



# BREIHZ QAZI ENGINEERING, INC.

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Civil & Structural Engineering  
Seismic Hazard Reduction  
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Fax: (310) 530-0184

By: <u>KK</u>	Project: <u>Aluminum Shapes Solar Panel Assembly</u>	Sheet: <u>1 Of 9</u>
Date: <u>6/9/09</u>	<u>4231 Liberty Blvd., South Gate, CA 90280</u>	Job No: <u>9-026E</u>
Checked: _____	<u>Bryan Bosveld: (775) 580-2120</u>	

## STRUCTURAL DESIGN CALCULATIONS

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:

LOADING CRITERIA	Pg. 2
SOLAR PANEL FRAME DESIGN	Pg. 4
PANEL ROOF ANCHORAGE DESIGN	Pg. 8
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### 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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DATE	06/09/09		Solar Panel Assembly Design	JOB NO	9-026ER
CHECKED			(Rated for 90mph)		

## 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)

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

↑  
GOVERNS

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

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

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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CHECKED							

## 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":

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

$$K_d = 0.85 \quad (\text{Eq. 6-3})$$

$$V = 90 \text{ mph} \quad (\text{Figure 6-1})$$

$$I = 1.0 \quad (\text{Table 6-1})$$

$$K_z = 1.04 \quad (\text{Table 6-3})$$

$$G = 0.85 \quad (\text{Sec. 6.5.8.1})$$

$$C_N = (-2.2) \text{ and } (2.0) \quad (\text{Figure 6-18A})$$

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

$$= 0.00256 (1.04)(1.0)(0.85)(90)^2 (1.0) = 18.3$$

$$p = q_h G C_N \quad (\text{Eq. 6-26})$$

$$p_{down} = 18.3(0.85)(2.0) = 31.2 \text{ psf}$$

$$p_{up} = 18.3(0.85)(-2.2) = 34.3 \text{ psf}$$





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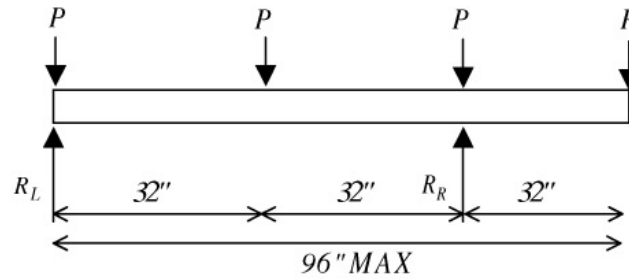
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## SOLAR PANEL FRAME DESIGN:

### Extrusion Beam:



$$P_{max} = \frac{32'' \times 63''}{2 \left( 144 \frac{in}{ft} \right)} (0.98)(34.3psf) = 235lbs \quad \text{of uplift}$$

$$R_L = 480lbs \quad R_R = 235lbs$$

$$M_{max} = 640kip - ft$$

$$S_{x,req} = \frac{M_{max}}{(0.6)(F_y)} = \frac{0.64kip - ft \left( 12 \frac{in}{ft} \right)}{(0.6)(16ksi)} = 0.8in^3 \leq S_{x,provided} = 1.39in^3$$

$$A_{req} = \frac{V_{max}}{F_y} \left( \frac{2}{3} \right) = \frac{480lbs}{16ksi} \left( \frac{2}{3} \right) = 0.02in^2 \leq A_{provided} = 1.6in^2$$

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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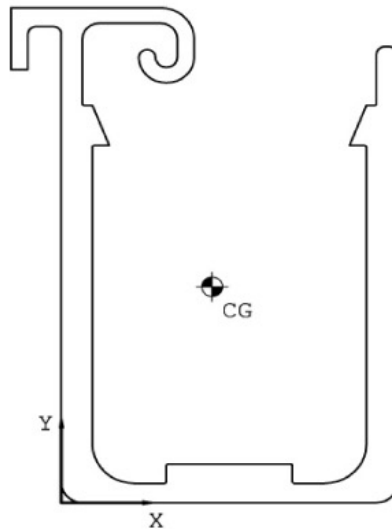
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BY	<u>KK</u>	PROJECT	<u>Aluminum Shapes, Inc.</u>	SHEET	<u>6</u> OF
DATE	<u>06/09/09</u>		<u>Solar Panel Assembly Design</u>	JOB NO	<u>9-026ER</u>
CHECKED	_____		_____		

## SOLAR PANEL FRAME DESIGN:

### *Extrusion Beam: (cont.)*

#### MAIN EXTRUSION BEAM PROPERTIES



```

Area: 1.6089 sq in
Perimeter: 19.6336 in
Bounding box: X: -0.3000 -- 2.0000 in
               Y: 0.0000 -- 3.2000 in
Centroid: X: 0.8971 in
           Y: 1.3964 in
Moments of inertia: X: 4.9946 sq in sq in
                   Y: 2.3724 sq in sq in
Product of inertia: XY: 1.7418 sq in sq in
Radii of gyration: X: 1.7619 in
                  Y: 1.2143 in
Principal moments (sq in sq in) and X-Y directions about centroid:
I: 0.9910 along [0.3012 -0.9536]
J: 1.9439 along [0.9536 0.3012]
Section Modulus: X: 1.3921 cu in

```





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## SOLAR PANEL FRAME DESIGN:

### **Riser Plate:**

$$V_{max} = \frac{32" \times 63"}{144 \text{ in/ft}} (0.98)(34.3 \text{ psf}) = 471 \text{ lbs}$$

TRY: (4) 1/8" diameter screws

$$V_{allow} = 0.4 \times 24 \text{ ksi} \times \left(\frac{1"}{8}\right)^2 \times \frac{\pi}{4} \times 4 \times 0.75 \times 1.33 = 471 \text{ lbs} \geq V_{max}$$

Check Plate Rupture:

$$V_{allow} = \left(\frac{3"}{16}\right) \times \left[ (1.37") - \left(2 \left(\frac{1"}{8} + \frac{1"}{16}\right)\right) \right] \times 0.75 \times 16 \text{ ksi} \times 1.33 = 2,977 \text{ lbs} \geq V_{max}$$

<b>Provide: (4) 1/8" diameter screws</b>
--



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CHECKED							

## SOLAR PANEL FRAME DESIGN:

### **Riser Bolt:**

$$T_{max} = \frac{32" \times 63"}{\left(\frac{144 \text{ in}}{\text{ft}}\right)} (0.98)(34.3 \text{ psf}) = 471 \text{ lbs}$$

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

TRY: 5/8" diameter bolt

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

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

Check Combined Loading:

$$\left(\frac{V_{max}}{V_{allow}} + \frac{T_{max}}{T_{allow}}\right) = \left(\frac{57 \text{ lbs}}{7,344 \text{ lbs}} + \frac{471 \text{ lbs}}{13,770 \text{ lbs}}\right) = 0.0078 + 0.034 = 0.041 \leq 1.0$$

<b>Provide:</b> <b>5/8" diameter bolt</b>
---

### **Lag Bolts to Rafter Connection:**

$$T_{max} = 471 \text{ lbs} \quad (\text{see above})$$

$$V_{max} = 57 \text{ lbs}$$

TRY: (2) 3/8" diameter x 4" long wood screws

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

$$T_{allow} = 296 \text{ lbs/inch} \times 2 \text{ in} \times 2 \times 1.33 = 1,574 \text{ lbs} \geq T_{max}$$

Check Combined Loading:

$$\left(\frac{V_{max}}{V_{allow}} + \frac{T_{max}}{T_{allow}}\right) = \left(\frac{57 \text{ lbs}}{478 \text{ lbs}} + \frac{471 \text{ lbs}}{1,574 \text{ lbs}}\right) = 0.119 + 0.300 = 0.419 \leq 1.0$$

<b>Provide:</b> <b>(2) 3/8" diameter x 4" long screws</b>
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**TABLE 11.1 Mechanical Property Limits—Extruded Wire, Rod, Bar and Profiles®**  
(continued)

#9

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.	
<b>6061</b>							
6061-O	All	All	..	22.0	..	16.0	16
6061-T1	Up thru 0.625	All	26.0	..	14.0	..	16
6061-T4, T4510 ④⑦ and T4511 ④⑦	All	All	26.0	..	16.0	..	16
6061-T42 ④⑥	All	All	26.0	..	12.0	..	16
6061-T51	Up thru 0.625	All	35.0	..	30.0	..	8
6061-T6, T62 ④⑥, T6510 ④ and T6511 ④	Up thru 0.249 0.250 and over	All	38.0	..	35.0	..	8
		All	38.0	..	35.0	..	10
<b>6063</b>							
6063-O	All	All	..	19.0	..	..	18
	Up thru 0.500	All	17.0	..	9.0	..	12
6063-T1	0.501-1.000	All	16.0	..	8.0	..	12
	Up thru 0.500	All	19.0	..	10.0	..	14
6063-T4 and T42 ④⑥	0.501-1.000	All	18.0	..	9.0	..	14
	Up thru 0.500	All	22.0	..	16.0	..	8
6063-T5	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
	Up thru 0.124	All	30.0	..	25.0	..	8
6063-T6 and T62 ④⑥	0.125-1.000	All	30.0	..	25.0	..	10
<b>6066</b>							
6066-O	All	All	..	29.0	..	18.0	16
6066-T4, T4510 ④⑦ and T4511 ④⑦	All	All	40.0	..	25.0	..	14
6066-T42 ④⑥	All	All	40.0	..	24.0	..	14
6066-T6, T6510 ④ and T6511 ④	All	All	50.0	..	45.0	..	8
6066-T62 ④⑥	All	All	50.0	..	42.0	..	8
<b>6070</b>							
6070-T6 and T62 ④⑥	Up thru 2.999	Up thru 32	48.0	..	45.0	..	6
<b>6105</b>							
6105-T1	Up thru 0.500	All	25.0	..	15.0	..	16
6105-T5	Up thru 0.500	All	38.0	..	35.0	..	8
<b>6162</b>							
6162-T5, T5510 ④ and T5511 ④	Up thru 1.000	All	37.0	..	34.0	..	7
	Up thru 0.249	All	38.0	..	35.0	..	8
6162-T6, T6510 ④ and T6511 ④	0.250-0.499	All	38.0	..	35.0	..	10
<b>6262</b>							
6262-T6, T62 ④⑥, T6510 ④ and T6511 ④	All	All	38.0	..	35.0	..	10
<b>6351</b>							
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
<b>6463</b>							
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
	Up thru 0.124	Up thru 20	30.0	..	25.0	..	8
6463-T6 and T62 ④⑥	0.125-0.500	Up thru 20	30.0	..	25.0	..	10
<b>7005</b>							
7005-T53	Up thru 0.750	All	50.0	..	44.0	..	10
<b>7050</b>							
7050-T73510 ④ and T73511 ④	Up thru 5.000	Up thru 32	70.0	..	60.0	..	8
7050-T74510 ④⑤ and T74511 ④⑤	Up thru 5.000	Up thru 32	73.0	..	63.0	..	7
	Up thru 0.499	Up thru 32	77.0	..	68.0	..	7
7050-T76510 ④ and T76511 ④	0.500-5.000	Up thru 32	79.0	..	69.0	..	7

For all numbered footnotes, see page 11-5.