28357 Industrial Blvd
Hayward, CA 94545
1-800-227-9523
IronRidge.com

Attn: Corey Geiger, COO, IronRidge Inc.
Date: December 10th, 2018

Re: Structural Certification for IronRidge *Knockout Tile* Roof Attachment

This letter addresses the structural capacity of the IronRidge *Knockout Tile* for use as a tile roof attachment for flush mounted PV solar systems. *Knockout Tile* assembly consists of an extruded aluminum base, a rail mounting bracket (L-foot), and an aluminum tile replacement flashing fastened to the assembly. The base is attached to an underlying roof rafter using one (1) 5/16” stainless steel lag bolt and the L-foot is secured to the base by a 5/16" stainless steel threaded stud and nut. Assembly of *Knockout Tile* and accompanying hardware shall be installed in accordance with IronRidge *Knockout Tile Installation Manual*. Full assembly details are shown in Exhibit EX-0018.

The referenced uplift, compression and lateral capacities of *Knockout Tile* tabulated below are based on mechanical load tests conducted along the four load directions shown in Figure 1, using a Universal Instron Test Unit, conforming to the following standards:

ASTM D1761-12, Standard Test Methods for Mechanical Fasteners in Wood
ASTM B 557-15, Standard Test Method for Tension Testing Wrought and Cast Aluminum and Magnesium-Alloy Products
NDS-2015, National Design Specification (NDS) for Wood Construction
ICC-428, Acceptance Criteria for Modular Framing Systems Used to Support Photovoltaic (PV) Modules

For each load test, a *Knockout Tile* assembly was installed onto a preconditioned sample roof deck composed of 15/32” OSB board and 2x4 Douglas Fir rafters. The measured moisture contents of the conditioned roof decks ranged from 10% to 12%, and average specific gravity applying to uplift and lateral (across slope) directions is 0.47. For each test, loads were applied at the highest slot position on the L-foot as shown in Figure 1 and testing was performed to consider all orientations of L-foot and base as allowed per the *Knockout Tile Installation Manual*. Table 1 below summarizes the average peak load, its associated failure mode, and the calculated allowable capacity for the respective load direction. The listed average peak load reflects the orientation of L-foot and base which results in the lowest capacity and can be applied to other allowable orientations.

For wood species with specific gravity other than 0.47, capacities associated with lag pull out failure mode (uplift & lateral across slope) shall be adjusted per American Wood Counsel (AWC) National Design Specification Eq. (12.2-1). Adjusted results for various wood species are presented in Table 2 below.

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Table 1: IronRidge Knockout Tile Roof Assembly Allowable Capacities [1]						
Load Direction	**Specimen Quantity**	**Average Peak Load at Failure (lbs)**	**Deviation of Test Results [3]**	**Critical Failure Mode**	**Safety Factor [4]**	**Allowable Capacity (lbs) [5]**
Uplift Load Perpendicular to Roof Surface[2]	4	1440	4%	Lag Bolt Pull-out	3.0	480
Compression Load Perpendicular to Roof Surface	4	2385	7%	OSB Deck Rupture	2.54	939
Lateral Load Parallel to Rafter (Downslope)	4	461	2%	Rupture of Base at Lag Bolt Connection	1.95	237
Lateral Load Perpendicular to Rafter (Across Slope)[2]	4	592	9%	Lag Bolt Pull-out	3.00	197

Table 1 Notes:
(1) Capacity applies to rafter size of 2x4 or greater at 24" O.C. or less, deck thickness 15/32" or greater, and are based on securing lag bolts within the center 1/3 of rafter width with a minimum 2.5" end distance.
(2) For rafter specific gravity not equal to 0.47, uplift and lateral (across slope) capacities shall be adjusted and can be referenced in Table 2.
(3) Deviation reflects the variance of the highest or the lowest test value from the group mean for the respective load direction.
(4) Safety Factor is associated with the respective failure mode determined by the specific code referenced on Page 1.
(5) Allowable capacity is equal to Average Peak Load divided by its associated Safety Factor.

Table 2: Allowable Capacities Adjusted for Various Wood Species			
Wood Species	**NDS Assigned Specific Gravity[1]**	**Allowable Uplift Capacity (lbs)[2]**	**Allowable Lateral (Across Slope) Capacity (lbs)[2]**
Southern Pine	0.55	608	249
Douglas Fir-Larch	0.5	527	216
Douglas Fir-South	0.46	465	191
Hem-Fir (North)	0.46	465	191
Hem-Fir	0.43	420	172
Spruce-Pine-Fir	0.42	405	166

Table 2 Notes:
(1) Wood specific gravity is per NDS-2015 Table 12.3.3.A.
(2) Allowable Capacity = Table 1 Allowable Capacity x Adjustment Factor
Adjustment Factor = (Wood Density/0.47)$^{3/2}$ per (AWC) National Design Specification Eq. (12.2-1)

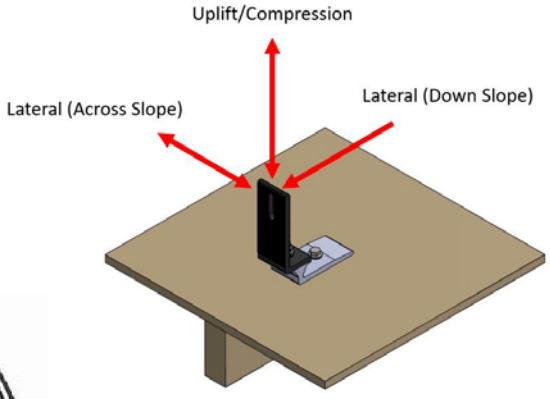


Figure 1

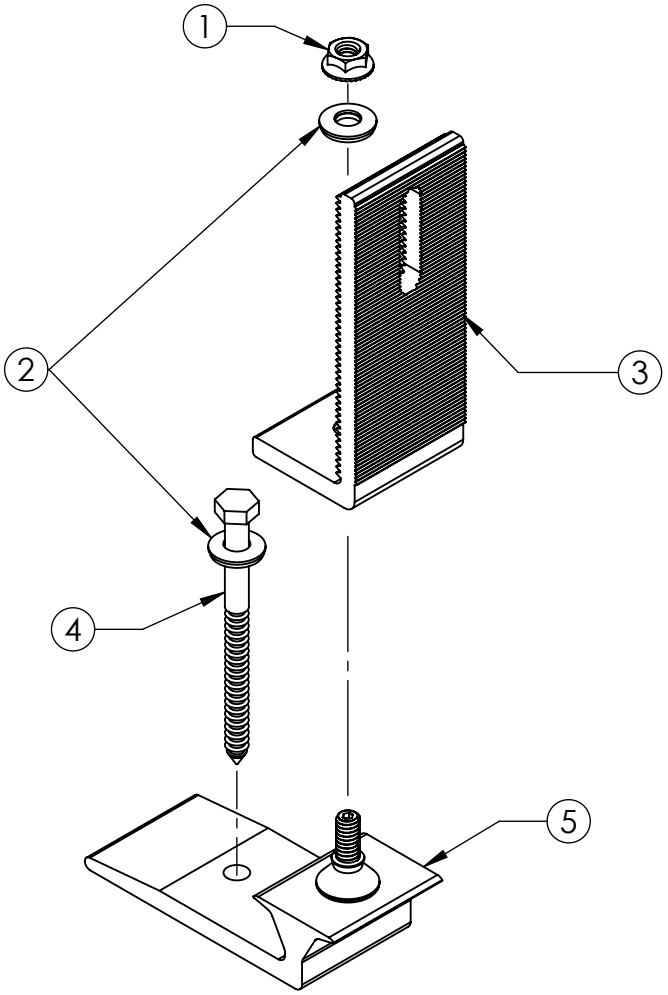
Sincerely,

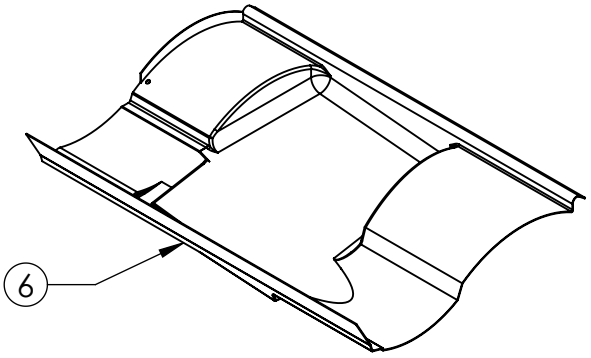
REGISTERED PROFESSIONAL ENGINEER
GANG XUAN
NO. 6504
STRUCTURAL
STATE OF CALIFORNIA

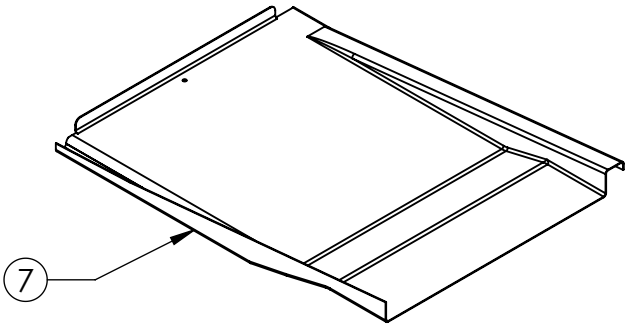
Date: 2018.12.10 15:45:13 -08'00'

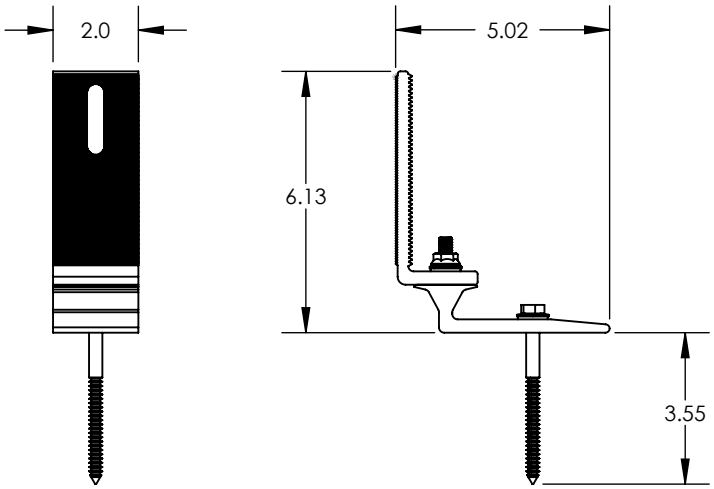
Gang Xuan, SE
Senior Structural Engineer

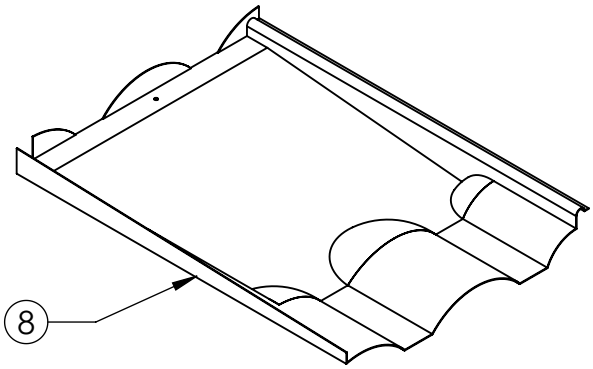
EXHIBIT: EX-0018











ITEM NO.	DESCRIPTION
1	NUT, FLANGE, HEX, 5/16-18 SS
2	WASHER, EPDM BACKED
3	L-FOOT
4	BOLT, LAG 5/16 X 4"
5	ASSY, BASE
6	FLASHING, TILE REPLACEMENT, S-TILE
7	FLASHING, TILE REPLACEMENT, FLAT TILE
8	FLASHING, TILE REPLACEMENT, W-TILE

IRONRIDGE

Assy, Knockout Tile

DWG. NO. EX-0018