ICC-ES Evaluation Report

ESR-3083

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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 $^1/_4$-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/m^2).
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 SI:

1 pound = 4.48 Newtons
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)

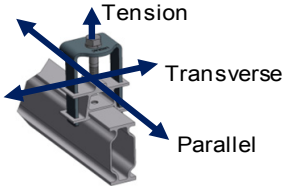
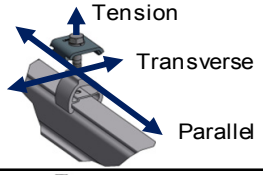
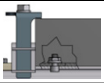
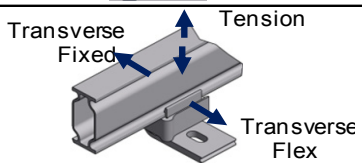
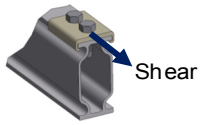
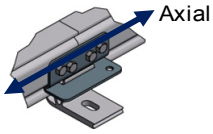
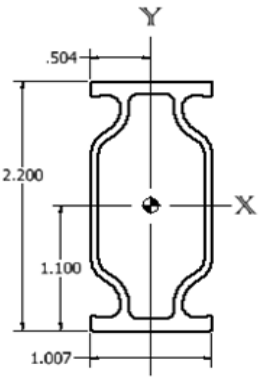
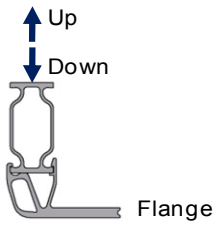
Component	Load Direction	Allowable Load (pounds)	
End Clamp to beam	Tension	958	
	Transverse to beam (as friction clip)	315	
	Parallel to beam	204	
Note - Forces appied to the clamps shall be orthogonal to the beam			
Mid Clamp to beam	Tension	1061	
	Transverse to beam (as friction clip)	636	
	Parallel to beam	244	
Note - Forces appied 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	109 124/247	105 121/259	100 118/295	95 111/329	89 105/361	88 104/367	84 100/393	73 91/436	67 85/490	63 80/542
44	97 154/305	93 147/320	87 139/365	81 131/407	76 124/446	75 123/454	71 119/486	63 106/525	59 99/591	55 94/652
65	79 192/391	76 188/410	71 177/468	66 168/522	62 160/572	61 159/582	58 153/622	53 132/657	46 123/738	39 115/812
67	78 195/397	75 191/416	70 180/475	65 170/530	61 162/581	60 161/591	57 155/631	52 135/669	44 125/751	38 117/826
68	78 196/399	75 192/419	70 181/478	65 172/533	60 164/585	60 162/595	57 156/635	52 136/674	44 126/757	37 118/832
72	76 202/413	73 198/434	68 187/494	63 177/550	59 168/603	58 167/614	55 161/655	49 140/697	41 130/781	Special Eng. Required
78	73 209/430	70 205/451	66 194/514	61 183/573	57 175/629	56 173/640	53 167/684	45 146/729	Special Eng. Required	Special Eng. Required
85	70 219/449	68 215/471	63 202/540	59 192/603	55 183/661	54 182/673	51 175/719	Special Eng. Required	Special Eng. Required	Special Eng. 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	107 138/250	104 135/259	100 132/295	94 125/329	88 118/361	87 117/367	83 113/393	73 102/436	67 95/490	63 90/542
44	95 171/310	92 165/320	87 155/365	80 147/407	75 140/446	74 139/454	71 134/486	63 119/525	59 112/591	55 106/652
65	78 217/391	75 213/410	71 201/468	66 190/522	61 181/572	61 180/582	58 173/622	53 150/657	46 139/738	39 130/812
67	77 220/397	74 216/416	70 204/475	65 193/530	60 184/581	60 182/591	57 176/631	52 153/669	44 141/751	38 132/826
68	76 222/399	73 218/419	69 205/478	64 195/533	60 185/585	59 184/595	56 177/635	52 154/674	44 143/757	37 134/832
72	74 229/413	72 224/434	67 211/494	62 200/550	58 191/603	58 189/614	55 182/655	49 159/697	41 147/781	Special Eng. Required
78	72 237/430	69 232/451	65 219/514	60 208/573	56 198/629	56 196/640	53 190/684	45 165/729	Special Eng. Required	Special Eng. Required
85	69 248/449	67 243/471	63 229/540	58 218/603	54 208/661	54 206/673	51 199/719	Special Eng. Required	Special Eng. Required	Special Eng. 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	103 171/276	100 167/276	98 159/295	93 153/329	87 145/361	86 144/367	82 138/393	72 126/436	67 118/490	63 111/542
44	92 213/341	89 208/334	85 195/365	79 185/407	74 176/446	73 175/454	70 169/486	62 150/525	58 139/591	55 131/652
65	75 273/420	73 267/410	69 252/468	64 239/522	60 227/572	60 226/582	57 217/622	52 188/657	46 174/738	39 163/812
67	74 277/426	72 271/416	68 256/475	63 242/530	59 231/581	59 229/591	56 221/631	51 192/669	44 178/751	38 166/826
68	74 279/429	71 273/419	68 258/478	63 244/533	59 233/585	58 231/595	56 222/635	51 193/674	44 179/757	37 168/832
72	72 287/441	69 281/434	66 265/494	61 251/550	57 239/603	57 237/614	54 229/655	49 199/697	41 184/781	Special Eng. Required
78	69 298/459	67 291/451	64 275/514	59 261/573	56 249/629	55 246/640	52 238/684	45 208/729	Special Eng. Required	Special Eng. Required
85	67 311/479	65 305/471	61 288/540	57 273/603	53 261/661	53 258/673	50 249/719	Special Eng. Required	Special Eng. Required	Special Eng. 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	99 210/303	97 205/303	95 192/305	91 182/329	85 174/361	84 172/367	81 167/393	71 152/436	66 142/490	62 134/542
44	89 261/375	86 255/370	82 239/365	77 226/407	73 216/446	72 214/454	69 207/486	61 183/525	57 171/591	54 160/652
65	72 327/464	70 327/448	67 309/468	63 292/522	59 279/572	59 276/582	56 266/622	52 231/657	46 214/738	39 200/812
67	71 332/471	69 332/455	66 313/475	62 297/530	58 283/581	58 280/591	55 270/631	51 235/669	44 217/751	38 204/826
68	71 334/474	69 334/458	66 316/478	62 299/533	58 285/585	57 282/595	55 272/635	50 237/674	44 219/757	37 205/832
72	69 344/488	67 344/472	64 325/494	60 308/550	56 293/603	56 291/614	53 280/655	49 244/697	41 226/781	Special Eng. Required
78	67 357/507	65 357/494	62 337/514	58 319/573	55 304/629	54 302/640	51 291/684	45 254/729	Special Eng. Required	Special Eng. Required
85	64 374/529	62 373/517	60 352/540	56 334/603	52 319/661	52 316/673	49 305/719	Special Eng. Required	Special Eng. Required	Special Eng. Required

key: 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	94 253/331	94 247/331	93 231/329	89 219/343	84 209/365	83 207/372	79 200/397	70 183/436	65 169/490	62 159/542
44	85 306/409	83 306/408	79 287/391	75 272/413	71 260/452	70 258/459	67 249/491	60 220/525	57 205/591	53 192/652
65	70 372/509	68 372/493	65 371/479	62 351/522	58 335/572	58 332/582	55 320/622	51 277/657	46 257/738	39 240/812
67	69 377/517	67 377/500	64 376/486	61 357/531	57 340/581	57 337/591	54 325/631	50 282/669	44 261/751	38 245/826
68	68 380/521	66 380/504	63 379/490	60 359/534	57 342/585	56 339/595	54 327/635	50 284/674	44 263/757	37 246/832
72	67 392/535	65 392/520	62 390/504	59 370/551	55 352/603	55 349/614	52 336/655	48 293/697	41 271/781	Special Eng. Required
78	64 406/557	62 406/543	60 404/522	57 383/576	53 366/629	53 362/640	51 350/684	45 305/729	Special Eng. Required	Special Eng. Required
85	62 425/581	60 425/569	58 423/545	55 401/603	51 383/661	51 379/673	49 366/719	Special Eng. Required	Special Eng. Required	Special Eng. 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	84 354/422	84 354/422	84 354/422	82 348/416	79 333/423	78 330/424	75 319/433	67 292/469	63 270/503	59 254/542
44	75 417/522	74 417/522	72 417/506	69 416/488	67 412/498	66 409/505	64 395/535	58 351/562	54 326/604	52 306/652
65	62 507/651	61 507/635	59 507/612	57 506/590	55 505/621	54 505/628	52 504/656	48 440/693	46 408/740	39 382/812
67	61 514/661	60 514/645	58 514/620	56 513/599	54 513/630	53 513/637	51 512/666	48 448/704	44 415/751	38 389/826
68	61 518/666	59 518/649	57 518/625	55 517/603	53 516/635	53 516/642	51 516/671	47 452/709	44 418/757	37 392/832
72	59 534/684	58 534/669	56 534/644	54 533/621	52 532/653	52 532/661	50 530/691	46 465/729	41 431/781	Special Eng. Required
78	57 554/712	56 554/698	54 554/672	52 553/647	50 552/682	50 552/689	48 552/720	45 485/758	Special Eng. Required	Special Eng. Required
85	55 579/743	54 579/731	52 579/703	50 579/677	48 579/713	48 579/721	46 579/754	Special Eng. Required	Special Eng. Required	Special Eng. 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	103 173/278	100 169/278	97 161/295	92 154/329	87 147/361	86 145/367	82 140/393	72 127/436	67 119/490	63 112/542
44	92 216/343	89 211/336	84 197/365	79 187/407	74 178/446	73 177/454	70 171/486	62 151/525	58 141/591	55 132/652
65	75 276/423	73 270/410	69 255/468	64 242/522	60 230/572	60 228/582	57 220/622	52 191/657	46 177/738	39 165/812
67	74 280/429	71 274/416	68 259/475	63 245/530	59 234/581	59 232/591	56 223/631	51 194/669	44 180/751	38 168/826
68	73 282/432	71 276/419	67 261/478	63 247/533	59 235/585	58 233/595	56 225/635	51 196/674	44 181/757	37 170/832
72	72 291/444	69 285/434	66 269/494	61 254/550	57 242/603	57 240/614	54 231/655	49 202/697	41 187/781	Special Eng. Required
78	69 301/462	67 295/451	64 278/514	59 264/573	55 252/629	55 249/640	52 241/684	45 210/729	Special Eng. Required	Special Eng. Required
85	66 315/482	65 309/471	61 291/540	57 276/603	53 264/661	53 261/673	50 252/719	Special Eng. Required	Special Eng. Required	Special Eng. 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	100 196/293	99 191/293	96 179/297	91 171/329	86 164/361	85 162/367	81 156/393	72 142/436	66 133/490	62 126/542
44	90 244/363	87 238/357	83 223/365	78 211/407	73 202/446	72 200/454	69 193/486	62 171/525	58 159/591	54 149/652
65	73 311/449	71 305/432	68 288/468	64 273/522	60 260/572	59 258/582	56 249/622	52 215/657	46 200/738	39 187/812
67	72 316/455	70 310/439	67 293/475	63 277/530	59 264/581	58 262/591	55 252/631	51 219/669	44 203/751	38 190/826
68	72 318/458	69 312/442	66 295/478	62 279/533	58 266/585	58 264/595	55 254/635	51 221/674	44 205/757	37 192/832
72	70 328/471	68 321/456	65 303/494	60 287/550	57 274/603	56 271/614	54 261/655	49 228/697	41 211/781	Special Eng. Required
78	68 340/490	66 333/476	62 314/514	58 298/573	55 284/629	54 282/640	52 272/684	45 237/729	Special Eng. Required	Special Eng. Required
85	65 356/512	63 349/500	60 329/540	56 312/603	53 298/661	52 295/673	50 285/719	Special Eng. Required	Special Eng. Required	Special Eng. Required

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

Table 12: Allowable distance between attachments, reaction loads (up/dow 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	95 245/326	95 240/326	94 225/325	89 213/339	84 203/363	83 201/370	80 195/395	71 178/436	66 164/490	62 155/542
44	86 300/404	83 298/401	80 279/386	76 264/410	71 252/449	71 250/457	68 242/488	61 214/525	57 199/591	54 187/652
65	70 364/502	68 364/486	65 360/476	62 341/522	58 325/572	58 322/582	55 310/622	51 269/657	46 249/738	39 233/812
67	69 370/509	67 370/493	64 365/483	61 346/530	57 330/581	57 327/591	54 315/631	50 274/669	44 254/751	38 237/826
68	69 372/513	67 372/496	64 368/486	60 349/533	57 332/585	56 329/595	54 317/635	50 276/674	44 256/757	37 239/832
72	67 384/527	65 384/511	62 379/501	59 359/550	56 342/603	55 339/614	53 326/655	49 284/697	41 263/781	Special Eng. Required
78	65 398/549	63 398/535	60 393/519	57 372/573	54 355/629	53 352/640	51 340/684	45 296/729	Special Eng. Required	Special Eng. Required
85	62 417/572	61 417/560	58 411/540	55 390/603	52 372/661	51 368/673	49 356/719	Special Eng. Required	Special Eng. Required	Special Eng. Required

Table 13: Allowable distance between attachments, reaction loads (up/dow 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	90 291/361	90 291/361	90 274/361	87 260/367	82 248/377	81 246/383	78 238/408	69 217/445	65 201/490	61 189/542
44	81 343/446	80 343/446	77 341/428	74 323/430	70 308/467	69 305/474	66 295/505	59 261/534	56 243/591	53 228/652
65	67 417/557	65 417/540	63 417/517	60 416/542	57 396/581	56 393/589	54 379/622	50 328/658	46 304/738	39 285/812
67	66 424/565	64 424/548	62 424/525	59 422/551	56 402/590	56 399/597	53 384/631	49 334/669	44 309/751	38 290/826
68	66 427/569	64 427/552	61 427/528	59 425/555	56 405/594	55 402/602	53 387/635	49 337/674	44 312/757	37 292/832
72	64 440/585	62 440/569	60 440/544	57 438/572	54 417/612	54 413/620	51 398/655	48 347/697	41 321/781	Special Eng. Required
78	62 456/609	60 456/595	58 456/568	55 454/597	52 433/639	52 429/647	50 414/684	45 362/729	Special Eng. Required	Special Eng. Required
85	59 477/635	58 477/623	56 477/595	53 476/626	50 454/669	50 449/678	48 434/719	Special Eng. Required	Special Eng. Required	Special Eng. Required

Table 14: Allowable distance between attachments, reaction loads (up/dow 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	86 329/397	86 329/397	86 329/397	84 312/395	80 298/403	79 295/405	76 285/423	68 260/459	64 241/494	60 227/542
44	78 387/491	76 387/491	74 387/474	71 386/463	68 369/485	67 366/492	65 354/523	58 313/550	55 291/593	52 273/652
65	64 471/613	63 471/597	60 471/573	58 470/567	56 469/605	55 469/612	53 454/641	49 393/678	46 364/738	39 341/812
67	63 478/622	62 478/605	59 478/581	57 477/576	55 476/613	54 476/621	52 461/650	48 400/689	44 371/751	38 347/826
68	63 481/626	61 481/610	59 481/585	57 480/580	54 479/618	54 479/625	52 464/655	48 403/694	44 374/757	37 350/832
72	61 496/644	60 496/628	57 496/603	55 495/598	53 494/636	52 494/644	50 477/674	47 416/714	41 385/781	Special Eng. Required
78	59 514/670	58 514/656	56 514/629	54 513/624	51 513/664	51 513/672	49 496/704	45 433/742	Special Eng. Required	Special Eng. Required
85	57 538/699	56 538/687	54 538/659	52 538/653	49 538/695	49 538/703	47 520/736	Special Eng. Required	Special Eng. Required	Special Eng. Required

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

key: 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	85/240 240/240 75/43	85/240 240/240 88/42	85/240 240/189 110/40	85/240 240/155 126/38	85/240 240/131 140/36	85/240 240/127 143/36	85/240 240/112 154/34	85/240 240/91 170/64	85/240 220/76 187/67	85/240 197/66 203/70
44	85/240 240/214 91/53	85/240 240/174 107/52	85/240 240/138 129/48	85/240 240/113 147/46	85/240 240/95 164/43	85/240 240/92 167/43	85/240 240/81 180/42	85/240 181/66 197/77	84/240 160/55 219/81	73/240 143/48 239/84
65	85/240 240/145 110/68	85/240 240/118 129/66	85/240 240/93 156/62	85/240 240/76 178/58	85/240 240/64 198/56	85/240 240/62 202/55	84/240 240/55 217/53	68/240 122/45 243/96	57/240 108/37 243/100	49/216 97/32 243/105
67	85/240 240/140 111/69	85/240 240/114 131/67	85/240 240/90 158/63	85/240 240/74 180/59	85/240 240/62 200/57	85/240 240/61 204/56	82/240 240/54 220/54	66/240 119/43 243/98	55/240 105/36 243/102	48/210 94/31 243/107
68	85/240 240/138 112/69	85/240 240/113 132/68	85/240 240/89 159/63	85/240 240/73 181/60	85/240 240/62 202/57	85/240 240/60 206/56	80/240 240/53 222/54	65/240 117/43 243/98	55/240 103/36 243/103	47/207 93/31 243/107
72	85/240 229/131 116/72	85/240 229/107 137/70	85/240 229/84 164/65	85/240 229/69 187/62	85/240 229/58 208/59	85/240 229/56 212/58	76/240 229/50 229/56	61/240 110/40 243/102	52/227 98/34 243/106	Special Eng. Required
78	85/240 212/121 121/74	85/240 212/98 143/73	85/240 212/78 172/68	85/240 212/64 196/64	82/240 212/54 218/61	79/240 212/52 222/61	70/240 212/46 239/59	57/240 102/37 243/106	Special Eng. Required	Special Eng. Required
85	85/240 194/111 127/78	85/240 194/90 150/76	85/240 194/71 181/71	85/240 194/58 206/67	75/240 194/49 228/64	73/240 194/48 233/64	64/240 194/42 243/62	Special Eng. Required	Special Eng. Required	Special Eng. Required

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.

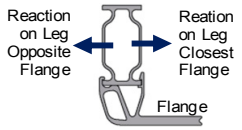


Table 17: Adjustment Factors to spans for tables 4 through 15 (note that factors are independent of Module Size)*

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

key:

Zone 2
Seismic Ss=1.5 / Importance factor 1.25
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"

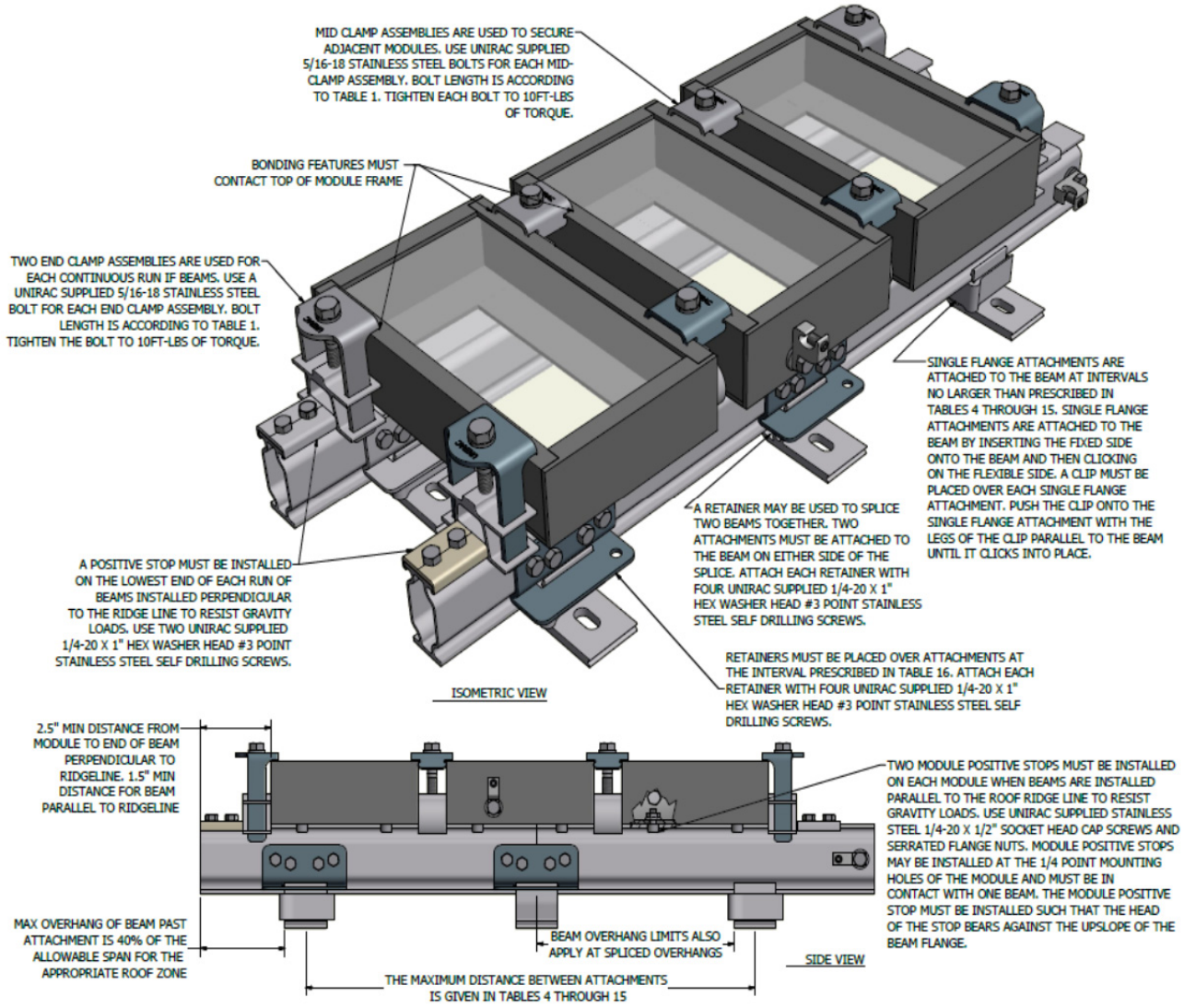

MID CLAMP ASSEMBLIES ARE USED TO SECURE ADJACENT MODULES. USE UNIRAC SUPPLIED 5/16-18 STAINLESS STEEL BOLTS FOR EACH MID-CLAMP ASSEMBLY. BOLT LENGTH IS ACCORDING TO TABLE 1. TIGHTEN EACH BOLT TO 10FT-LBS OF TORQUE.
BONDING FEATURES MUST CONTACT TOP OF MODULE FRAME
TWO END CLAMP ASSEMBLIES ARE USED FOR EACH CONTINUOUS RUN IF BEAMS. USE A UNIRAC SUPPLIED 5/16-18 STAINLESS STEEL BOLT FOR EACH END CLAMP ASSEMBLY. BOLT LENGTH IS ACCORDING TO TABLE 1. TIGHTEN THE BOLT TO 10FT-LBS OF TORQUE.
SINGLE FLANGE ATTACHMENTS ARE ATTACHED TO THE BEAM AT INTERVALS NO LARGER THAN PRESCRIBED IN TABLES 4 THROUGH 15. SINGLE FLANGE ATTACHMENTS ARE ATTACHED TO THE BEAM BY INSERTING THE FIXED SIDE ONTO THE BEAM AND THEN CLICKING ON THE FLEXIBLE SIDE. A CLIP MUST BE PLACED OVER EACH SINGLE FLANGE ATTACHMENT. PUSH THE CLIP ONTO THE SINGLE FLANGE ATTACHMENT WITH THE LEGS OF THE CLIP PARALLEL TO THE BEAM UNTIL IT CLICKS INTO PLACE.
A RETAINER MAY BE USED TO SPLICE TWO BEAMS TOGETHER. TWO ATTACHMENTS MUST BE ATTACHED TO THE BEAM ON EITHER SIDE OF THE SPLICE. ATTACH EACH RETAINER WITH FOUR UNIRAC SUPPLIED 1/4-20 X 1" HEX WASHER HEAD #3 POINT STAINLESS STEEL SELF DRILLING SCREWS.
A POSITIVE STOP MUST BE INSTALLED ON THE LOWEST END OF EACH RUN OF BEAMS INSTALLED PERPENDICULAR TO THE RIDGE LINE TO RESIST GRAVITY LOADS. USE TWO UNIRAC SUPPLIED 1/4-20 X 1" HEX WASHER HEAD #3 POINT STAINLESS STEEL SELF DRILLING SCREWS.
ISOMETRIC VIEW
RETAINERS MUST BE PLACED OVER ATTACHMENTS AT THE INTERVAL PRESCRIBED IN TABLE 16. ATTACH EACH RETAINER WITH FOUR UNIRAC SUPPLIED 1/4-20 X 1" HEX WASHER HEAD #3 POINT STAINLESS STEEL SELF DRILLING SCREWS.
2.5" MIN DISTANCE FROM MODULE TO END OF BEAM PERPENDICULAR TO RIDGELINE. 1.5" MIN DISTANCE FOR BEAM PARALLEL TO RIDGELINE
TWO MODULE POSITIVE STOPS MUST BE INSTALLED ON EACH MODULE WHEN BEAMS ARE INSTALLED PARALLEL TO THE ROOF RIDGE LINE TO RESIST GRAVITY LOADS. USE UNIRAC SUPPLIED STAINLESS STEEL 1/4-20 X 1/2" SOCKET HEAD CAP SCREWS AND SERRATED FLANGE NUTS. MODULE POSITIVE STOPS MAY BE INSTALLED AT THE 1/4 POINT MOUNTING HOLES OF THE MODULE AND MUST BE IN CONTACT WITH ONE BEAM. THE MODULE POSITIVE STOP MUST BE INSTALLED SUCH THAT THE HEAD OF THE STOP BEARS AGAINST THE UPSLOPE OF THE BEAM FLANGE.
MAX OVERHANG OF BEAM PAST ATTACHMENT IS 40% OF THE ALLOWABLE SPAN FOR THE APPROPRIATE ROOF ZONE
BEAM OVERHANG LIMITS ALSO APPLY AT SPLICED OVERHANGS
SIDE VIEW
THE MAXIMUM DISTANCE BETWEEN ATTACHMENTS IS GIVEN IN TABLES 4 THROUGH 15

FIGURE 1