TAYLOR & SYFAN CONSULTING ENGINEERS, INC

Central Coast:
684 Clarion Court
San Luis Obispo, California 93401
805.547.2000 800.617.2235 fax

Southern California:
1276 E. Colorado Blvd, Suite 201
Pasadena, California 91106
626.793.7438 626.793.7439 fax

STRUCTURAL CALCULATIONS

PREPARED FOR:

SYSTEM:

SnapNrack Roof Mount Racking System

DESIGNER OF RECORD:

AEE Solar, Inc.
775 Fiero Lane Suite 200
San Luis Obispo, CA 93401

PROJECT ENGINEERS:

Matthew Gilliss, LEED AP
Nathan B. White, S.E., LEED AP

NATHANIEL B. WHITE
LICENSED PROFESSIONAL ENGINEER
No. 11011-S
HAWAII U.S.A.

This work was prepared by me or under my supervision.

Expiration Date of License: April 30, 2010

Valid Through December 31, 2010
Subject to Annual Review & Reissuance

Job No. 8445
January 28, 2010

Central Coast
684 Clarion Court
San Luis Obispo, CA 93401
(805)547.2000
(805)547.2001 fax
(800)579.3881

Southern California
1276 E. Colorado Blvd.
Suite 201
Pasadena, CA 91106
(626)793.7438
(626)793.7439 fax

Date: January 28, 2010

To: Tim Vaughn
AEE Solar

From: Matthew Gilliss
Taylor & Syfan Consulting Engineers

Project: SnapNrack Roof Mount Racking System

T&S Job No.: 8445

Subject: Summary Letter for SnapNrack

INTRODUCTION

This Project Summary Letter is in reference to the Structural Calculation Packet for the AEE Solar Racking System "SnapNrack", dated December 2009. The calculations have been performed in accordance with the 2003 International Building Code (IBC), the governing structural code in Hawaii. Several factors contained within this code govern the overall design of the racking system. The racking system has been designed to withstand code-prescribed forces due to the racking system's own weight, the weight of the solar panels, snow loads, and wind forces.

RAIL SPANS

In terms of variable conditions for the racking system, the main rails which support the solar panels (referred to as the "standard rails") have an adjustable length, which is the distance between their attachments to the roof (called standoffs). For the purpose of the calculation packet, that length was taken to be 8'-0", 6'-0", 4'-0", or 2'-0".

Due to the many variables that are required to be taken into account during a wind analysis, we have determined multiple cases that we feel are the most common. These cases are based upon several factors which include building height, pitch of the panels, wind exposure region, wind speed, snow loads, and topographic factors.

TAYLOR & SYFAN
CONSULTING ENGINEERS, INC

Central Coast	Southern California
684 Clarion Court	1276 E. Colorado Blvd.
San Luis Obispo, CA 93401	Suite 201
(805)547.2000	Pasadena, CA 91106
(805)547.2001 fax	(626)793.7438
(800)579.3881	(626)793.7439 fax

SITE-SPECIFIC ANALYSIS

We have determined that the rails are able to span a maximum of 8'-0" for many of the common cases, but that there are certain cases which will require shorter spans and/or a location-sensitive analysis to be performed on a case-by-case basis. A site-specific analysis may be required if it is found that the location of the solar panel install corresponds to any of the following criteria:

- The total pitch of the solar panel (solar panel pitch & roof pitch) is greater than 60 degrees above the horizontal.
- A topographic factor applies to the location. Topographic factors apply, for general purposes, when the structure is on a hill, mesa or bluff, or is adjacent to a large body of water. For complete descriptions of topographic factors, please refer to ASCE 7-05 Section 6.5.7.
- The roof of the structure that the solar panels will be installed on is greater than 50 ft. above grade.
- A combination of loads and/or site conditions applies that is not addressed in the attached rail span charts.

If one of more of these factors applies to the project location, please contact Taylor & Syfan, and we will be able to analyze the site conditions and recommend a standoff spacing for each specific site.

RAIL TESTING

Due to the possibility of structural failure of the rails due to their non-symmetrical shape, testing was conducted per the standards set forth by the 2006 IBC Section 1714: Preconstruction Load Tests. The results of this testing procedure were used in comparison with the calculated values to help establish the maximum load allowed by the rails. The full procedure and results of these tests can be found in this packet.

RACKING CONNECTIONS TO THE EXISTING ROOF

Also contained within the calculation packet are calculations for the connection of the rails to the roof framing. Using the sizes provided by AEE, we have calculated the maximum forces

TAYLOR & SYFAN CONSULTING ENGINEERS, INC

Central Coast	Southern California
684 Clarion Court San Luis Obispo, CA 93401 (805)547.2000 (805)547.2001 fax (800)579.3881	1276 E. Colorado Blvd. Suite 201 Pasadena, CA 91106 (626)793.7438 (626)793.7439 fax

that will be resisted based on the withdrawal value of the lag screws, and the strength of the aluminum components which are involved in transferring these forces from the rail to the roof framing. These components consist of the L-foot (AEE Drawing ATCH-D01), the Standoff (ATCH-D02), the Hybrid (ATCH-D05), and the Hanger Bolt (ATCH-D06 - which is discussed below). All (4) options are acceptable under the parameters shown in AEE's plans. The results from our analysis have been integrated into the summary charts.

SUMMARY CHARTS AND TOPGRAPHIC FACTORS

The attached pages of this summary contain what we feel are some of the most common building configurations with varying wind speeds. These charts can be used as a quick reference for looking up maximum rail span lengths based on the building and site conditions, but it must be noted that for any building where a topographic factor is to be applied (e.g. hills, mesas, seashore) the rail span lengths given may exceed what is allowed for the given site condition. A registered structural engineer should evaluate the exact topographic conditions for this specific site prior to construction.

UNIVERSAL END CLAMP

AEE Solar has also developed a "Universal End Clamp" which is used to connect individual solar panels to the rails (see AEE Solar's drawing "UEC INSTALL"). These have been developed and tested by AEE Solar, and they are adequate to resist the maximum uplift and shear forces generated by code prescribed wind forces when installed as specified. The testing results may be submitted upon request.

HANGER BOLT OPTION

The Hanger Bolt consists of a 3/8" diameter bolt that is used in place of the typical standoff connection to connect the racking components to the existing roof framing. Because the connection between the hanger bolt and the racking consists of a clamp that relies on friction, extensive testing has been done and a factor of safety over 4 has been applied to the ultimate loads that the assembly safely carried. With the factor of safety, the hanger bolt was able to resist the same loads required of the other standoff options. Please see AEE

TAYLOR & SYFAN CONSULTING ENGINEERS, INC

Central Coast	Southern California
684 Clarion Court San Luis Obispo, CA 93401 (805)547.2000 (805)547.2001 fax (800)579.3881	1276 E. Colorado Blvd. Suite 201 Pasadena, CA 91106 (626)793.7438 (626)793.7439 fax

Solar's plans for limits on the bolt parameters, including minimum required installation torque. The testing results may be submitted upon request.

EXISTING BUILDING LIMITATIONS

This summary letter discusses the structural adequacy of the solar racking system itself only and does not investigate or validate the adequacy of the structure that the racking system is being placed upon. It does not address the ability of the existing roofing or roof framing to support the new loads imposed upon them by the new system nor does it address the new localized forces between the roofing and the roof framing that may be imposed by the new standoff connections. It also does not address the additional lateral forces that will be imposed upon the building due to the seismic mass the new system adds to the existing roof. These various building-specific issues need to be evaluated by the appropriate registered professional(s) prior to the addition of the photovoltaic and racking systems. Taylor & Syfan may be consulted for building-specific structural evaluation. Taylor and Syfan assumes that systems are installed to the specifications presented here and using good structural judgment by the installer. Additionally, as an optional service, we recommend the performance of structural observations of the installation, as a best practice service, by Taylor & Syfan.

Please note that all sizes, material specifications, and weights have been provided by AEE Solar. All waterproofing, roofing, and drainage issues are the responsibility of AEE Solar's customer otherwise known as the contractor or professional solar installer.

Please let us know if you have any questions or comments. Thank you.

Sincerely,

Matthew B. Gilliss
Project Engineer
Taylor & Syfan Consulting Engineers

For Tilts of 19 Degrees or Less

MAXIMUM RAIL SPANS BETWEEN STANDOFFS (FT.)

	Conditions	Windspeed (Nominal 3-sec. Gust in mph)				
		90	105	120	135	150
Building Ht. is 30 ft. or Less	0 to 19 Degree Pitch 0 psf Ground Snow Load	8*	8	6	6	6
	0 to 19 Degree Pitch 0 – 10 psf Ground Snow Load	6	6	6	4	4
	0 to 19 Degree Pitch 11 – 20 psf Ground Snow Load	6	4	4	4	2
	0 to 19 Degree Pitch 21 – 30 psf Ground Snow Load	4	4	4	2	2
	0 to 19 Degree Pitch 31 – 40 psf Ground Snow Load	4	4	2	2	2
	0 to 19 Degree Pitch 41 – 60 psf Ground Snow Load	2	2	2	2	2
	0 to 19 Degree Pitch 61 – 80 psf Ground Snow Load	2	2	2	2	2
	0 to 19 Degree Pitch 81 – 100 psf Ground Snow Load	2	2	NG	NG	NG
Building Ht. is 31 ft. to 50 ft.	0 to 19 Degree Pitch 0 psf Ground Snow Load	8	6	6	6	4
	0 to 19 Degree Pitch 0 – 10 psf Ground Snow Load	6	6	4	4	4
	0 to 19 Degree Pitch 11 – 20 psf Ground Snow Load	4	4	4	4	2
	0 to 19 Degree Pitch 21 – 30 psf Ground Snow Load	4	4	4	2	2
	0 to 19 Degree Pitch 31 – 40 psf Ground Snow Load	4	2	2	2	2
	0 to 19 Degree Pitch 41 – 60 psf Ground Snow Load	2	2	2	2	2
	0 to 19 Degree Pitch 61 – 80 psf Ground Snow Load	2	2	2	2	2
	0 to 19 Degree Pitch 81 – 100 psf Ground Snow Load	2	2	NG	NG	NG

* For 90 MPH Wind Speed, Building Ht. up to 30 ft., and 0 psf Snow Load, an 8 ft. span may be used up to 28 deg. pitch

Note: For Solar Installations 50 ft. Above Ground Level or Less. If Location of Solar Installation Is Higher than 50 ft. Above Ground Level, Please Contact Taylor & Syfan.

For Tilts of 20 – 30 Degrees

MAXIMUM RAIL SPANS BETWEEN STANDOFFS (FT.)

	Conditions	Windspeed (Nominal 3-sec. Gust in mph)				
		90	105	120	135	150
Building Ht. is 30 ft. or Less	20 to 30 Degree Pitch 0 psf Ground Snow Load	6*	6	6	4	4
	20 to 30 Degree Pitch 0 – 10 psf Ground Snow Load	6	6	4	4	2
	20 to 30 Degree Pitch 11 – 20 psf Ground Snow Load	4	4	4	2	2
	20 to 30 Degree Pitch 21 – 30 psf Ground Snow Load	4	4	4	2	2
	20 to 30 Degree Pitch 31 – 40 psf Ground Snow Load	4	4	2	2	2
	20 to 30 Degree Pitch 41 – 60 psf Ground Snow Load	2	2	2	2	2
	20 to 30 Degree Pitch 61 – 80 psf Ground Snow Load	2	2	2	2	2
	20 to 30 Degree Pitch 81 – 100 psf Ground Snow Load	2	2	NG	NG	NG
Building Ht. is 31 ft. to 50 ft.	20 to 30 Degree Pitch 0 psf Ground Snow Load	6	6	6	4	4
	20 to 30 Degree Pitch 0 – 10 psf Ground Snow Load	6	4	4	4	2
	20 to 30 Degree Pitch 11 – 20 psf Ground Snow Load	4	4	2	2	2
	20 to 30 Degree Pitch 21 – 30 psf Ground Snow Load	4	4	2	2	2
	20 to 30 Degree Pitch 31 – 40 psf Ground Snow Load	4	2	2	2	2
	20 to 30 Degree Pitch 41 – 60 psf Ground Snow Load	2	2	2	2	2
	20 to 30 Degree Pitch 61 – 80 psf Ground Snow Load	2	2	2	2	2
	20 to 30 Degree Pitch 81 – 100 psf Ground Snow Load	2	2	NG	NG	NG

* For 90 MPH Wind Speed, Building Ht. up to 30 ft., and 0 psf Snow Load, an 8 ft. span may be used up to 28 deg. pitch

Note: For Solar Installations 50 ft. Above Ground Level or Less. If Location of Solar Installation Is Higher than 50 ft. Above Ground Level, Please Contact Taylor & Syfan.

For Tilts of 31 - 45 Degrees

MAXIMUM RAIL SPANS BETWEEN STANDOFFS (FT.)

	Conditions	Windspeed (Nominal 3-sec. Gust in mph)				
		90	105	120	135	150
Building Ht. is 30 ft. or Less	31 to 45 Degree Pitch 0 psf Ground Snow Load	6	6	4	4	2
	31 to 45 Degree Pitch 0 – 10 psf Ground Snow Load	6	4	4	2	2
	31 to 45 Degree Pitch 11 – 20 psf Ground Snow Load	4	4	2	2	2
	31 to 45 Degree Pitch 21 – 30 psf Ground Snow Load	4	4	2	2	2
	31 to 45 Degree Pitch 31 – 40 psf Ground Snow Load	4	4	2	2	2
	31 to 45 Degree Pitch 41 – 60 psf Ground Snow Load	4	4	2	2	2
	31 to 45 Degree Pitch 61 – 80 psf Ground Snow Load	4	4	2	2	2
	31 to 45 Degree Pitch 81 – 100 psf Ground Snow Load	4	2	2	2	2
Building Ht. is 31 ft. to 50 ft.	31 to 45 Degree Pitch 0 psf Ground Snow Load	6	6	4	4	2
	31 to 45 Degree Pitch 0 – 10 psf Ground Snow Load	6	4	4	2	2
	31 to 45 Degree Pitch 11 – 20 psf Ground Snow Load	4	4	2	2	2
	31 to 45 Degree Pitch 21 – 30 psf Ground Snow Load	4	4	2	2	2
	31 to 45 Degree Pitch 31 – 40 psf Ground Snow Load	4	4	2	2	2
	31 to 45 Degree Pitch 41 – 60 psf Ground Snow Load	4	4	2	2	2
	31 to 45 Degree Pitch 61 – 80 psf Ground Snow Load	4	4	2	2	2
	31 to 45 Degree Pitch 81 – 100 psf Ground Snow Load	4	2	2	2	2

Note: For Solar Installations 50 ft. Above Ground Level or Less. If Location of Solar Installation Is Higher than 50 ft. Above Ground Level, Please Contact Taylor & Syfan.

For Tilts of 46 - 60 Degrees

MAXIMUM RAIL SPANS BETWEEN STANDOFFS (FT.)

	Conditions	Windspeed (Nominal 3-sec. Gust in mph)				
		90	105	120	135	150
Building Ht. is 30 ft. or Less	46 to 60 Degree Pitch 0 psf Ground Snow Load	6	6	6	4	4
	46 to 60 Degree Pitch 0 – 10 psf Ground Snow Load	6	6	4	4	2
	46 to 60 Degree Pitch 11 – 20 psf Ground Snow Load	4	4	4	2	2
	46 to 60 Degree Pitch 21 – 30 psf Ground Snow Load	4	4	4	2	2
	46 to 60 Degree Pitch 31 – 40 psf Ground Snow Load	4	4	4	2	2
	46 to 60 Degree Pitch 41 – 60 psf Ground Snow Load	4	4	4	2	2
	46 to 60 Degree Pitch 61 – 80 psf Ground Snow Load	4	4	4	2	2
	46 to 60 Degree Pitch 81 – 100 psf Ground Snow Load	4	4	4	2	2
Building Ht. is 31 ft. to 50 ft.	46 to 60 Degree Pitch 0 psf Ground Snow Load	6	6	6	4	4
	46 to 60 Degree Pitch 0 – 10 psf Ground Snow Load	6	4	4	2	2
	46 to 60 Degree Pitch 11 – 20 psf Ground Snow Load	4	4	2	2	2
	46 to 60 Degree Pitch 21 – 30 psf Ground Snow Load	4	4	2	2	2
	46 to 60 Degree Pitch 31 – 40 psf Ground Snow Load	4	4	2	2	2
	46 to 60 Degree Pitch 41 – 60 psf Ground Snow Load	4	4	2	2	2
	46 to 60 Degree Pitch 61 – 80 psf Ground Snow Load	4	4	2	2	2
	46 to 60 Degree Pitch 81 – 100 psf Ground Snow Load	4	4	2	2	2

* For 90 MPH Wind Speed, Building Ht. up to 30 ft., and 0 psf Snow Load, an 8 ft. span may be used up to 28 deg. pitch

Note: For Solar Installations 50 ft. Above Ground Level or Less. If Location of Solar Installation Is Higher than 50 ft. Above Ground Level, Please Contact Taylor & Syfan.

MAXIMUM RAIL SPANS BETWEEN STANDOFFS (FT.) (Topographic Effects)

Conditions	Windspeed (Nominal 3-sec. Gust in mph)				
	90	105	120	135	150
0 to 15 Degree Pitch Building Ht. up to 30 ft. Top Of Hill	8	6	6	4	4
0 to 15 Degree Pitch Building Ht. up to 30 ft. Coastal Condition	6	6	4	4	2
0 to 15 Degree Pitch Building Ht. up to 30 ft. Mesa Condition	6	6	4	4	2
16 to 30 Degree Pitch Building Ht. up to 30 ft. Top Of Hill	6	6	4	4	2
16 to 30 Degree Pitch Building Ht. up to 30 ft. Coastal Condition	6	4	4	2	2
16 to 30 Degree Pitch Building Ht. up to 30 ft. Mesa Condition	6	4	4	2	2
31 to 45 Degree Pitch Building Ht. up to 30 ft. Top Of Hill	6	4	4	2	2
31 to 45 Degree Pitch Building Ht. up to 30 ft. Coastal Condition	6	4	2	2	2
31 to 45 Degree Pitch Building Ht. up to 30 ft. Mesa Condition	6	4	2	2	2
46 to 60 Degree Pitch Building Ht. up to 30 ft. Top Of Hill	6	6	4	4	2
46 to 60 Degree Pitch Building Ht. up to 30 ft. Coastal Condition	6	4	4	2	2
46 to 60 Degree Pitch Building Ht. up to 30 ft. Mesa Condition	6	4	4	2	2

***No Snow Load Taken Into Account With Topographic Effects. If Site Has Snow Loads AND Topographic Effects, Please Contact Taylor & Syfan.**

THIS CHART IS FOR ESTIMATION PURPOSES ONLY. SITES WITH TOPOGRAPHIC FACTORS SHOULD HAVE A STRUCTURAL ENGINEER CALCULATE THE EXACT FACTOR PRIOR TO CONSTRUCTION

MAXIMUM RAIL SPANS BETWEEN STANDOFFS (FT.) (Topographic Effects)

Conditions	Windspeed (Nominal 3-sec. Gust in mph)				
	90	105	120	135	150
0 to 15 Degree Pitch Building Ht. 31 – 50 ft. Top Of Hill	6	6	6	4	4
0 to 15 Degree Pitch Building Ht. 31 – 50 ft. Coastal Condition	6	6	4	4	2
0 to 15 Degree Pitch Building Ht. 31 – 50 ft. Mesa Condition	6	6	4	4	2
16 to 30 Degree Pitch Building Ht. 31 – 50 ft. Top Of Hill	6	4	4	2	2
16 to 30 Degree Pitch Building Ht. 31 – 50 ft. Coastal Condition	6	4	2	2	2
16 to 30 Degree Pitch Building Ht. 31 – 50 ft. Mesa Condition	6	4	2	2	2
31 to 45 Degree Pitch Building Ht. 31 – 50 ft. Top Of Hill	6	4	4	2	2
31 to 45 Degree Pitch Building Ht. 31 – 50 ft. Coastal Condition	4	4	2	2	2
31 to 45 Degree Pitch Building Ht. 31 – 50 ft. Mesa Condition	4	4	2	2	2
46 to 60 Degree Pitch Building Ht. 31 – 50 ft. Top Of Hill	6	4	4	2	2
46 to 60 Degree Pitch Building Ht. 31 – 50 ft. Coastal Condition	6	4	2	2	2
46 to 60 Degree Pitch Building Ht. 31 – 50 ft. Mesa Condition	6	4	2	2	2

***No Snow Load Taken Into Account With Topographic Effects. If Site Has Snow Loads AND Topographic Effects, Please Contact Taylor & Syfan.**

Note: For Solar Installations 50 ft. Above Ground Level or Less. If Location of Solar Installation Is Higher than 50 ft. Above Ground Level, Please Contact Taylor & Syfan.

THIS CHART IS FOR ESTIMATION PURPOSES ONLY. SITES WITH TOPOGRAPHIC FACTORS SHOULD HAVE A STRUCTURAL ENGINEER CALCULATE THE EXACT FACTOR PRIOR TO CONSTRUCTION