius of gyration, X-axis	in	0.8295
Radius of gyration, Y-axis	in	0.3504
Torsional Constant (J)	in ⁴	0.113
Minimum thickness of element (tb)	in	0.062
Mean Area of inner and outer boundaries (A _m)	in ²	1.53
Allowable Web Crippling Reaction X-Axis (R _{wcx})	lbs	1592
Allowable Web Crippling Reaction Y-Axis (R _{wcy})	lbs	3541



Notes - Local buckling of Flanges and webs does not control flexural design of beam.

- Reactions to the beam are limited to those shown in Table 2 above.

Notes for tables 4 through 15:

1. The top row of each cell contains the maximum distance between flange attachments (inches)
2. The bottom row of each cell contains reaction forces on the attachment:
 up force perpendicular to the module (pounds)/ down force perpendicular to the module (pounds).
3. Beam positive stops are required for installations with the beam perpendicular to the roof ridgeline.
4. Module positive stops are required for installations with the beam parallel to the roof ridgeline.
5. The reaction forces up/down are used to design the connection between the attachment and supporting structure.

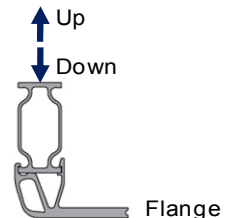


Table 4: Allowable distance between attachments, reaction loads (up/down) 85 mph wind speed, exposure category B

Module Length ± Beam (in)	Ground Snow Load in psf (or Roof Live Load, whichever is greater)									
	0	5	10	15	20	25	30	40	50	60
32	109	105	100	95	89	88	84	73	67	63
	124/247	121/259	118/295	111/329	105/361	104/367	100/393	91/436	85/490	80/542
44	97	93	87	81	76	75	71	63	59	55
	154/305	147/320	139/365	131/407	124/446	123/454	119/486	106/525	99/591	94/652
65	79	76	71	66	62	61	58	53	46	39
	192/391	188/410	177/468	168/522	160/572	159/582	153/622	132/657	123/738	115/812
67	78	75	70	65	61	60	57	52	44	38
	195/397	191/416	180/475	170/530	162/581	161/591	155/631	135/669	125/751	117/826
68	78	75	70	65	60	60	57	52	44	37
	196/399	192/419	181/478	172/533	164/585	162/595	156/635	136/674	126/757	118/832
72	76	73	68	63	59	58	55	49	41	Special Eng.
	202/413	198/434	187/494	177/550	168/603	167/614	161/655	140/697	130/781	Required
78	73	70	66	61	57	56	53	45	Special Eng.	Special Eng.
	209/430	205/451	194/514	183/573	175/629	173/640	167/684	146/729	Required	Required
85	70	68	63	59	55	54	51	Special Eng.	Special Eng.	Special Eng.
	219/449	215/471	202/540	192/603	183/661	182/673	175/719	Required	Required	Required

Table 5: Allowable distance between attachments, reaction loads (up/down) 90 mph wind speed, exposure category B

Module Length ± Beam (in)	Ground Snow Load in psf (or Roof Live Load, whichever is greater)									
	0	5	10	15	20	25	30	40	50	60
32	107	104	100	94	88	87	83	73	67	63
	138/250	135/259	132/295	125/329	118/361	117/367	113/393	102/436	95/490	90/542
44	95	92	87	80	75	74	71	63	59	55
	171/310	165/320	155/365	147/407	140/446	139/454	134/486	119/525	112/591	106/652
65	78	75	71	66	61	61	58	53	46	39
	217/391	213/410	201/468	190/522	181/572	180/582	173/622	150/657	139/738	130/812
67	77	74	70	65	60	60	57	52	44	38
	220/397	216/416	204/475	193/530	184/581	182/591	176/631	153/669	141/751	132/826
68	76	73	69	64	60	59	56	52	44	37
	222/399	218/419	205/478	195/533	185/585	184/595	177/635	154/674	143/757	134/832
72	74	72	67	62	58	58	55	49	41	Special Eng.
	229/413	224/434	211/494	200/550	191/603	189/614	182/655	159/697	147/781	Required
78	72	69	65	60	56	56	53	45	Special Eng.	Special Eng.
	237/430	232/451	219/514	208/573	198/629	196/640	190/684	165/729	Required	Required
85	69	67	63	58	54	54	51	Special Eng.	Special Eng.	Special Eng.
	248/449	243/471	229/540	218/603	208/661	206/673	199/719	Required	Required	Required

Table 6: Allowable distance between attachments, reaction loads (up/down) 100 mph wind speed, exposure category B

Module Length ± Beam (in)	Ground Snow Load in psf (or Roof Live Load, whichever is greater)									
	0	5	10	15	20	25	30	40	50	60
32	103	100	98	93	87	86	82	72	67	63
	171/276	167/276	159/295	153/329	145/361	144/367	138/393	126/436	118/490	111/542
44	92	89	85	79	74	73	70	62	58	55
	213/341	208/334	195/365	185/407	176/446	175/454	169/486	150/525	139/591	131/652
65	75	73	69	64	60	60	57	52	46	39
	273/420	267/410	252/468	239/522	227/572	226/582	217/622	188/657	174/738	163/812
67	74	72	68	63	59	59	56	51	44	38
	277/426	271/416	256/475	242/530	231/581	229/591	221/631	192/669	178/751	166/826
68	74	71	68	63	59	58	56	51	44	37
	279/429	273/419	258/478	244/533	233/585	231/595	222/635	193/674	179/757	168/832
72	72	69	66	61	57	57	54	49	41	Special Eng.
	287/441	281/434	265/494	251/550	239/603	237/614	229/655	199/697	184/781	Required
78	69	67	64	59	56	55	52	45	Special Eng.	Special Eng.
	298/459	291/451	275/514	261/573	249/629	246/640	238/684	208/729	Required	Required
85	67	65	61	57	53	53	50	Special Eng.	Special Eng.	Special Eng.
	311/479	305/471	288/540	273/603	261/661	258/673	249/719	Required	Required	Required

Table 7: Allowable distance between attachments, reaction loads (up/down) 110 mph wind speed, exposure category B

Module Length ± Beam (in)	Ground Snow Load in psf (or Roof Live Load, whichever is greater)									
	0	5	10	15	20	25	30	40	50	60
32	99	97	95	91	85	84	81	71	66	62
	210/303	205/303	192/305	182/329	174/361	172/367	167/393	152/436	142/490	134/542
44	89	86	82	77	73	72	69	61	57	54
	261/375	255/370	239/365	226/407	216/446	214/454	207/486	183/525	171/591	160/652
65	72	70	67	63	59	59	56	52	46	39
	327/464	327/448	309/468	292/522	279/572	276/582	266/622	231/657	214/738	200/812
67	71	69	66	62	58	58	55	51	44	38
	332/471	332/455	313/475	297/530	283/581	280/591	270/631	235/669	217/751	204/826
68	71	69	66	62	58	57	55	50	44	37
	334/474	334/458	316/478	299/533	285/585	282/595	272/635	237/674	219/757	205/832
72	69	67	64	60	56	56	53	49	41	Special Eng.
	344/488	344/472	325/494	308/550	293/603	291/614	280/655	244/697	226/781	Required
78	67	65	62	58	55	54	51	45	Special Eng.	Special Eng.
	357/507	357/494	337/514	319/573	304/629	302/640	291/684	254/729	Required	Required
85	64	62	60	56	52	52	49	Special Eng.	Special Eng.	Special Eng.
	374/529	373/517	352/540	334/603	319/661	316/673	305/719	Required	Required	Required

key: M maximum distance between flange attachments, beam span (inch)
 Reaction forces up/down (pounds)

Table 8: Allowable distance between attachments, reaction loads (up/down) 120 mph wind speed, exposure category B

Module Length ± Beam (in)	Ground Snow Load in psf (or Roof Live Load, whichever is greater)									
	0	5	10	15	20	25	30	40	50	60
32	94	94	93	89	84	83	79	70	65	62
	253/331	247/331	231/329	219/343	209/365	207/372	200/397	183/436	169/490	159/542
44	85	83	79	75	71	70	67	60	57	53
	306/409	306/408	287/391	272/413	260/452	258/459	249/491	220/525	205/591	192/652
65	70	68	65	62	58	58	55	51	46	39
	372/509	372/493	371/479	351/522	335/572	332/582	320/622	277/657	257/738	240/812
67	69	67	64	61	57	57	54	50	44	38
	377/517	377/500	376/486	357/531	340/581	337/591	325/631	282/669	261/751	245/826
68	68	66	63	60	57	56	54	50	44	37
	380/521	380/504	379/490	359/534	342/585	339/595	327/635	284/674	263/757	246/832
72	67	65	62	59	55	55	52	48	41	Special Eng. Required
	392/535	392/520	390/504	370/551	352/603	349/614	336/655	293/697	271/781	Special Eng. Required
78	64	62	60	57	53	53	51	45	Special Eng. Required	Special Eng. Required
	406/557	406/543	404/522	383/576	366/629	362/640	350/684	305/729	Special Eng. Required	Special Eng. Required
85	62	60	58	55	51	51	49	Special Eng. Required	Special Eng. Required	Special Eng. Required
	425/581	425/569	423/545	401/603	383/661	379/673	366/719	Required	Required	Required

Table 9: Allowable distance between attachments, reaction loads (up/down) 150 mph wind speed, exposure category B

Module Length ± Beam (in)	Ground Snow Load in psf (or Roof Live Load, whichever is greater)									
	0	5	10	15	20	25	30	40	50	60
32	84	84	84	82	79	78	75	67	63	59
	354/422	354/422	354/422	348/416	333/423	330/424	319/433	292/469	270/503	254/542
44	75	74	72	69	67	66	64	58	54	52
	417/522	417/522	417/506	416/488	412/498	409/505	395/535	351/562	326/604	306/652
65	62	61	59	57	55	54	52	48	46	39
	507/651	507/635	507/612	506/590	505/621	505/628	504/656	440/693	408/740	382/812
67	61	60	58	56	54	53	51	48	44	38
	514/661	514/645	514/620	513/599	513/630	513/637	512/666	448/704	415/751	389/826
68	61	59	57	55	53	53	51	47	44	37
	518/666	518/649	518/625	517/603	516/635	516/642	516/671	452/709	418/757	392/832
72	59	58	56	54	52	52	50	46	41	Special Eng. Required
	534/684	534/669	534/644	533/621	532/653	532/661	530/691	465/729	431/781	Special Eng. Required
78	57	56	54	52	50	50	48	45	Special Eng. Required	Special Eng. Required
	554/712	554/698	554/672	553/647	552/682	552/689	552/720	485/758	Required	Required
85	55	54	52	50	48	48	46	Special Eng. Required	Special Eng. Required	Special Eng. Required
	579/743	579/731	579/703	579/677	579/713	579/721	579/754	Required	Required	Required

Table 10: Allowable distance between attachments, reaction loads (up/down) 85 mph wind speed, exposure category C

Module Length ± Beam (in)	Ground Snow Load in psf (or Roof Live Load, whichever is greater)									
	0	5	10	15	20	25	30	40	50	60
32	103	100	97	92	87	86	82	72	67	63
	173/278	169/278	161/295	154/329	147/361	145/367	140/393	127/436	119/490	112/542
44	92	89	84	79	74	73	70	62	58	55
	216/343	211/336	197/365	187/407	178/446	177/454	171/486	151/525	141/591	132/652
65	75	73	69	64	60	60	57	52	46	39
	276/423	270/410	255/468	242/522	230/572	228/582	220/622	191/657	177/738	165/812
67	74	71	68	63	59	59	56	51	44	38
	280/429	274/416	259/475	245/530	234/581	232/591	223/631	194/669	180/751	168/826
68	73	71	67	63	59	58	56	51	44	37
	282/432	276/419	261/478	247/533	235/585	233/595	225/635	196/674	181/757	170/832
72	72	69	66	61	57	57	54	49	41	Special Eng. Required
	291/444	285/434	269/494	254/550	242/603	240/614	231/655	202/697	187/781	Special Eng. Required
78	69	67	64	59	55	55	52	45	Special Eng. Required	Special Eng. Required
	301/462	295/451	278/514	264/573	252/629	249/640	241/684	210/729	Required	Required
85	66	65	61	57	53	53	50	Special Eng. Required	Special Eng. Required	Special Eng. Required
	315/482	309/471	291/540	276/603	264/661	261/673	252/719	Required	Required	Required

Table 11: Allowable distance between attachments, reaction loads (up/down) 90 mph wind speed, exposure category C

Module Length ± Beam (in)	Ground Snow Load in psf (or Roof Live Load, whichever is greater)									
	0	5	10	15	20	25	30	40	50	60
32	100	99	96	91	86	85	81	72	66	62
	196/293	191/293	179/297	171/329	164/361	162/367	156/393	142/436	133/490	126/542
44	90	87	83	78	73	72	69	62	58	54
	244/363	238/357	223/365	211/407	202/446	200/454	193/486	171/525	159/591	149/652
65	73	71	68	64	60	59	56	52	46	39
	311/449	305/432	288/468	273/522	260/572	258/582	249/622	215/657	200/738	187/812
67	72	70	67	63	59	58	55	51	44	38
	316/455	310/439	293/475	277/530	264/581	262/591	252/631	219/669	203/751	190/826
68	72	69	66	62	58	58	55	51	44	37
	318/458	312/442	295/478	279/533	266/585	264/595	254/635	221/674	205/757	192/832
72	70	68	65	60	57	56	54	49	41	Special Eng. Required
	328/471	321/456	303/494	287/550	274/603	271/614	261/655	228/697	211/781	Special Eng. Required
78	68	66	62	58	55	54	52	45	Special Eng. Required	Special Eng. Required
	340/490	333/476	314/514	298/573	284/629	282/640	272/684	237/729	Required	Required
85	65	63	60	56	53	52	50	Special Eng. Required	Special Eng. Required	Special Eng. Required
	356/512	349/500	329/540	312/603	298/661	295/673	285/719	Required	Required	Required

key: M maximum distance between flange attachments, beam span (inch)
 Reaction forces up/down (pounds)

Table 12: Allowable distance between attachments, reaction loads (up/down) 100 mph wind speed, exposure category C

Module Length ± Beam (in)	Ground Snow Load in psf (or Roof Live Load, whichever is greater)									
	0	5	10	15	20	25	30	40	50	60
32	95	95	94	89	84	83	80	71	66	62
	245/326	240/326	225/325	213/339	203/363	201/370	195/395	178/436	164/490	155/542
44	86	83	80	76	71	71	68	61	57	54
	300/404	298/401	279/386	264/410	252/449	250/457	242/488	214/525	199/591	187/652
65	70	68	65	62	58	58	55	51	46	39
	364/502	364/486	360/476	341/522	325/572	322/582	310/622	269/657	249/738	233/812
67	69	67	64	61	57	57	54	50	44	38
	370/509	370/493	365/483	346/530	330/581	327/591	315/631	274/669	254/751	237/826
68	69	67	64	60	57	56	54	50	44	37
	372/513	372/496	368/486	349/533	332/585	329/595	317/635	276/674	256/757	239/832
72	67	65	62	59	56	55	53	49	41	Special Eng.
	384/527	384/511	379/501	359/550	342/603	339/614	326/655	284/697	263/781	Required
78	65	63	60	57	54	53	51	45	Special Eng.	Special Eng.
	398/549	398/535	393/519	372/573	355/629	352/640	340/684	296/729	Required	Required
85	62	61	58	55	52	51	49	Special Eng.	Special Eng.	Special Eng.
	417/572	417/560	411/540	390/603	372/661	368/673	356/719	Required	Required	Required

Table 13: Allowable distance between attachments, reaction loads (up/down) 110 mph wind speed, exposure category C

Module Length ± Beam (in)	Ground Snow Load in psf (or Roof Live Load, whichever is greater)									
	0	5	10	15	20	25	30	40	50	60
32	90	90	90	87	82	81	78	69	65	61
	291/361	291/361	274/361	260/367	248/377	246/383	238/408	217/445	201/490	189/542
44	81	80	77	74	70	69	66	59	56	53
	343/446	343/446	341/428	323/430	308/467	305/474	295/505	261/534	243/591	228/652
65	67	65	63	60	57	56	54	50	46	39
	417/557	417/540	417/517	416/542	396/581	393/589	379/622	328/658	304/738	285/812
67	66	64	62	59	56	56	53	49	44	38
	424/565	424/548	424/525	422/551	402/590	399/597	384/631	334/669	309/751	290/826
68	66	64	61	59	56	55	53	49	44	37
	427/569	427/552	427/528	425/555	405/594	402/602	387/635	337/674	312/757	292/832
72	64	62	60	57	54	54	51	48	41	Special Eng.
	440/585	440/569	440/544	438/572	417/612	413/620	398/655	347/697	321/781	Required
78	62	60	58	55	52	52	50	45	Special Eng.	Special Eng.
	456/609	456/595	456/568	454/597	433/639	429/647	414/684	362/729	Required	Required
85	59	58	56	53	50	50	48	Special Eng.	Special Eng.	Special Eng.
	477/635	477/623	477/595	476/626	454/669	449/678	434/719	Required	Required	Required

Table 14: Allowable distance between attachments, reaction loads (up/down) 120 mph wind speed, exposure category C

Module Length ± Beam (in)	Ground Snow Load in psf (or Roof Live Load, whichever is greater)									
	0	5	10	15	20	25	30	40	50	60
32	86	86	86	84	80	79	76	68	64	60
	329/397	329/397	329/397	312/395	298/403	295/405	285/423	260/459	241/494	227/542
44	78	76	74	71	68	67	65	58	55	52
	387/491	387/491	387/474	386/463	369/485	366/492	354/523	313/550	291/593	273/652
65	64	63	60	58	56	55	53	49	46	39
	471/613	471/597	471/573	470/567	469/605	469/612	454/641	393/678	364/738	341/812
67	63	62	59	57	55	54	52	48	44	38
	478/622	478/605	478/581	477/576	476/613	476/621	461/650	400/689	371/751	347/826
68	63	61	59	57	54	54	52	48	44	37
	481/626	481/610	481/585	480/580	479/618	479/625	464/655	403/694	374/757	350/832
72	61	60	57	55	53	52	50	47	41	Special Eng.
	496/644	496/628	496/603	495/598	494/636	494/644	477/674	416/714	385/781	Required
78	59	58	56	54	51	51	49	45	Special Eng.	Special Eng.
	514/670	514/656	514/629	513/624	513/664	513/672	496/704	433/742	Required	Required
85	57	56	54	52	49	49	47	Special Eng.	Special Eng.	Special Eng.
	538/699	538/687	538/659	538/653	538/695	538/703	520/736	Required	Required	Required

Table 15: Allowable distance between attachments, reaction loads (up/down) 150 mph wind speed, exposure category C

Module Length ± Beam (in)	Ground Snow Load in psf (or Roof Live Load, whichever is greater)									
	0	5	10	15	20	25	30	40	50	60
32	76	76	76	75	73	73	71	64	60	57
	441/513	441/513	441/513	440/511	440/498	440/495	437/498	392/506	381/538	359/570
44	68	67	66	64	62	62	60	55	52	50
	519/635	519/634	519/617	518/600	518/583	518/580	517/584	470/606	460/645	433/679
65	56	55	54	52	51	51	49	46	44	39
	630/786	630/771	630/747	629/725	629/705	629/701	628/714	588/746	575/790	540/832
67	56	54	53	51	50	50	49	46	43	38
	639/798	639/782	639/758	639/736	638/715	638/711	637/725	598/758	585/803	549/845
68	55	54	52	51	50	49	48	45	43	37
	644/804	644/788	644/763	643/741	643/720	643/716	642/730	603/764	589/809	553/851
72	54	53	51	50	48	48	47	44	41	Special Eng.
	664/826	664/811	664/786	663/762	662/741	662/737	660/751	622/785	607/831	Required
78	52	51	49	48	47	46	45	42	Special Eng.	Special Eng.
	689/860	689/846	689/819	688/795	687/772	687/768	687/783	649/815	Required	Required
85	50	49	48	46	45	45	44	Special Eng.	Special Eng.	Special Eng.
	720/897	720/886	720/857	720/831	720/807	720/803	720/818	Required	Required	Required

key: M maximum distance between flange attachments, beam span (inch)
 Reaction forces up/down (pounds)

Table 16: Limits for module length along beam, run of beams parallel to roof slope, and distance between retainers

Module Length ⊥ Beam (in)	Ground Snow Load in psf (or Roof Live Load, whichever is greater)									
	0	5	10	15	20	25	30	40	50	60
32	85/240	85/240	85/240	85/240	85/240	85/240	85/240	85/240	85/240	85/240
	240/240	240/240	240/189	240/165	240/131	240/127	240/112	240/91	220/76	197/66
	75/43	88/42	110/40	126/38	140/36	143/36	154/34	170/64	187/67	203/70
44	85/240	85/240	85/240	85/240	85/240	85/240	85/240	85/240	84/240	73/240
	240/214	240/174	240/138	240/113	240/95	240/92	240/81	181/66	160/55	143/48
	91/53	107/52	129/48	147/46	164/43	167/43	180/42	197/77	219/81	239/84
65	85/240	85/240	85/240	85/240	85/240	85/240	84/240	68/240	57/240	49/216
	240/145	240/118	240/93	240/76	240/64	240/62	240/55	122/45	108/37	97/32
	110/68	129/66	156/62	178/58	198/56	202/55	217/53	243/96	243/100	243/105
67	85/240	85/240	85/240	85/240	85/240	85/240	82/240	66/240	55/240	48/210
	240/140	240/114	240/90	240/74	240/62	240/61	240/54	119/43	105/36	94/31
	111/69	131/67	158/63	180/59	200/57	204/56	220/54	243/98	243/102	243/107
68	85/240	85/240	85/240	85/240	85/240	85/240	80/240	65/240	55/240	47/207
	240/138	240/113	240/89	240/73	240/62	240/60	240/53	177/43	103/36	93/31
	112/69	132/68	159/63	181/60	202/57	206/56	222/54	243/98	243/103	243/107
72	85/240	85/240	85/240	85/240	85/240	85/240	76/240	61/240	52/227	Special Eng. Required
	229/131	229/107	229/84	229/69	229/58	229/56	229/50	110/40	98/34	
	116/72	137/70	164/65	187/62	208/59	212/58	229/56	243/102	243/106	
78	85/240	85/240	85/240	85/240	82/240	79/240	70/240	57/240	Special Eng. Required	Special Eng. Required
	212/121	212/98	212/78	212/64	212/54	212/52	212/46	102/37		
	121/74	143/73	172/68	196/64	218/61	222/61	239/59	243/106		
85	85/240	85/240	85/240	85/240	75/240	73/240	64/240	Special Eng. Required	Special Eng. Required	Special Eng. Required
	194/111	194/90	194/71	194/58	194/49	194/48	194/42			
	127/78	150/76	181/71	206/67	228/64	233/64	243/62			

key: Module length along beam (in)/ Maximum continuous run of beam(s) (in)
 Maximum distance between retainers: beam parallel to ridge (in)/ beam perpendicular to ridge (in)
 Reaction on attachment leg opposite flange (lb)/ Reaction on attachment leg closest to flange (lb)
 Note: The maximum reaction force applied parallel to beam at attachments with retainers is 160 lbs.
 The reaction force applied parallel to beams at attachments without retainers is 0 lbs.

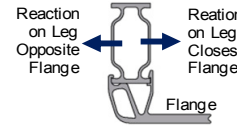


Table 17: Adjustment Factors to spans for tables 4 through 15 (note that factors are independent of Module Size)*

Basic Wind Speed (mph)	Ground Snow Load in psf (or Roof Live Load, whichever is greater)									
	0	5	10	15	20	25	30	40	50	60
85	-4.7%	-4.6%	-4.1%	-1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	-2.9%/-6.6%	-2.8%/-7.2%	-2.3%/-8%	-2.1%/-8.5%	-1.9%/-8.8%	-1.9%/-8.9%	-1.7%/-15%	-1.8%/-16.1%	-0.6%/-16.8%	0%/-17.3%
	0.8%/0.9%	1.8%/1.9%	0.3%/0%	0.1%/0%	1.6%/0%	1.9%/0%	3.5%/0%	7.6%/0%	8.8%/0%	9.6%/0%
90	-3.4%	-2.8%	-2.2%	-1.6%	-1.4%	-1.3%	-1.2%	-1.0%	-0.8%	-0.7%
	-6.1%	-6.0%	-5.6%	-3.0%	-0.7%	-0.2%	0.0%	0.0%	0.0%	0.0%
	-2.8%/-6.8	-2.7%/-7.4	-2.3%/-7.9	-2%/-8.5	-1.9%/-8.9	-1.8%/-8.9	-1.7%/-14.7	-1.8%/-16.1	-0.6%/-16.8	0%/-17.3
100	2.2%/2.4%	3.2%/3.4%	0.5%/0.2%	0.5%/0.4%	2.3%/0.7%	2.7%/0.7%	4.2%/0.6%	7.6%/0%	8.8%/0%	9.6%/0%
	-3.5%	-3.1%	-2.5%	-1.8%	-1.6%	-1.6%	-1.4%	-1.1%	-0.8%	-0.8%
	-8.6%	-8.5%	-8.4%	-6.1%	-3.7%	-3.3%	-1.6%	0.0%	0.0%	0.0%
110	-2.9%/-7	-2.5%/-7.6	-2.2%/-8	-2%/-8.7	-1.8%/-9	-1.8%/-9	-1.7%/-13.4	-1.8%/-16.1	-0.6%/-16.8	0%/-17.3
	5.8%/5.9%	6.3%/6.5%	2.6%/2.3%	2.5%/2.4%	4.1%/2.5%	4.5%/2.4%	5.8%/2.1%	9%/1.3%	9.3%/0.4%	9.6%/0%
	-4.6%	-3.6%	-3.1%	-2.1%	-1.9%	-1.8%	-1.7%	-1.4%	-1.2%	-1.0%
120	-11.0%	-10.6%	-10.2%	-8.9%	-6.5%	-6.1%	-4.3%	-1.4%	0.0%	0.0%
	-2.7%/-6.9	-2.4%/-7.9	-2.1%/-8.3	-1.9%/-8.8	-1.8%/-9	-1.8%/-9.1	-1.7%/-13.2	-1.7%/-16.1	-0.6%/-16.8	0%/-17.3
	9.8%/10.5%	9.6%/9.8%	4.8%/4.5%	4.7%/4.6%	6.1%/4.3%	6.4%/4.2%	7.5%/3.8%	10.4%/2.6%	10.5%/1.6%	10.7%/1%
150	-4.9%	-4.0%	-3.6%	-2.8%	-2.2%	-2.1%	-1.9%	-1.6%	-1.4%	-1.2%
	-14.8%	-13.1%	-11.8%	-10.8%	-9.0%	-8.6%	-6.9%	-3.9%	-1.5%	0.0%
	-2.2%/-7.1	-2.3%/-8.1	-2%/-8.4	-1.9%/-8.7	-1.7%/-9.1	-1.7%/-9.2	-1.6%/-13.1	-1.7%/-16.1	-0.6%/-16.8	0%/-17.3
150	8.2%/9.4%	10.9%/8.9%	7.4%/6.3%	7%/6.2%	8.2%/5.7%	8.4%/5.6%	9.4%/5%	11.9%/3.6%	11.8%/2.8%	11.9%/2.1%
	-5.0%	-5.0%	-4.0%	-3.2%	-2.5%	-2.4%	-2.2%	-1.9%	-1.6%	-1.4%
	-38.3%	-37.3%	-35.5%	-33.5%	-31.6%	-31.2%	-29.5%	-24.9%	-14.3%	-5.8%
150	-14%/-16.7	-19%/-15.5	-17%/-12.9	-17%/-10.3	-16%/-9.3	-16%/-9.3	-15%/-13	-16%/-16.1	-0.6%/-16.8	0%/-17.3
	4.6%/6.9%	6.7%/6.3%	9.7%/6.3%	12.5%/5.8%	14.4%/5.5%	14.7%/5.4%	15.5%/5.3%	16.9%/5.4%	16.4%/4.5%	16%/4.4%
	-10.4%	-9.1%	-6.4%	-4.7%	-3.9%	-3.7%	-3.4%	-2.6%	-2.3%	-2.0%

key: Zone 2
 Seismic Ss=15 / Importance factor 125
 Roof angle 1° to 7° Roof angle 8° to 27°
 60 foot Building Height

* Example: 67"x42" module, 90 mph basic wind
 Category C, 5 psf snow, Roof pitch 6/12 (27°).
 Max. beam span = 70" (from table 11) x (1+0.034) = 72"

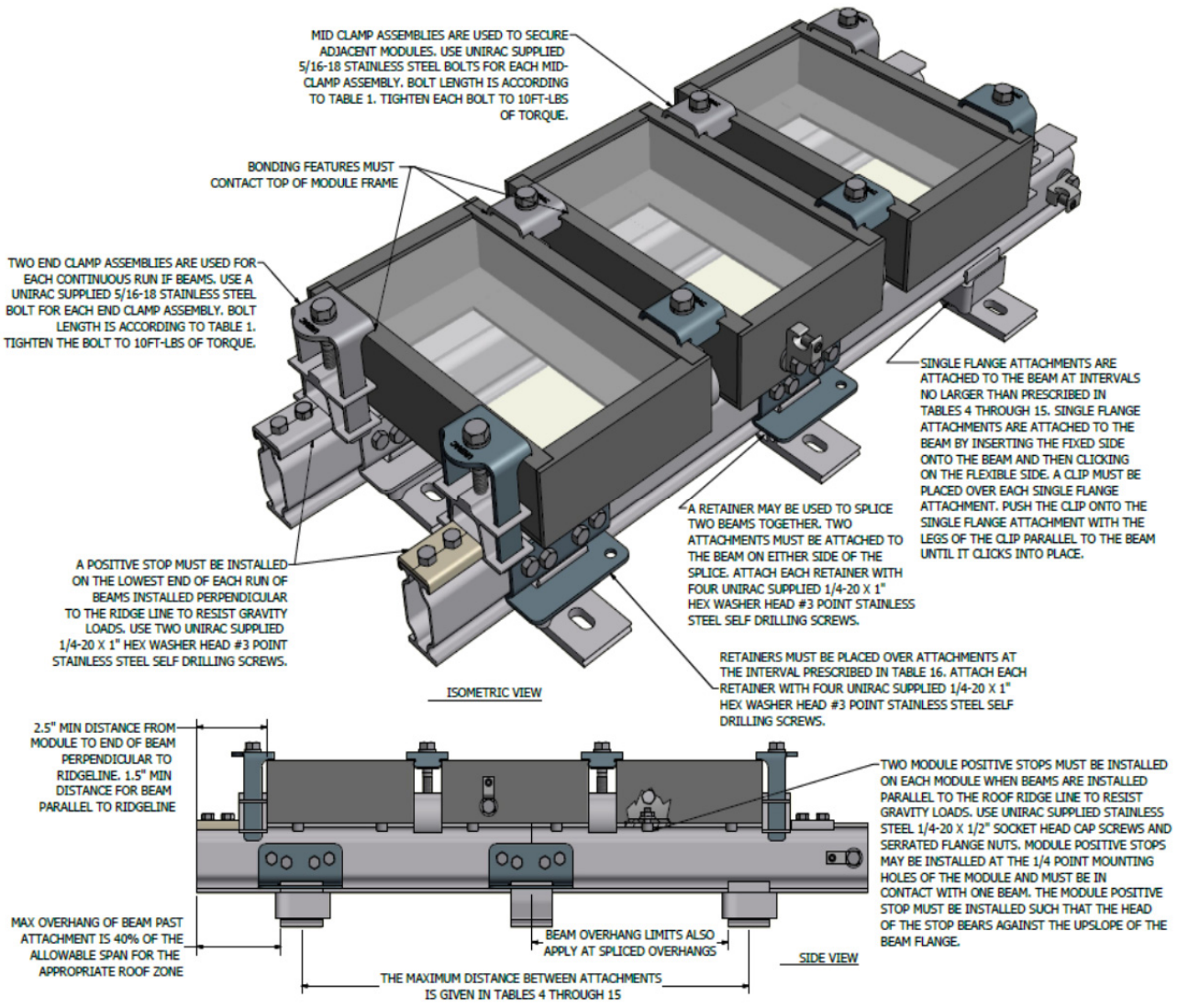


FIGURE 1