



March 12, 2019

Mr. Ryan Hagen
Everest Solar Systems, LLC
2835 La Mirada Drive, Suite A
Vista, CA 92081

Project Number 1190134C

Subject: Flat Tile Hook (Part # 4000010) Laboratory Load Testing

Dear Mr. Hagen:

As requested, Applied Materials & Engineering, Inc. (AME) has completed load-testing the Flat Tile Hook (Part # 4000010). The purpose of our testing was to evaluate the compressive, tensile and shear load capacity of the Flat Tile Hook attached to a 2"x4" Douglas Fir rafter using two 5/16"Øx4" lag screws.

SAMPLE DESCRIPTION

Eight Flat Tile Hooks with 2"x4" Douglas Fir samples were delivered to our laboratory on February 25, 2019. Mockup configuration consisted of three 12" long rafters at 6.5"o.c., screwed to 1/2" Structural I plywood. The Flat Tile Hook is attached through the plywood into a rafter with two 5/16"Øx4" lag screws.

TEST PROCEDURES & RESULTS

1. Compression Load Test

A total of three tests were conducted for compressive load capacity on March 5, 2019 using a United Universal testing machine. Samples were rigidly attached to the testing machine and a compressive load was applied to the hook. The samples were loaded in compression at a constant rate of axial deformation of 0.10 in. /min. without shock until the hook was bent and came in contact with the test board; displacement at maximum load was recorded. Based on the above testing, the average maximum compression load and displacement of the Flat Tile Hook attached to a 2"x4" Douglas Fir rafter using two 5/16"Øx4" lag screws was determined to be 807 lbs and 2.1 in., respectively. Detailed results are provided in Table I and compressive load vs. displacement curves are provided in Figure 1. Test setup and mode of failure are provided in Appendix A, Figure 4.

The specific gravity and moisture content of the rafter was tested in accordance with ASTM D2395, Method A (oven-dry). The average specific gravity and moisture content were determined to be 0.415 and 18.3%, respectively.

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2. Tensile Load Test

A total of three tests were conducted for tensile (uplift) load capacity on March 5, 2019 using a United Universal testing machine. Samples were rigidly attached to the testing machine and a tensile load was applied to the hook. The samples were loaded in tension at a constant rate of axial deformation of 0.10 in. /min. without shock until failure occurred; displacement at maximum load was recorded. Based on the above testing, the average maximum tensile load and displacement of the Flat Tile Hook attached to a 2"x4" Douglas Fir rafter using two 5/16"Øx4" lag screws was determined to be 1474 lbs and 3.0 in., respectively. Detailed results are provided in Table II and tensile load vs. displacement curves are provided in Figure 2. Test setup and mode of failure are provided in Appendix A, Figure 5.

The specific gravity and moisture content of the rafter was tested in accordance with ASTM D2395, Method A (oven-dry). The average specific gravity and moisture content were determined to be 0.396 and 19.4%, respectively.

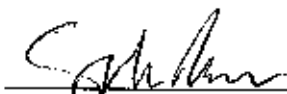
3. Shear Load Test Parallel to Rafter

A total of two tests were conducted for shear load capacity parallel to the rafter on March 6, 2019 using a United Universal testing machine. Samples were rigidly attached to the testing machine and a tensile load was applied to the hook. The samples were loaded in compression at a constant rate of axial deformation of 0.10 in. /min. without shock until failure occurred; displacement at maximum load was recorded. Based on the above testing, the average maximum tensile load and displacement of the Flat Tile Hook attached to a 2"x4" Douglas Fir rafter using two 5/16"Øx4" lag screws was determined to be 1311 lbs and 0.5 in., respectively. Detailed results are provided in Table III and shear load vs. displacement curves are provided in Figure 3. Test setup and mode of failure are provided in Appendix A, Figure 6.

The specific gravity and moisture content of the rafter was tested in accordance with ASTM D2395, Method A (oven-dry). The average specific gravity and moisture content were determined to be 0.363 and 19.2%, respectively.

Respectfully Submitted,

APPLIED MATERIALS & ENGINEERING, INC.


Sophia Poulos
Laboratory Manager



Reviewed by:

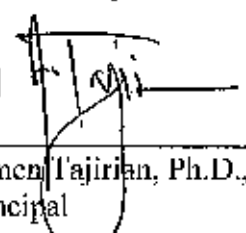

Armen Tajirian, Ph.D., P.E.
Principal

TABLE I

COMPRESSION LOAD TEST RESULTS

FLAT TILE HOOK (Part #4000010)

PROJECT NUMBER 1190134C

TEST NUMBER	MAXIMUM COMPRESSION LOAD (lbs)	DISPLACEMENT AT MAXIMUM LOAD (in.)	MODE OF FAILURE	RAFTER SPECIFIC GRAVITY	RAFTER MOISTURE CONTENT (%)
1	784	2.1	Hook Contacted Plywood	0.406	18.1
2	826	2.2		0.384	17.1
3	812	2.0		0.454	19.6
AVERAGE	807	2.1	..	0.415	18.3

COMPRESSION LOAD-DISPLACEMENT CURVES

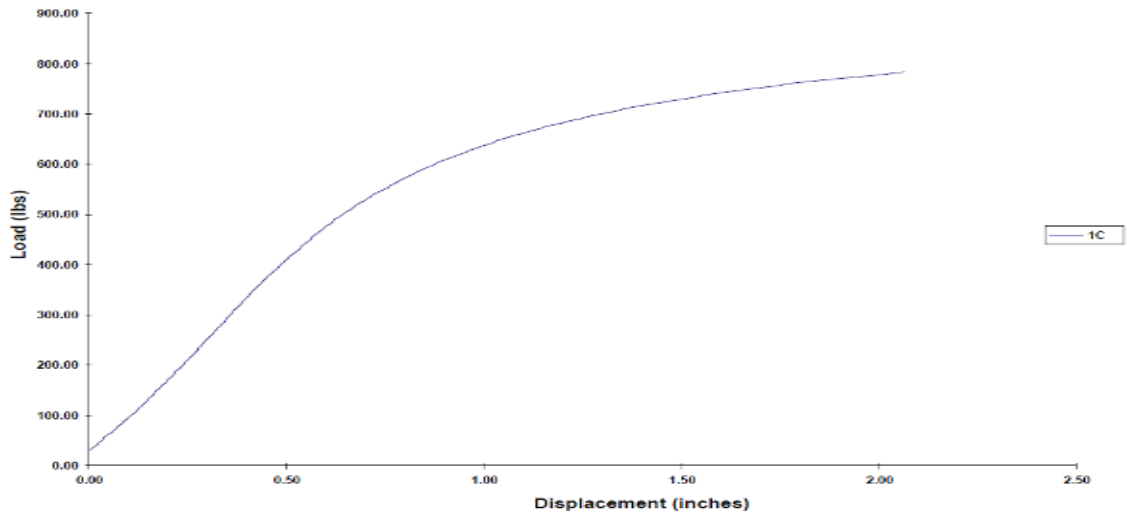


Figure 1a. Sample 1 compression load vs. displacement curve.

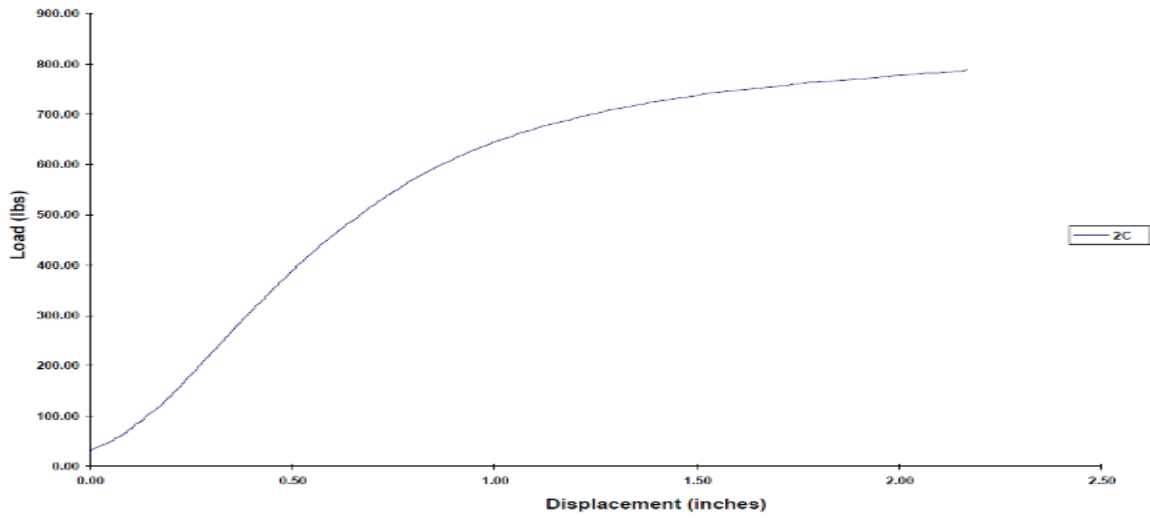


Figure 1b. Sample 2 compression load vs. displacement curve.

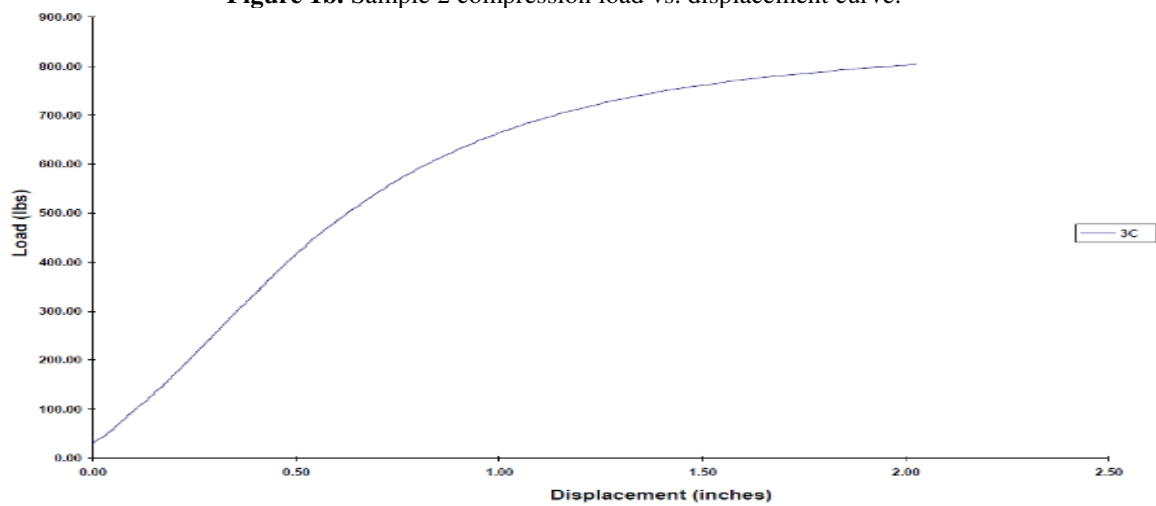


Figure 1c. Sample 3 compression load vs. displacement curve.

TABLE II
TENSILE (UPLIFT) LOAD TEST RESULTS
FLAT TILE HOOK (Part #4000010)
PROJECT NUMBER 1190134C

TEST NUMBER	MAXIMUM TENSILE LOAD (lbs)	DISPLACEMENT AT MAXIMUM LOAD (in.)	MODE OF FAILURE	RAFTER SPECIFIC GRAVITY	RAFTER MOISTURE CONTENT (%)
4	1656	2.9	Lag Screw Pull-out	0.444	18.1
5	1116	2.6		0.379	20.5
6	1650	3.6		0.365	19.7
AVERAGE	1474	3.0	..	0.396	19.4

TENSILE LOAD-DISPLACEMENT CURVES

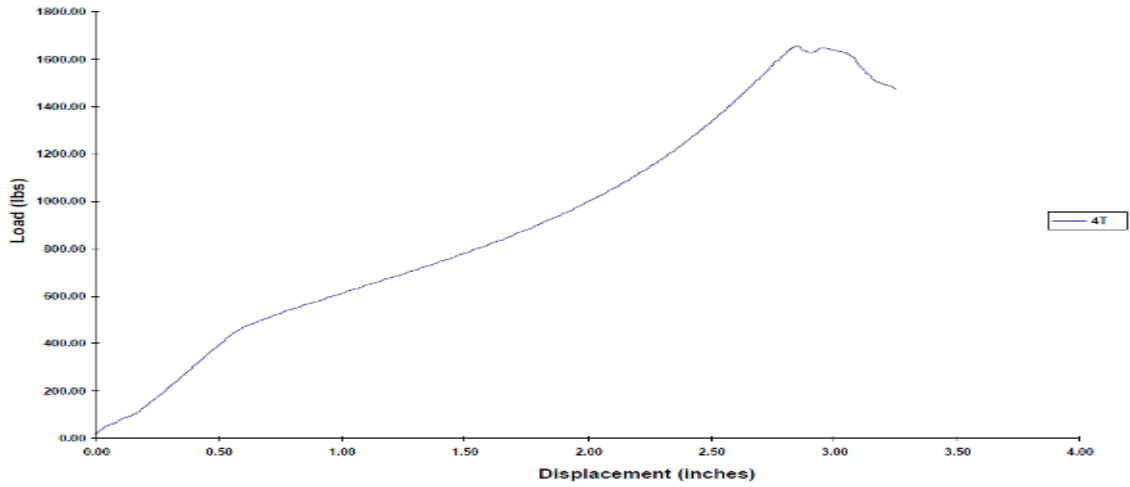


Figure 2a. Sample 4 tensile load vs. displacement curve.

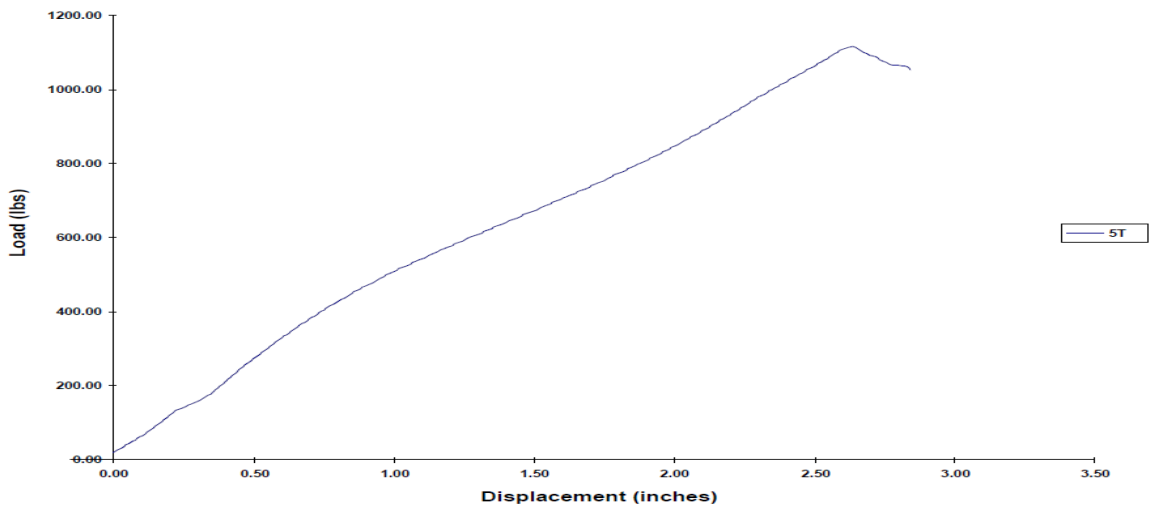


Figure 2b. Sample 5 tensile load vs. displacement curve.

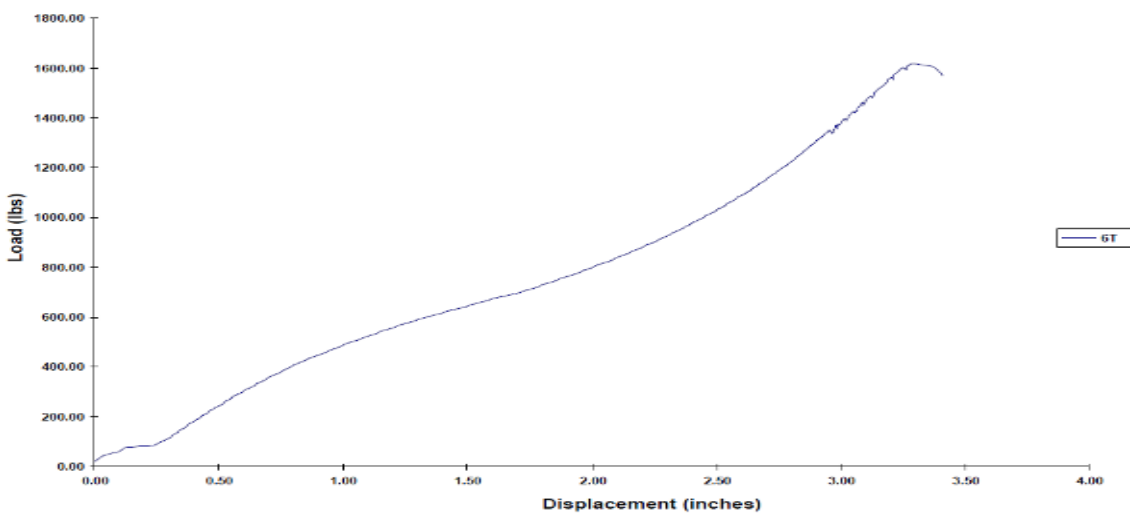


Figure 2c. Sample 6 tensile load vs. displacement curve.

TABLE III

SHEAR LOAD TEST RESULTS

FLAT TILE HOOK (Part #4000010)

PROJECT NUMBER 1190134C

TEST NUMBER	MAXIMUM SHEAR LOAD (lbs)	DISPLACEMENT AT MAXIMUM LOAD (in.)	MODE OF FAILURE	RAFTER SPECIFIC GRAVITY	RAFTER MOISTURE CONTENT (%)
7	1300	0.5	Bent Hook	0.360	20.0
8	1321	0.5		0.367	18.4
AVERAGE	1311	0.5	..	0.363	19.2

SHEAR LOAD-DISPLACEMENT CURVES

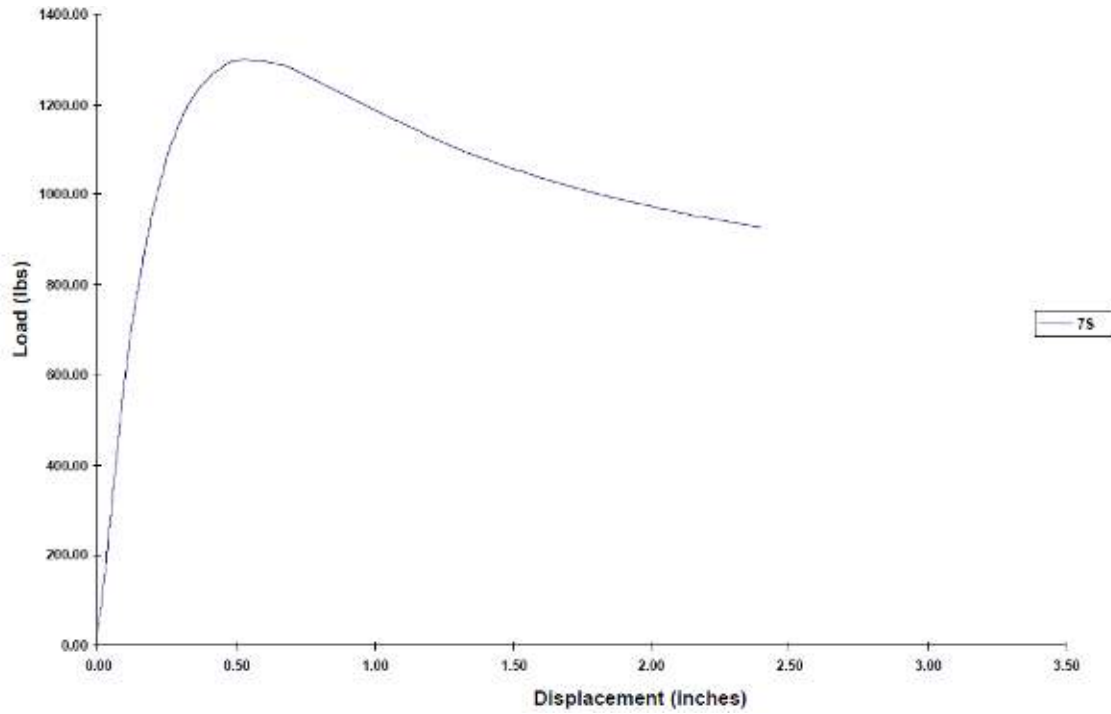


Figure 3a. Sample 7 shear load vs. displacement curve.

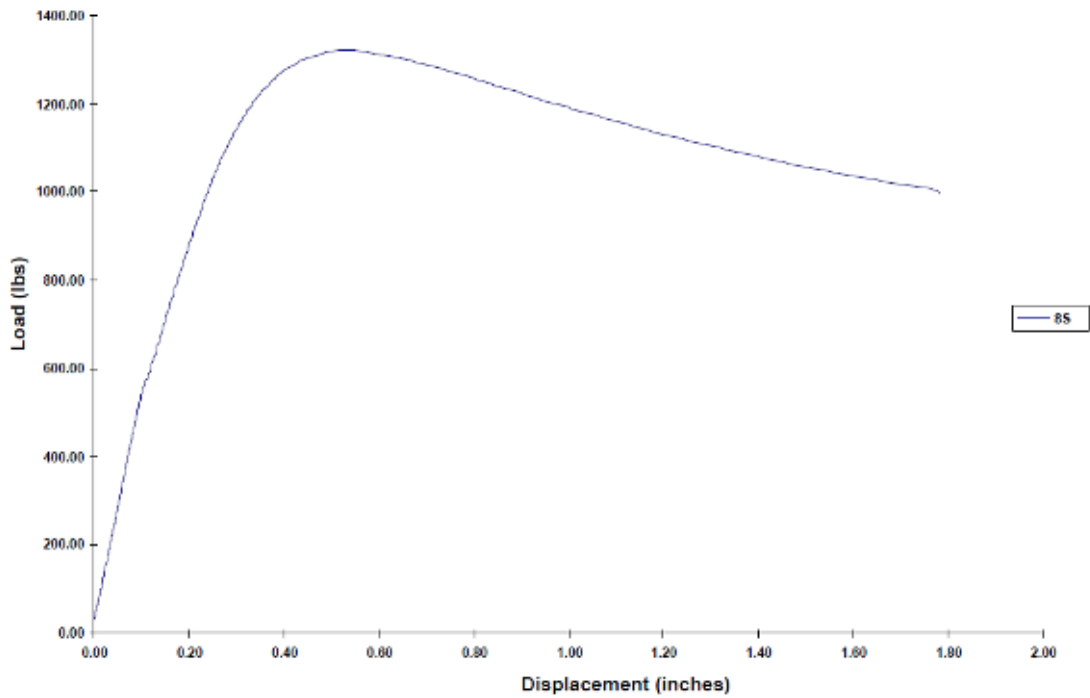


Figure 3b. Sample 8 shear load vs. displacement curve.

REFERENCES

AC13-2010, “*Acceptance Criteria for Joist Hangers and Similar Devices*”, ICC Evaluation Service.

AC85-2008, “*Acceptance Criteria for Test Reports*”, ICC Evaluation Service.

ASTM D1761-2010, “*Standard Test Methods for Mechanical Fasteners in Wood*”, ASTM International.

ASTM D2395-2014, “*Standard Test Method for Specific Gravity of Wood and Wood-Based Materials*”,
ASTM International

APPENDIX A

FIGURE 4
FLAT TILE HOOK (Part #4000010)
COMPRESSION LOAD TEST SETUP
PROJECT NUMBER 1190134C



Figure 4a. Test setup.



Figure 4b. Typical failure mode.

FIGURE 5
FLAT TILE HOOK (Part #4000010)
TENSILE LOAD TEST SETUP
PROJECT NUMBER 1190134C



Figure 5a. Test setup.



Figure 5b. Typical failure mode.

FIGURE 6
FLAT TILE HOOK (Part #4000010)
SHEAR LOAD TEST SETUP
PROJECT NUMBER 1190134C



Figure 6a. Test setup.



Figure 6b. Typical failure mode.