April 29, 2016

Quick Mount PV
Attn: Amy Rodriguez (email)
2700 Mitchell Drive
Walnut Creek, CA 94598

Job No: 11304

Job Name: Quick Mount PV On-Call Lab Testing
Walnut Creek, CA

Subject: Quick Mount PV Load Testing - Tile Replacement Mount
[QMPV# 1-28-2016-Rev C]

Ms. Rodriguez,

In accordance with your authorization, Construction Testing Services (CTS) performed load testing on the Quick Mount PV 1-1/4" OD by 4-1/2" long post attached to the Tile Replacement Mount. Structural tests included tensile (uplift), compressive (downwards), lateral (Parallel and perpendicular to rafter), and resultant load applied at a 6:12 roof slope/pitch. The Tile Replacement Mount was fastened to a 2"x4" Douglas Fir Rafter using (2) 5/16" diameter by 4" long GRK RSS Rugged Structural Screws. Testing was conducted in general accordance with industry standard testing procedures, including ASTM D1761-12, D2395-14, and ICC AC13.

Test Equipment

Equipment used to perform the various tests include:

- Instron 100HDX Universal Tensile/Compression Machine; Calibrated 10/16/2015
- Delmhorst BD-2100 Moisture Meter; Calibrated daily
- Quincy Lab Inc. 21-250 Oven; Calibrated 04/14/2015
- Digital Caliper AB11881; Calibrated 04/13/2015
- AE Adam PGL 30001 Scale; Calibrated 04/13/2015

Sample Description

(34) 16”x16” wood test boards were delivered to our laboratory on February 26, 2016. Each specimen was made up of 2”x4” lumber, topped with ½” plywood and 30 lb. felt paper. The specimens were equipped with the flashing and 1-1/4” OD by 4-1/2” long post fastened to a 2”x4” Douglas Fir with 4” long, 5/16” diameter GRK RSS Rugged Structural Screws. (31) Tests were conducted with a Unirac L-foot (representative of typical L-foot on the market), and (3) tests were conducted without a Unirac L-foot. Test loads were applied directly to the L-foot for tensile. Compressive, lateral and resultant test loads were applied to a block attached to the L-foot to represent typical transfer of load from the rail into the L-foot. When no L-foot was present, the test load was applied directly to the post. See Figure 1 and Figure 2 for a typical test board.

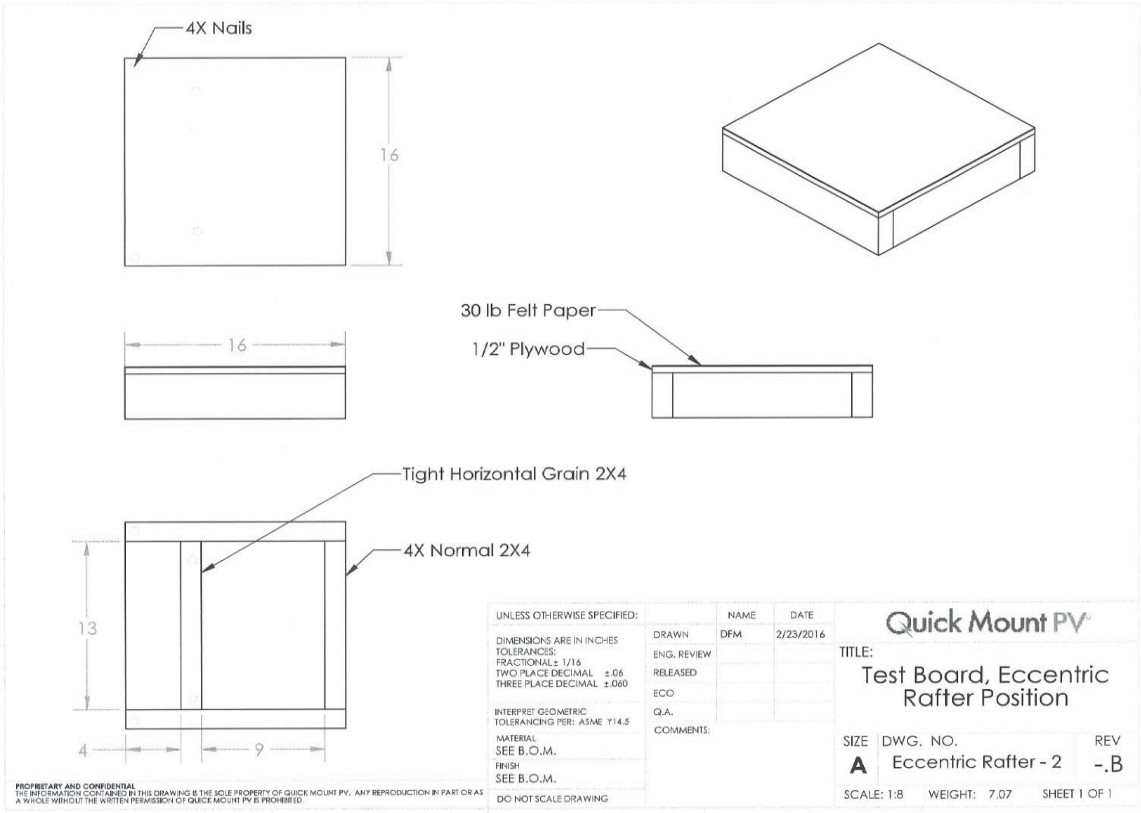

Figure 1: Typical Tensile Test Board

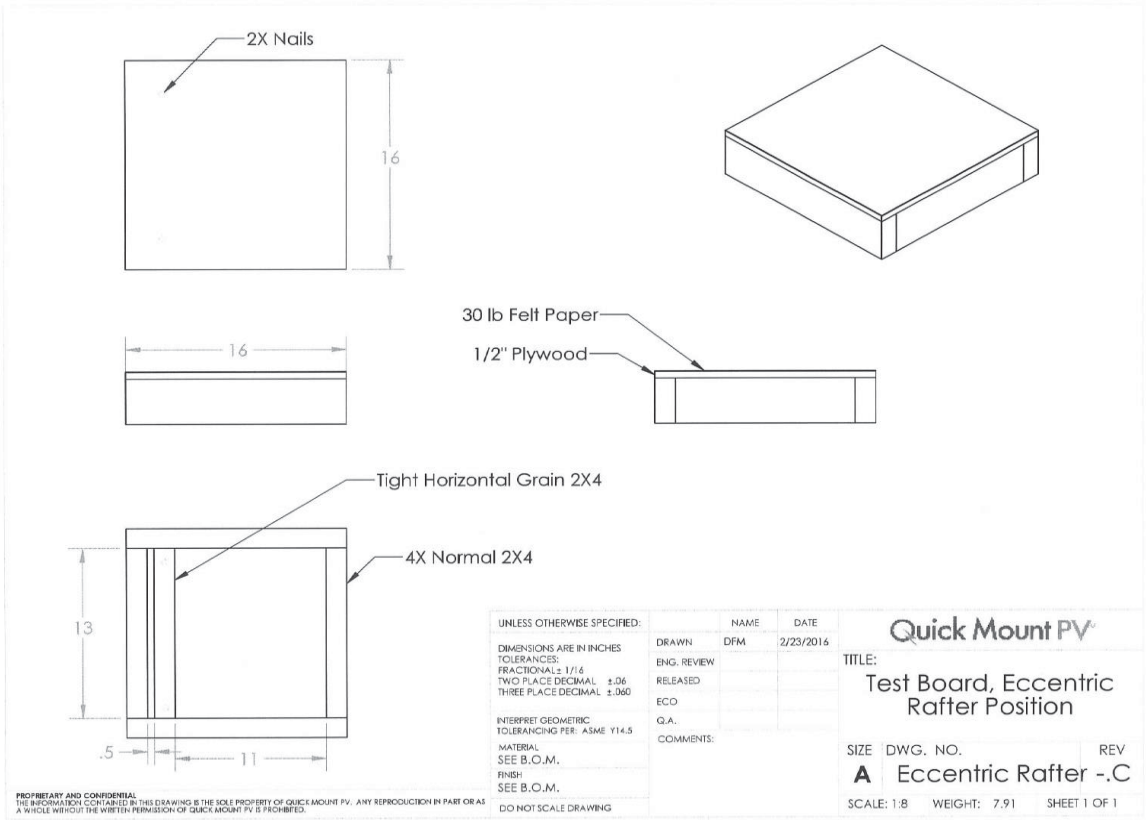

Figure 2: Typical Compressive, Lateral, and Resultant Test Board

Structural Test Configurations and Results

Tensile (Uplift)

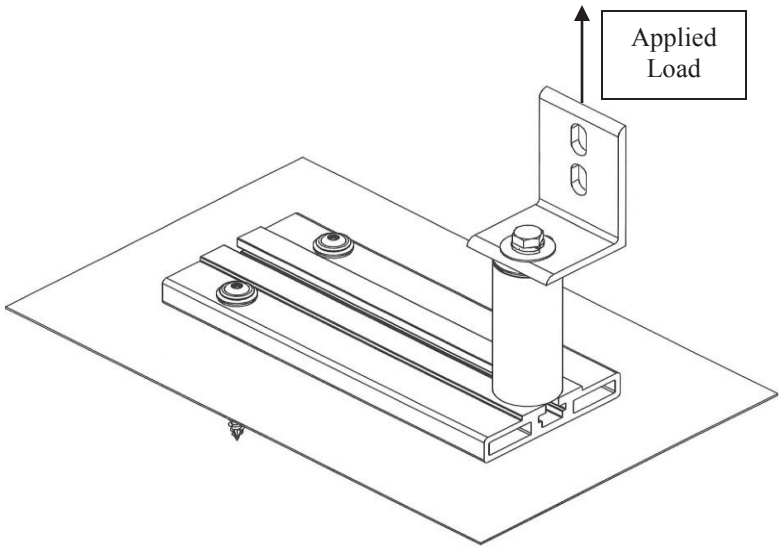

Figure 3: Tensile Eccentric Load

Sample Number	L-Foot	Rafter Specific Gravity at Moisture	Test Rafter Moisture Content [%]	Peak Load [lbs]	Deflection at Peak Load [in]	Failure Mode
1	Unirac	0.536	12.0	1233	3.0585	Bolt Track Fractured (Al Brittle)
2	Unirac	0.505	12.5	1358	2.4038	Post Crushing (Al Ductile) / Post Hub Ruptured (Al Brittle)
3	Unirac	0.523	12.4	1508	3.0447	Steel Bolt Fractured (Steel Failure)
4	Unirac	0.513	12.7	989	2.9945	Bolt Track Fractured (Al Brittle)
5	Unirac	0.518	11.6	1396	2.9100	Post Hub Ruptured (Al Brittle)
6	Unirac	0.531	11.8	1572	3.3687	Steel Bolt Fractured (Steel Failure)
7	Unirac	0.565	11.9	1385	3.1210	Post Hub Ruptured (Al Brittle)
8	Unirac	0.503	11.0	1297	3.2010	Post Hub Ruptured (Al Brittle)
9	Unirac	0.528	12.2	1606	3.3925	Post Hub Ruptured (Al Brittle)
10	Unirac	0.531	12.3	1630	3.3555	Post Hub Ruptured (Al Brittle)
11	Unirac	0.422	11.9	1379	3.0522	Post Hub Ruptured (Al Brittle)
12	Unirac	0.504	11.0	1478	3.2952	Steel Bolt Fractured (Steel Failure)
Average				1403		

Photo 1: Tensile Eccentric Load (pre-test)

Photo 2: Tensile Eccentric Load (post-test)

Compressive (Downwards with Unirac L-foot)

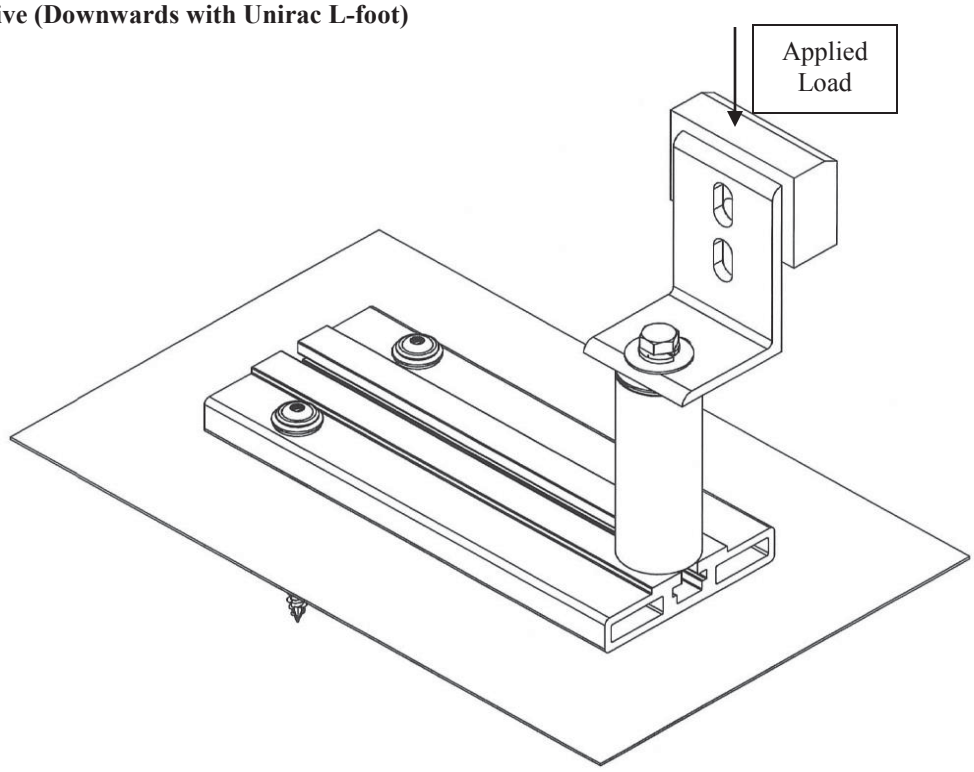

Figure 4: Compressive Eccentric Load (shown with Unirac L-foot)

Sample Number	L-Foot	Rafter Specific Gravity at Moisture	Test Rafter Moisture Content [%]	Peak Load [lbs]	Deflection at Peak Load [in]	Failure Mode
1	Unirac	0.547	12.1	1096	0.4622	L-Foot Bending (Al Ductile)
2	Unirac	0.490	12.7	1173	0.5440	L-Foot Bending (Al Ductile)
3	Unirac	0.498	12.3	1083	0.5363	L-Foot Bending (Al Ductile)
4	Unirac	0.474	11.7	1241	0.5832	L-Foot Bending (Al Ductile)
Average				1117		

Photo 3: Compression Eccentric Load (pre-test)

Photo 4: Compression Eccentric Load (post-test)

Compressive (Downwards without Unirac L-foot)

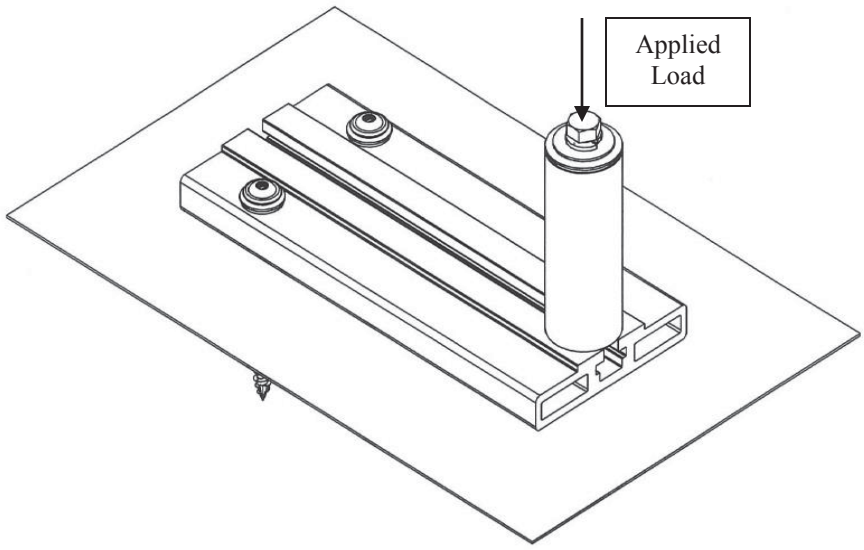

Figure 5: Compressive Eccentric Load (shown without Unirac L-foot)

Sample Number	L-Foot	Rafter Specific Gravity at Moisture	Test Rafter Moisture Content [%]	Peak Load [lbs]	Deflection at Peak Load [in]	Failure Mode
1	None	0.520	12.2	2988	0.8160	Plywood Failure (Wood Failure)
2	None	0.486	12.2	2799	1.4060	Plywood Failure (Wood Failure)
3	None	0.528	11.7	2587	0.9369	Plywood Failure (Wood Failure)
Average				2791		

Photo 5: Compressive Eccentric Load (shown without Unirac L-foot, pre-test)

Photo 6: Compressive Eccentric Load (shown without Unirac L-foot, post-test)

Lateral (Parallel to Rafter)

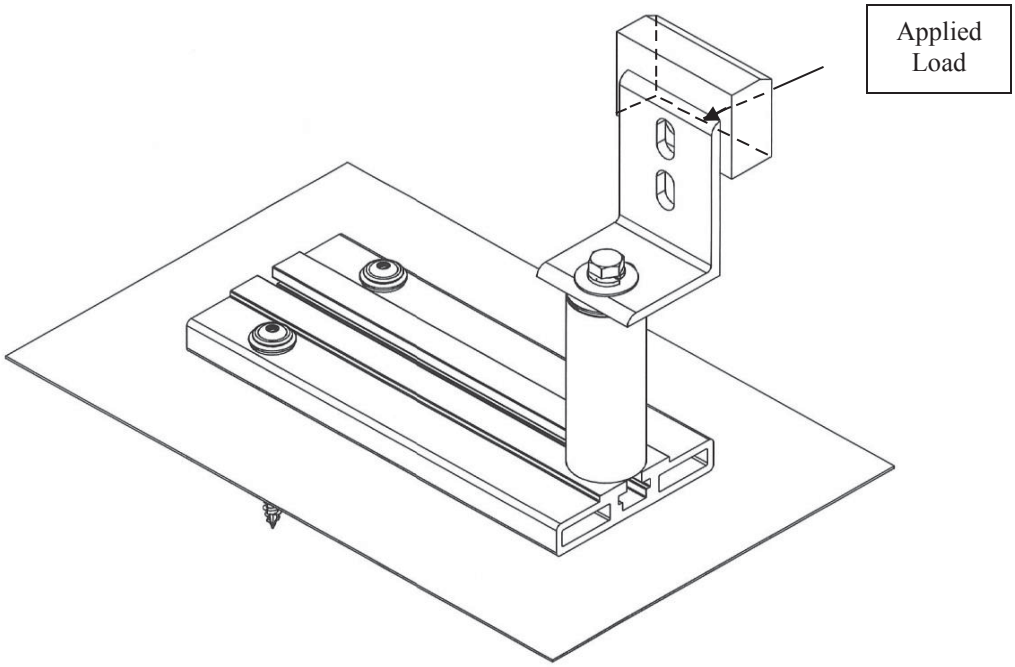

Figure 6: Lateral Parallel to Rafter Eccentric Load

Sample Number	L-Foot	Rafter Specific Gravity at Moisture	Test Rafter Moisture Content [%]	Peak Load [lbs]	Deflection at Peak Load [in]	Failure Mode
1	Unirac	0.500	11.6	440	3.2714	Post Crushing (Al Ductile) / Post Hub Ruptured (Al Brittle)
2	Unirac	0.531	12.1	430	3.4445	Post Crushing (Al Ductile)
3	Unirac	0.514	12.5	435	3.4340	Post Crushing (Al Ductile)
4	Unirac	0.457	12.0	445	3.4195	Post Crushing (Al Ductile)
Average				438		

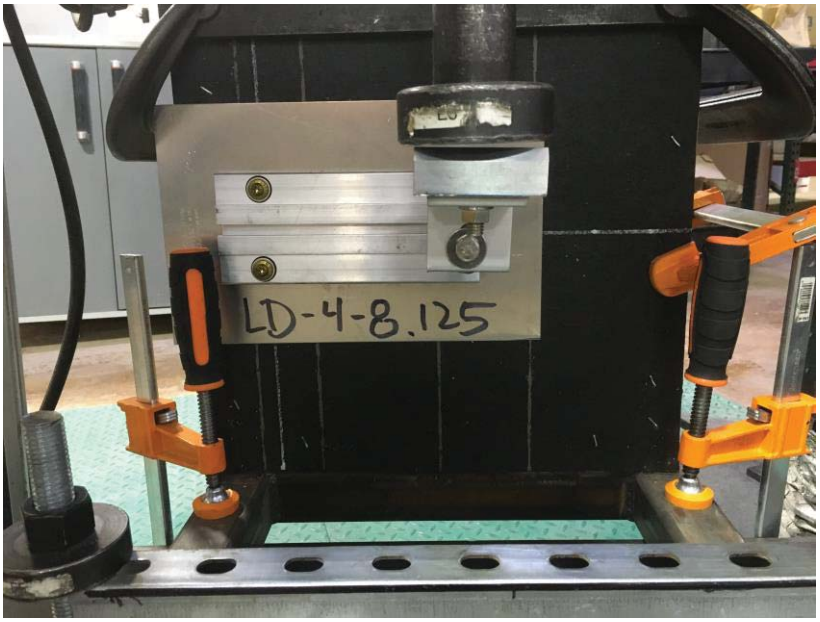

Photo 7: Lateral Parallel to Rafter Eccentric Load (pre-test)

Photo 8: Lateral Parallel to Rafter Eccentric Load (post-test)

Lateral (Perpendicular to rafter)

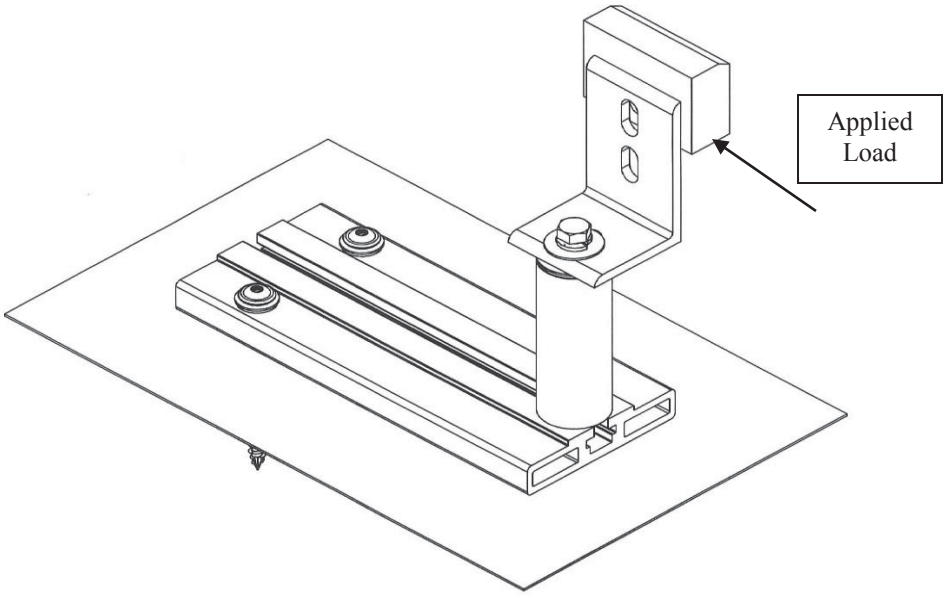

Figure 7: Lateral Perpendicular to Rafter Eccentric Load

Sample Number	L-Foot	Rafter Specific Gravity at Moisture	Test Rafter Moisture Content [%]	Peak Load [lbs]	Deflection at Peak Load [in]	Failure Mode
1	Unirac	0.500	12.3	351	1.3575	*see note below
2	Unirac	0.508	11.8	360	2.8407	Post Crushing (Al Ductile) / Steel Bolt Fractured (Steel Failure)
3	Unirac	0.552	12.0	398	3.3868	Post Crushing (Al Ductile) / Steel Bolt Fractured (Steel Failure)
4	Unirac	0.478	12.0	362	0.4853	*see note below
5	Unirac	0.532	12.0	403	0.6180	*see note below
6	Unirac	0.513	12.4	390	3.8326	Post Hub Ruptured (Al Brittle)
Average				377		

* Test terminated prior to failure. Test fixture was about to come into contact with L-foot. No failure mode visible upon termination of the test.

Photo 9: Lateral Perpendicular to Rafter Eccentric Load (pre-test)

Photo 10: Lateral Perpendicular to Rafter Eccentric Load (post-test)

Resultant Load at 6:12 Roof Slope/Pitch

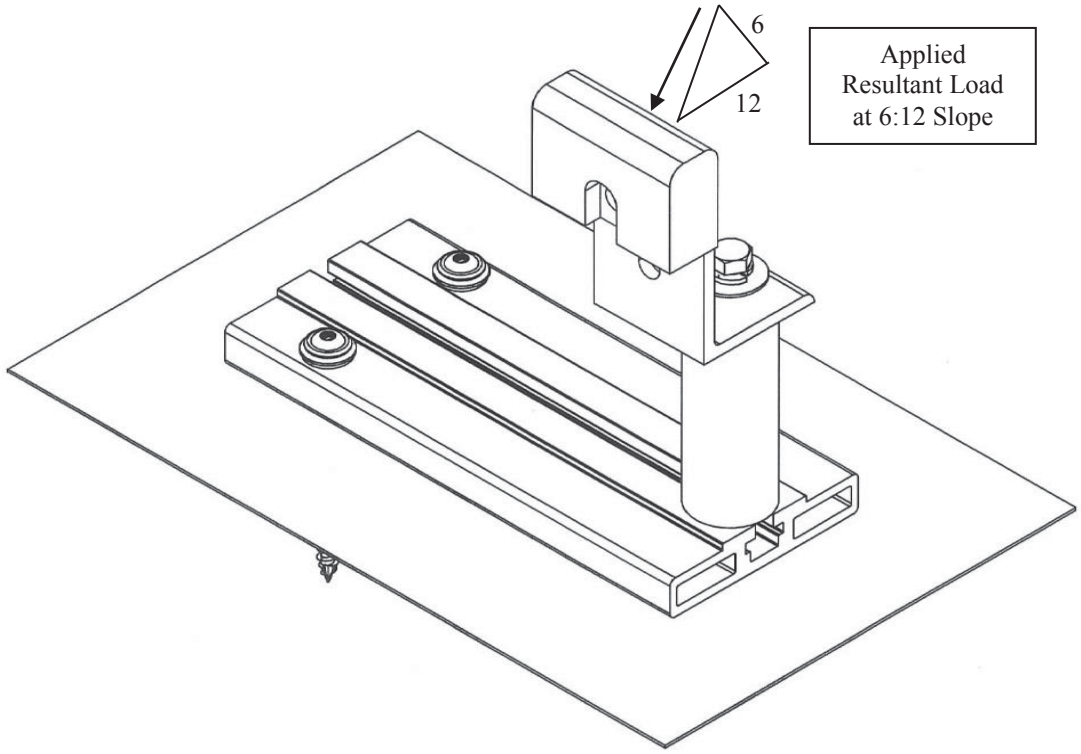

Figure 8: Resultant 6:12 Eccentric Load (Downslope)

Sample Number	L-Foot	Rafter Specific Gravity at Moisture	Test Rafter Moisture Content [%]	Peak Load [lbs]	Deflection at Peak Load [in]	Failure Mode
1	Unirac	0.487	12.5	441	1.3365	L-Foot Bending (Al Ductile)
2	Unirac	0.506	11.8	436	1.2139	L-Foot Bending (Al Ductile)
3	Unirac	0.547	11.3	433	1.1209	L-Foot Bending (Al Ductile)
4	Unirac	0.500	11.0	446	1.0705	L-Foot Bending (Al Ductile)
Average				439		

Photo 11: Resultant 6:12 Eccentric Load (Downslope, pre-test)

Photo 12: Resultant 6:12 Eccentric Load (Downslope, post-test)

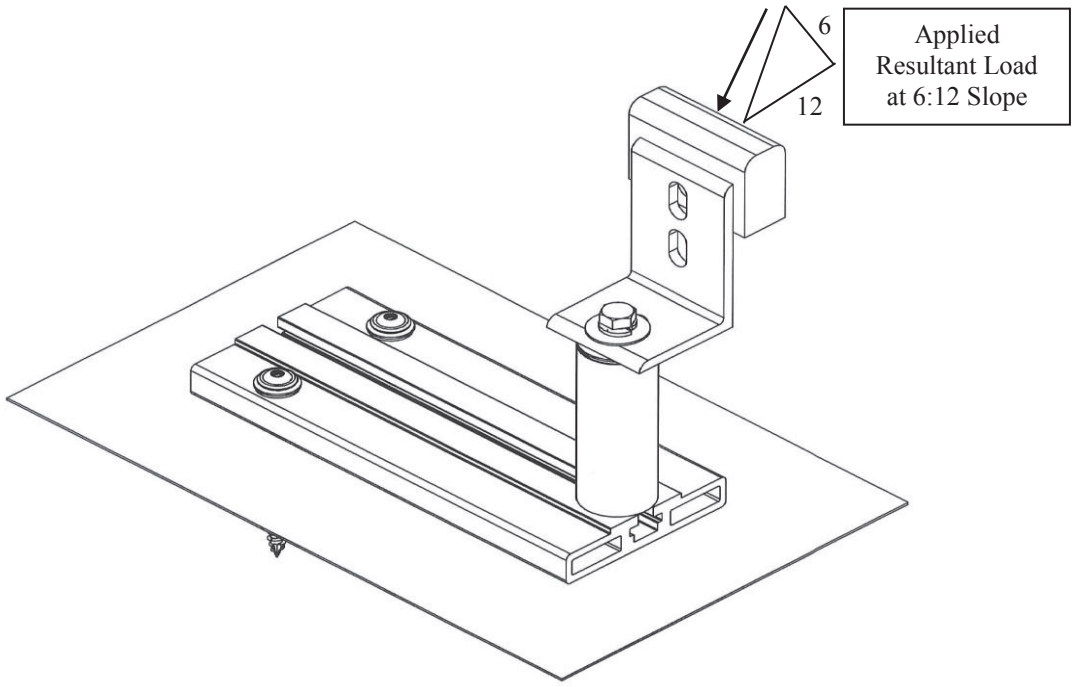

Figure 9: Resultant 6:12 Eccentric Load (Upslope)

Sample Number	L-Foot	Rafter Specific Gravity at Moisture	Test Rafter Moisture Content [%]	Peak Load [lbs]	Deflection at Peak Load [in]	Failure Mode
1	Unirac	0.472	12.4	1845	1.5212	L-Foot Bending (Al Ductile)
2	Unirac	0.436	11.8	1917	1.0633	L-Foot Bending (Al Ductile)
3	Unirac	0.472	12.4	1815	1.6158	L-Foot Bending (Al Ductile)
4	Unirac	0.515	11.1	1946	1.6303	L-Foot Bending (Al Ductile)
Average				1881		

Photo 13: Resultant 6:12 Eccentric Load (Upslope, pre-test)

Photo 14: Resultant 6:12 Eccentric Load (Upslope, post-test)

Installation Drawings

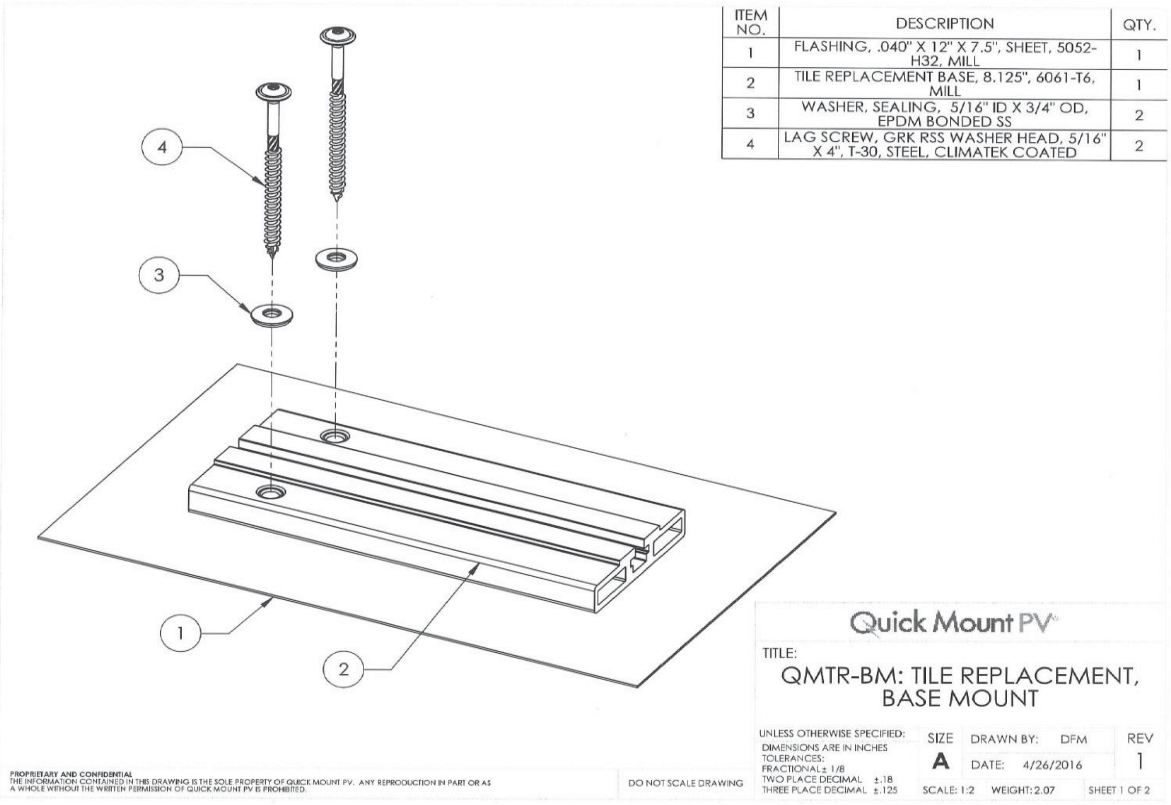

Figure 10a: Installation Drawing

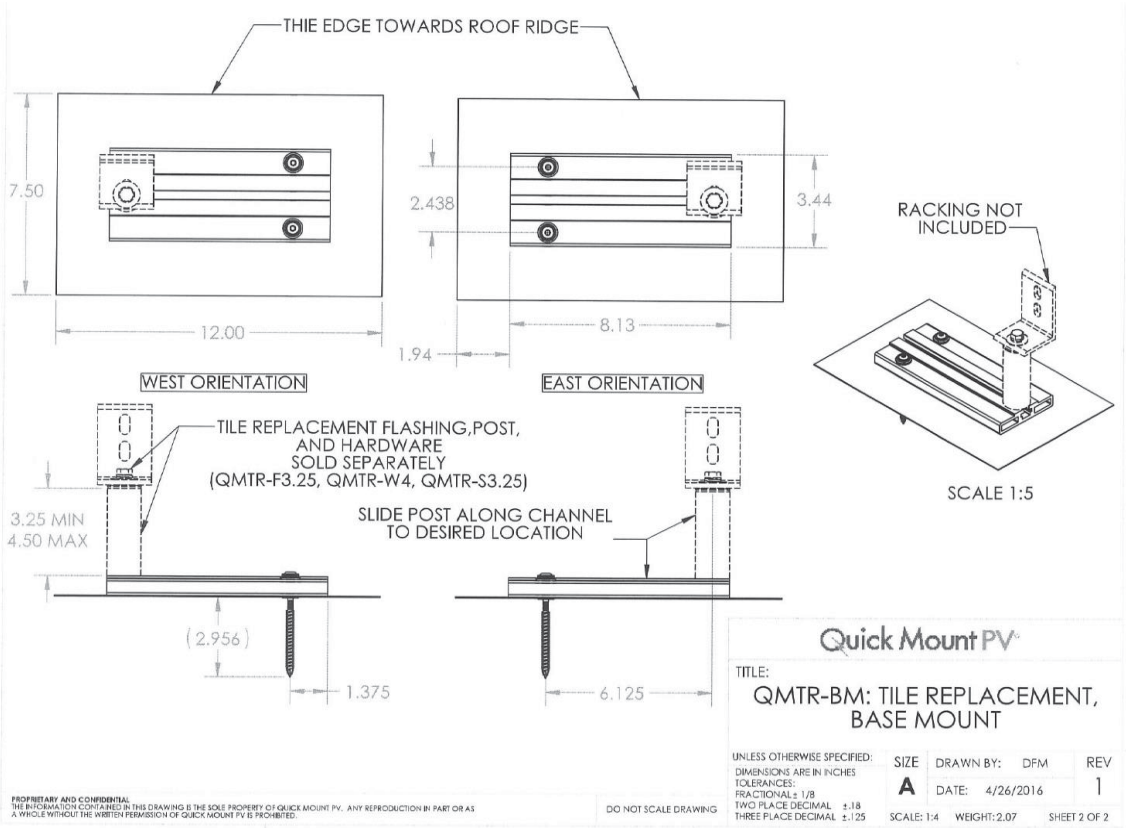

Figure 10b: Installation Drawing

Limitations: Testing was conducted in general accordance with industry standard testing procedures, including ASTM D1761-12, D2395-14, and ICC AC13. The data provided is the result of those tests. CTS assumes no liability and makes no warranty, expressed or implied, as to the usefulness of any information, product, apparatus, or process disclosed.

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