BREIHOLZ QAZI ENGINEERING, INC.

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Seismic Hazard Reduction
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By: KK	Project: Aluminum Shapes Solar Panel Assembly	Sheet:	1 Of 9
Date: 5/20/09	4231 Liberty Blvd., South Gate, CA 90280	Job No:	9-026ER
Checked:	Bryan Bosveld: (775) 580-2120		

STRUCTURAL DESIGN CALCULATIONS
MAXIMUM WIND LOADING PER 2007 CBC (GUAM)

BUILDING CODE: 2007 CBC

FOUNDATION SOIL: N/A

MISCELLANEOUS

STEEL

Per AISC- 360-05 and AWS. Steel shall conform to ASTM A572 Grade 50 for W-shapes, ASTM A53 Grade B for tubes and pipes, and ASTM A36 for plates and misc. steel. Shop and field welding shall be performed by electric arc process by certified welders or licensed fabricators. Bolts shall conform to ASTM A307 or ASTM A325 for high strength bolts. Reinforcing steel shall conform to ASTM 615 Grade 60 or ASTM A706 Grade 60 for welding applications.

CONCRETE N/A

Per ACI 318-05. Cement and aggregates shall conform to ASTM C150 (type II) and ASTM C33, respectively. Minimum compressive strength at 28 day shall be as follows:

Slabs_____ Walls_____ Columns_____.

Joists_____ Beams_____ Footings_____.

MASONRY N/A

Per ACI 530-05. Material shall conform as follows: concrete block per ASTM C90 (lightweight, Grade A, Type II), bricks per ASTM C62 (Grade MW or Grade II), mortar mix 1:3½ :¼ (cement, sand & hydrated lime of lime putty), grout mix 1:3:2 (cement, sand & 3/8" maximum pea gravel). Ultimate compressive strength shall be:

f'm = 1,500 psi

WOOD

Per NDS, APA and UBC. Lumber and other engineered wood products shall be Douglas fir-larch.

Studs DF-L #2 Joists DF-L #2 Light Framing DF-L #2.

Posts DF-L#1 Beams DF-L #1 Plywood CDX.

Glue-Laminated_____ Steel Hardware SIMPSON.

INSPECTION

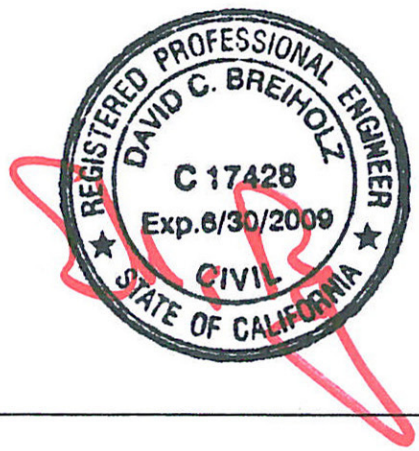
Special inspection by registered deputy inspector required for the following:

DESIGN LOADS: (SEE CALCS Pg. 2)

TABLE OF CONTENTS:

SCOPE OF WORK:

DESIGN OF ROOF-MOUNTED SOLAR PANELS TO INCLUDE THE ALUMINUM FRAME, ALL ITS CONNECTIONS AND ANCHORAGE TO EXISTING ROOF FRAMING.



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LOADING CRITERIA:

Dead Load

Solar Panels w/ Frame *2.5 psf*

Live Load

No Live Load *0 psf*

Total Load *2.5 psf*

Seismic Load *(Per ASCE 7-05 Section 13.3)*

$$F_p = \frac{0.4 a_p S_{DS} W_p}{\left(R_p / I_p\right)}\left(1+2\frac{z}{h}\right) = \frac{0.4(2.5)(1.33)(2.5\,psf)}{\left(3.5/1.0\right)}(1+2(1)) = 1.6(2.5\,psf) = 4\,psf$$ *(Eq. 13.3-1)*

GOVERNS

$$F_{p,max} = 1.6 S_{DS} I_p W_p = 1.6(1.33)(1.0)(2.5\,psf) = 5.3\,psf$$ *(Eq. 13.3-2)*

$$F_{p,min} = 0.3 S_{DS} I_p W_p = 0.3(1.33)(1.0)(2.5\,psf) = 1.0\,psf$$ *(Eq. 13.3-3)*

Assume minimum S_s = 2.0 and F_a = 1.0, so S_{DS} = (2/3)(2.0)=1.33
R_p = 3.5, a_p = 2.5, I_p = 1.0, z=h since solar panels attach at roof

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LOADING CRITERIA: (cont.)

Wind Load *(Per ASCE 7-05 Section 6.5)*

Assume worse-case building is 3-story, single-family home w/ exposure D (open water adjacent), mean roof height of 40'-0":

$K_{zt} = (1 + K_1 K_2 K_3)^2 = 1.0$ *(Eq. 6-3)*

$K_d = 0.85$ *(Eq. 6-3)*

$V = 170 \ mph$ *(Figure 6-1)*

$I = 1.0$ *(Table 6-1)*

$K_z = 1.22$ *(Table 6-3)*

$G = 0.85$ *(Sec. 6.5.8.1)*

$C_N = (-2.2) and (2.0)$ *(Figure 6-18A)*

$q_h = 0.00256 K_z K_{zt} K_d V^2 I$ *(Eq. 6-15)*

$= 0.00256\,(1.22)(1.0)(0.85)(170)^2(1.0) = 76.7$

$p = q_h G C_N$ *(Eq. 6-26)*

$p_{down} = 76.7(0.85)(2.0) = 130.4\,psf$

$p_{up} = 76.7(0.85)(-2.2) = 143.5\,psf$

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SOLAR PANEL FRAME DESIGN:

Solar Panel Clamp Anchorage:

$$P_{max} = \frac{32'' \times 63''}{2\left(144^{in}/_{ft}\right)}(0.98)(143.5psf) = 985lbs$$ *uplift per pair of clamps*

where effective wind area is 98% of total solar panel area due to 1/2" gap between solar panels

TRY: (4) 1/8" diameter bolts

$$P_{allow} = 45ksi \times \left(\frac{1}{8}''\right)^2 \times \frac{\pi}{4} \times 4 \times 0.75 \times 1.33 = 2{,}202lbs \geq P_{max}$$

Provide: ***(4) 1/8" diameter bolts (2 per clamp)***

Top Rack Pivot:

$V_{\max} = P_{\max} = 985lbs$ *(see above)*

TRY: (4) 1/4" diameter bolts

$$V_{allow} = 0.4 \times 24ksi \times \left(\frac{1''}{4}\right)^2 \times \frac{\pi}{4} \times 4 \times 0.75 \times 1.33 = 1{,}879lbs \geq V_{\max}$$

Provide: ***(4) 1/4" diameter bolts***

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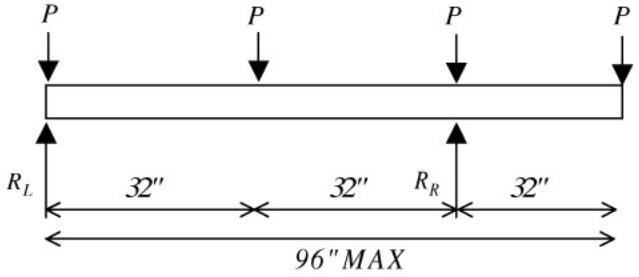
SOLAR PANEL FRAME DESIGN:

Extrusion Beam:



$$P_{max} = \frac{32'' \times 63''}{2\left(144^{in}/_{ft}\right)}(0.98)(143.5psf) = 985lbs \qquad \text{of uplift}$$

$$R_L = 1{,}096\,lbs \qquad R_R = 2{,}923\,lbs$$

$$M_{max} = 2.51kip-in$$

$$S_{x,req} = \frac{M_{max}}{(0.6)(F_y)} = \frac{2.51kip-in\left(12^{in}/_{ft}\right)}{(0.6)(16ksi)} = 3.14in^3 \le S_{x,provided}$$

$$A_{req} = \frac{V_{max}}{F_y}\left(\frac{2}{3}\right) = \frac{2{,}923lbs}{16ksi}\left(\frac{2}{3}\right) = 0.122in^2 \le A_{provided}$$

See following page for main extrusion beam section properties

Provide: ***Alluminum 6063-T5 Alloy U-Shaped Beam w/ required section properties shown above (96" maximum length)***

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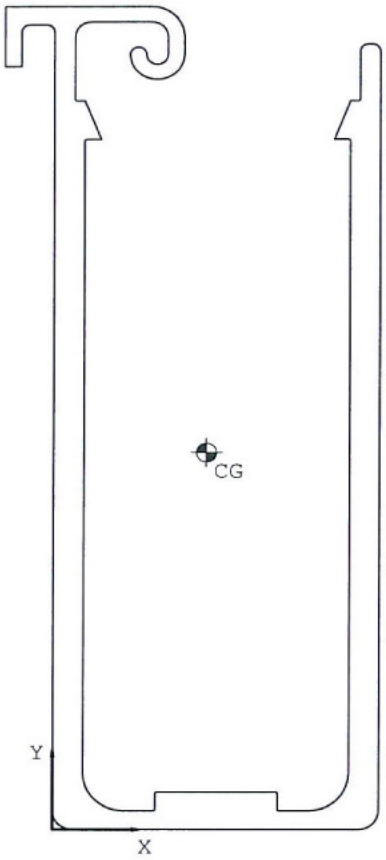
SOLAR PANEL FRAME DESIGN:

Extrusion Beam: (cont.)

MAIN EXTRUSION BEAM PROPERTIES
REVISED W/ 5½" DEPTH

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Area:                        2.4599 sq in
Perimeter:                   28.8336 in
Bounding box:          X: -0.3000  --  2.0000 in
                       Y: 0.0000  --  5.5000 in
Centroid:              X: 0.9327 in
                       Y: 2.5185 in
Moments of inertia:    X: 23.4994 sq in sq in
                       Y: 3.9266 sq in sq in
Product of inertia:   XY: 5.3097 sq in sq in
Radii of gyration:     X: 3.0908 in
                       Y: 1.2634 in
Principal moments (sq in sq in) and X-Y directions about centroid:
                       I: 1.7509 along [0.0760 -0.9971]
                       J: 7.9328 along [0.9971 0.0760]
Section Modulus:       X: 3.1498 cu in
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SOLAR PANEL FRAME DESIGN:

Riser Plate:

$$V_{max} = \frac{32'' \times 63''}{\left(144\,{}^{in}/_{ft}\right)}(0.98)(143.5psf) = 1{,}970\,lbs$$

TRY: (4) 5/16" diameter screws

$$V_{allow} = 0.4 \times 24ksi \times \left(\frac{5''}{16}\right)^2 \times \frac{\pi}{4} \times 4 \times 0.75 \times 1.33 = 2{,}937lbs \geq V_{max}$$

Check Plate Rupture:

$$V_{allow} = \left(\frac{3''}{16}\right) \times \left[(1.5'') - (2)\left(\frac{5''}{16} + \frac{1''}{16}\right)\right] \times 0.75 \times 16ksi \times 1.33 = 2{,}244lbs \geq V_{max}$$

Provide: ***(4) 5/16" diameter screws***

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SOLAR PANEL FRAME DESIGN:

Riser Bolt:

$$T_{max} = \frac{32'' \times 63''}{\left(144^{in}/_{ft}\right)}(0.98)(143.5psf) = 1{,}970lbs$$

$$V_{max} = \frac{63'' \times 196''}{\left(144in/_{ft}\right)} \times \frac{4psf}{6bolts} = 57lbs$$

TRY: 5/8" diameter bolt

$$T_{allow} = 0.75 \times \left(\frac{5''}{8}\right)^2 \times \frac{\pi}{4} \times 45ksi \times 1.33 = 13{,}770lbs \geq T_{max}$$

$$V_{allow} = 0.75 \times \left(\frac{5''}{8}\right)^2 \times \frac{\pi}{4} \times 24ksi \times 1.33 = 7{,}344lbs \geq V_{max}$$

Check Combined Loading:

$$\left(\frac{V_{max}}{V_{allow}} + \frac{T_{max}}{T_{allow}}\right) = \left(\frac{57lbs}{7{,}344lbs} + \frac{1{,}970lbs}{13{,}770lbs}\right) = 0.0078 + 0.143 = 0.151 \leq 1.0$$

Provide: ***5/8" diameter bolt***

Lag Bolts to Rafter Connection:

$T_{max} = 1{,}970lbs$ *(see above)*

$V_{max} = 57lbs$

TRY: (2) 3/8" diameter x 6" long wood screws

$$V_{allow} = 180lbs \times 1.33 \times 2 = 478lbs \geq V_{max}$$

$$T_{allow} = 296lbs/_{inch} \times 4in \times 2 \times 1.33 = 3{,}150lbs \geq T_{max}$$

Check Combined Loading:

$$\left(\frac{V_{max}}{V_{allow}} + \frac{T_{max}}{T_{allow}}\right) = \left(\frac{57lbs}{478lbs} + \frac{1{,}970lbs}{3{,}150lbs}\right) = 0.119 + 0.625 = 0.744 \leq 1.0$$

Provide: ***(2) 3/8" diameter x 6" long screws***

TABLE 11.1 Mechanical Property Limits—Extruded Wire, Rod, Bar and Profiles ⑥ (continued)

ALLOY AND TEMPER	SPECIFIED DIAMETER OR THICKNESS ① OR MINIMUM DISTANCE ACROSS FLATS in.	AREA sq. in.	TENSILE STRENGTH—ksi				ELONGATION ② percent min. in 2 in. or 4D ③
			ULTIMATE		YIELD		
			min.	max.	min.	max.	
6061							
6061-O	All	All	..	22.0	..	16.0	16
6061-T1	Up thru 0.625	All	26.0	..	14.0	..	16
6061-T4, T4510 ⑤⑦ and T4511 ⑤⑦	All	All	26.0	..	16.0	..	16
6061-T42 ④⑧	All	All	26.0	..	12.0	..	16
6061-T51	Up thru 0.625	All	35.0	..	30.0	..	8
6061-T6, T62 ④⑧, T6510 ⑤	Up thru 0.249	All	38.0	..	35.0	..	8
and T6511 ⑤	0.250 and over	All	38.0	..	35.0	..	10
6063							
6063-O	All	All	..	19.0	..	..	18
6063-T1	Up thru 0.500	All	17.0	..	9.0	..	12
	0.501-1.000	All	16.0	..	8.0	..	12
6063-T4 and T42 ④⑧	Up thru 0.500	All	19.0	..	10.0	..	14
	0.501-1.000	All	18.0	..	9.0	..	14
6063-T5	Up thru 0.500	All	22.0	..	16.0	..	8
	0.501-1.000	All	21.0	..	15.0	..	8
6063-T52	Up thru 1.000	All	22.0	30.0	16.0	25.0	8
6063-T6 and T62 ④⑧	Up thru 0.124	All	30.0	..	25.0	..	8
	0.125-1.000	All	30.0	..	25.0	..	10
6066							
6066-O	All	All	..	29.0	..	18.0	16
6066-T4, T4510 ⑤⑦ and T4511 ⑤⑦	All	All	40.0	..	25.0	..	14
6066-T42 ④⑧	All	All	40.0	..	24.0	..	14
6066-T6, T6510 ⑤ and T6511 ⑤	All	All	50.0	..	45.0	..	8
6066-T62 ④⑧	All	All	50.0	..	42.0	..	8
6070							
6070-T6 and T62 ④⑧	Up thru 2.999	Up thru 32	48.0	..	45.0	..	6
6105							
6105-T1	Up thru 0.500	All	25.0	..	15.0	..	16
6105-T5	Up thru 0.500	All	38.0	..	35.0	..	8
6162							
6162-T5, T5510 ⑤ and T5511 ⑤	Up thru 1.000	All	37.0	..	34.0	..	7
6162-T6, T6510 ⑤	Up thru 0.249	All	38.0	..	35.0	..	8
and T6511 ⑤	0.250-0.499	All	38.0	..	35.0	..	10
6262							
6262-T6, T62 ④⑧, T6510 ⑤ and T6511 ⑤	All	All	38.0	..	35.0	..	10
6351							
6351-T1	Up thru 0.499	Up thru 20	26.0	..	13.0	..	15
6351-T4	Up thru 0.749	All	32.0	..	19.0	..	16
6351-T5	Up thru 0.249	All	38.0	..	35.0	..	8
	0.250-1.000	All	38.0	..	35.0	..	10
6351-T51	0.125-1.000	Up thru 20	36.0	..	33.0	..	10
6351-T54	Up thru 0.500	Up thru 20	30.0	..	20.0	..	10
6351-T6	Up thru 0.124	All	42.0	..	37.0	..	8
	0.125-0.749	All	42.0	..	37.0	..	10
6463							
6463-T1	Up thru 0.500	Up thru 20	17.0	..	9.0	..	12
6463-T5	Up thru 0.500	Up thru 20	22.0	..	16.0	..	8
6463-T6 and T62 ④⑧	Up thru 0.124	Up thru 20	30.0	..	25.0	..	8
	0.125-0.500	Up thru 20	30.0	..	25.0	..	10
7005							
7005-T53	Up thru 0.750	All	50.0	..	44.0	..	10
7050							
7050-T73510 ⑨ and T73511 ⑨	Up thru 5.000	Up thru 32	70.0	..	60.0	..	8
7050-T74510 ⑪⑬ and T74511 ⑪⑬	Up thru 5.000	Up thru 32	73.0	..	63.0	..	7
7050-T76510 ⑫ and T76511 ⑫	Up thru 0.499	Up thru 32	77.0	..	68.0	..	7
	0.500-5.000	Up thru 32	79.0	..	69.0	..	7

For all numbered footnotes, see page 11-5.