Solar Master Plan

BERKELEY UNIFIED SCHOOL DISTRICT (BUSD)

Chapter 3

Structural Evaluations

Structural Evaluations

Once a school district has identified the buildings that it believes are the best candidates for a PV system, the district will want to consider whether the roofs can support the gravitational, wind and seismic loads of a PV system. In other words, can the PV system meet the strict building code requirements that apply to California's public schools?

The U.S. Department of Energy contracted with Interactive Resources in Richmond, CA to review the "as-built" drawings for a selection of schools identified as good candidates for PV systems. The purpose of the review was to identify any structural conditions that might indicate that the roof of a target building would not meet the building code requirements. The buildings were not physically inspected during this review; the assessment was based on a review of the drawings only.

The reports that follow describe in detail what Interactive Resources considered in its evaluation of several school roofs located in this district. While it is not necessary to conduct this type of evaluation prior to seeking bids on a PV project – a review and inspection can be done at a later point in the process – the district can save itself and interested vendors time and money by doing a preliminary assessment prior to seeking bids.

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94801
510.236.7435
Fax 510.232.5325
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October 8, 2010

Mr. Dan Olis
National Renewable Energy Laboratories
1617 Cole Blvd.
Golden, CO 80401

Subject: **NREL: Structural Evaluations** **2010-004.01**
BUSD - Berkeley Arts Magnet
Evaluation of Existing Framing

Dear Mr. Olis:

In accordance with the provisions of our agreement, we have completed our preliminary structural investigation of the existing roof framing for the Berkeley Arts Magnet School located in Berkeley, CA. The purpose of the evaluation is to rapidly assess if the existing framing can support a solar array and determine if there are potential structural deficiencies that may preclude the addition of a solar array.

The evaluation is based on an in-house review of the available "as-built" drawings furnished by the Berkeley Unified School District. No site visit has been performed as part of this phase of the work; however, should the project move forward, a site visit during a subsequent phase is planned to confirm that the structure, in general, conforms to the "as-built" drawings. At that time the results presented in this rapid evaluation should be reviewed and any refinement prepared as necessary.

This letter summarizes the results of our preliminary evaluation.

Existing Conditions

The existing structure is located at 2015 Virginia St in Berkeley, California. It is a 1 and 2 story U-shaped structure measuring approximately 27,500 sqft. The original year of construction was around 1940 with an upgrade designed around 1993/1994.

The roof of the existing structure is a membrane roof over a panelized plywood deck supported by timber trusses spaced at 24" on center. The trusses are supported by wood purlins and steel joists. The roof framing is supported by interior and perimeter concrete bearing walls. Resistance to lateral loads due to wind or earthquake forces is provided by the horizontal plywood diaphragm and the vertical concrete shear walls.

Preliminary Structural Evaluation

The evaluation involves investigating two distinct aspects of the framing. First, can the framing support the added gravity loads to be imposed by the proposed solar array and second, can the existing lateral force resisting system support the added wind and/or seismic horizontal forces without triggering a code required upgrade of the structure? The latter is limited to a maximum of 10% of the existing tributary structural dead load as permitted by ASCE 7-05 Section 11B.3 and the California Building Code (CBC) Section

3403.2.3.1, Exception 2. The analysis assumes that there is only one roof membrane present and that should a re-roof be performed either prior to installation of the solar array or during the life of the array that the existing will be removed and not roofed over. For the purposes of this analysis, a second roof membrane over the existing has been excluded to maximize the potential size of the solar array.

Where the racking system keeps the array close to the roof, wind loads generally do not represent a significant increase in forces to the existing main lateral force resisting elements. The proposed array used in the analysis is planned to be positively anchored to the structure without the use of any ballast. The design wind speed for this site is 85 MPH (3-second gust), Exposure C. A Suntech STP 260 solar module has been selected for use in the framing evaluations. To support the modules and provide a 20° tilt to the array, a SunLink racking system has been used. The anticipated weight of the array (module + racking system) use in the analysis is estimated to be 80.5# per module. A breakdown of the design loads used in the evaluation of the existing framing is shown in the Table at the end of this report.

1) Evaluation of Gravity Loads:

The existing roof deck is shown as ½" plywood over 2x trusses spaced at 24 inches on center. At this time the array layout has not been determined. In order to perform an evaluation of the gravity loads on the existing framing, we used a 4x1 panel arrangement as manufactured by SunLink. Our evaluation shows that the existing plywood deck and supporting framing are adequate to support the anticipated gravity loads and that, therefore, the existing framing is acceptable for any orientation or distribution of modules in the array(s). Attached for your reference are our preliminary calculations.

2) Evaluation of Lateral Loads:

The total existing roof area is approximately 27,488 sq. ft. with an estimated dead load of 15 psf. The minimum area of exterior walls that is tributary to the roof in either the north–south or east–west direction, is 4,329 sq ft. with an estimated dead load of 137.5 psf. Combined together the total effective existing roof dead load is = 1,007,558 lbs.

In order to avoid triggering a code required upgrade, the weight of any added solar array should not exceed 10% (Total Dead Load) or 100,756#. Dividing this weight by the combined weight per module of the proposed array (59.5+21) the maximum number of permissible modules for the array can be determined as 1,255. However, checking the available roof area against the plan area of each module, the actual number of modules that can be used is significantly less than that based on 10% of the existing mass. This module count is 884. Please note this module quantity does not account for any setbacks that may be required or aisle ways, shading restrictions or any other roof obstructions that may affect the final array layout.

Conclusions

In conclusion, we believe that positively anchored solar (PV) arrays can be supported on the existing structures. They should not exceed either the Maximum Array Weight or the

Maximum Number of Modules shown below. Either the SunLink 4x1 or 3x1 panel system is acceptable for this project.

Design Parameters	
Existing roof dead load	15 psf
Basic Wind Speed (3-second gust)	85 MPH (Exposure C)
Seismic force (Allowable Stress Design)	0.441 $W_p \simeq$ 35# per module
Module	Suntech STP 260
Module weight	Approximately 59.5# each
Module Area	20.9 square feet
Module Mounting System	By SunLink Corporation
System weight	Approximately 21# per module
System tilt angle	20º
Maximum PV Array	
Maximum Array Weight (10% Total Est. Roof DL) (with or w/o ballast)	100,756#
Maximum Number of Modules	884

If you have any questions regarding this letter, please call me at (209) 736-2079.

Sincerely,
Interactive Resources

Paul M. Westermann, P.E., S.E.
Principal

REGISTERED PROFESSIONAL ENGINEER
PAUL M. WESTERMANN
NO. S 003097
REN. 9-30-11
STRUCTURAL
STATE OF CALIFORNIA

Enclosure

Design Criteria

Roof Framing

Roof Live Load	20 psf	Slope 1/4:12 Reducible
Live Load at Solar Modules	10	(Special roof load, greenhouse)

Roof Dead Load

Built-up Roof	4.0 psf	
1/2" Plywood	1.5	
Insulation	1.5	
2x roof framing (trusses)	1.1	
Steel Beams	1.2	
Ceiling Framing (trusses)	1.5	
Acoustical Tile Ceiling	1.5	
Mech/Elec/Misc	2.0	
	14.3 psf	USE 15 psf

Existing Exterior Walls DL

11" Concrete 137.5 psf

Parapet Height ~ 3.0 ft

Determine Allowable Solar Array Size

Determine allowable loads as a percent of the exisitng tributary DL so as not to trigger a Code reqired Seismic Upgrade

Per ASCE 7-05, Section11B.3 - a seismic upgrade is not required if the addition does not increase the seismic forces by 10%

(E) Building Dimensions

B = 235.00' D = 234.00'

Existing Roof Area - 27,488 sf (per original construction documents)

(E) DL = 1,007,558 (= Roof Area * DL + Trib Wall DL * Trib Wall Area)

Trib Wall DL = 137.5 psf*min(235, 234')*2*(12.5/2+3' Parapet)

10% DL = 100756

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510.236.7435
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NREL Structural Evaluation
BUSD – Berkeley Arts Magnet

job 2010-004.01

rev.	description	date	by	drawn PMW
				scale
				date 10/8/10

Prposed Solar Array

Module - Suntech STP260   Titl-angle - 20°
Module Area - 20.9 sf   Plan Area ~ 1.49 * Module Area = 31.1 sf
Module Wt. - 59.5 #   Frmg per Module - 20.8

Basic Wind Speed = 85 mph
Exposure - C   (ASCE 7-05 Section 6.5.6.2)

Allowable number of Modules

$$\text{No. Modules Allowed} = \frac{\text{10\% (E) DL}}{\text{Array Wt}} = \text{1255 modules}$$

Array Wt = 80.3 #/module

$$\text{No. Mod. based on roof area} = \frac{\text{Roof Area}}{\text{Plan Area}} = \text{884 modules}$$

Check (E) Framing

(E) D+L = 1007558+27488*20 psf = 1,557,318
(E) D+L+ array = 1007558+27488*10 psf +884*1254.7 = 1,353,423

$$\Delta = \frac{1,353,423}{1,557,318} - 1 = -0.131 \quad \text{Ok}$$

Change in load on deck

(E) D+L = 35 psf
(E) D+L+ array = 27.6 psf

$$\Delta = \frac{27.6}{35} - 1 = -0.21 \quad \text{Ok}$$

Racking Point Loads

for SunLink System

No. Modules per Support ~ 2

P = 2 * (59.5+20.8) = 161

2010-004-01 10 Solar Design.xls, (E) Frmg Eval

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rev.	description	date	by	drawn PMW
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				date 10/8/10

job 2010-004.01

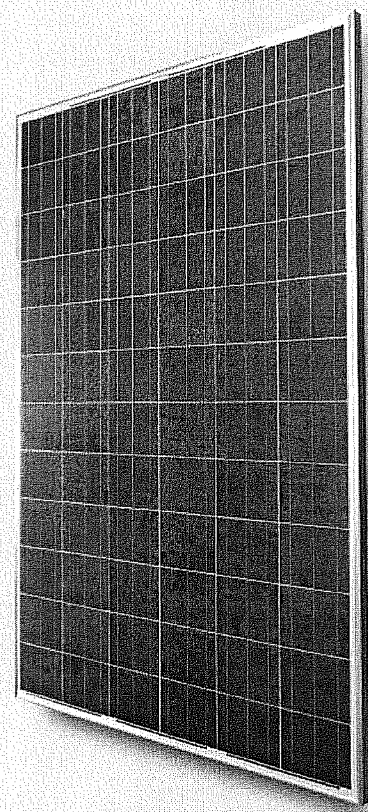
SUNTECH

Solar powering a green future™

STP280 - 24/Vb-1
STP270 - 24/Vb-1
STP260 - 24/Vb-1

270 Watt

POLY-CRYSTALLINE SOLAR PANEL



Features

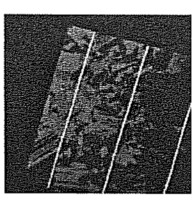
- High conversion eff ciency based on innovative photovoltaic technologies
- High reliability with guaranteed +/-3% power output tolerance
- Withstands high wind-pressure and snow load, and extreme temperature variations

Quality and Safety

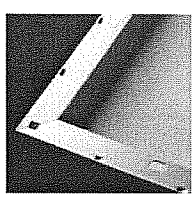
- Industry-leading, transferable 25-year power output warranty
- Rigorous quality control meeting the highest international standards
- ISO 9001:2000 (Quality Management System) and ISO 14001:2004 (Environmental Management System) certified factories deliver world class products
- UL listing:UL1703, CULus, Class C fire rating, conformity to CE

Recommended Applications

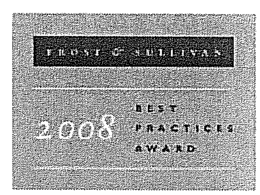
- On-grid utility systems
- On-grid commercial systems
- Off-grid ground mounted systems



Suntech's technology yields improvements to BSF structure and anti-reflective coating to increase conversion efficiency



Unique design on drainage holes and rigid construction prevents frame from deforming or breaking due to freezing weather and other forces



Suntech was named Frost and Sullivan's 2008 Solar Energy Development Company of the Year

The panel provides more field power output through an advanced cell texturing and isolation process, which improves low irradiance performance

BUSD- ARTS MAGNET 2010-004.01 3 OF A

SUNTECH

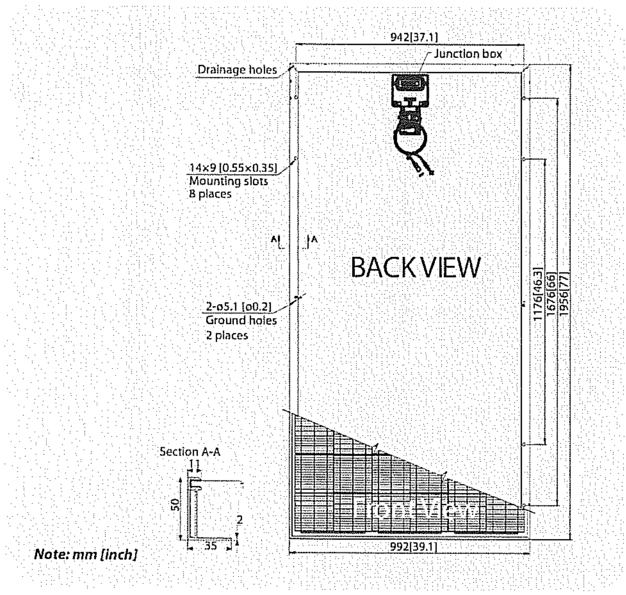
Solar powering a green future™

STP280 - 24/Vb-1
STP270 - 24/Vb-1
STP260 - 24/Vb-1

Electrical Characteristics

Characteristics	STP280-24/Vb-1	STP270-24/Vb-1	STP260-24/Vb-1
Open - Circuit Voltage (Voc)	44.8V	44.5V	44V
Optimum Operating Voltage (Vmp)	35.2V	35V	34.8V
Short - Circuit Current (Isc)	8.33A	8.2A	8.09A
Optimum Operating Current (Imp)	7.95A	7.71A	7.47A
Maximum Power at STC (Pmax)	280Wp	270Wp	260Wp
Operating Temperature	-40°C to +85°C	-40°C to +85°C	-40°C to +85°C
Maximum System Voltage	600V DC	600V DC	600V DC
Maximum Series Fuse Rating	20A	20A	20A
Power Tolerance	±3 %	±3 %	±3 %

STC: Irradiance 1000W/m², Module temperature 25°C, AM=1.5



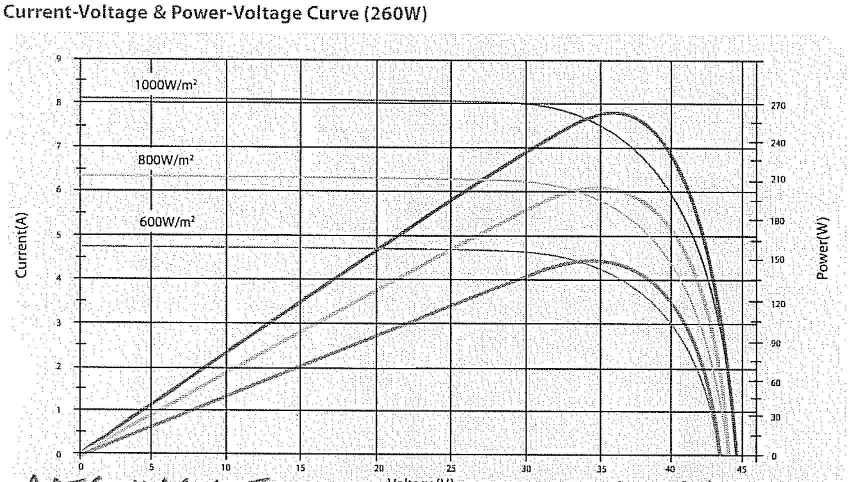
Mechanical Characteristics

Solar Cell	Poly-crystalline 156×156mm (6 inch)
No. of Cells	72 (6×12)
Dimensions	1956×992×50mm (77.0×39.1×2.0 inch)
Weight	27 kg (59.5 lbs.)
Front Glass	4mm(0.16 inch) tempered glass
Frame	Anodized aluminium alloy
Junction Box	IP65 rated
Output Cables	AIW(12AWG), asymmetrical lengths (-) 1200mm (47.2 inch) and (+) 800mm (31.5 inch), MC Plug Type IV connectors

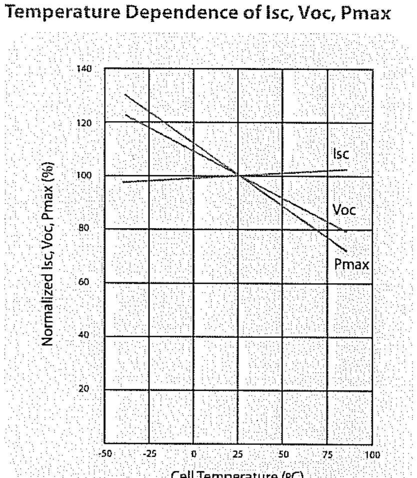
Temperature Coefficients

Nominal Operating Cell Temperature (**NOCT**)	45±2°C
Temperature Coefficient of Pmax	-(0.47 ± 0.05) %/°C
Temperature Coefficient of Voc	-(0.34 ± 0.01) %/°C
Temperature Coefficient of Isc	(0.055 ± 0.01) %/°C

Current-Voltage & Power-Voltage Curve (260W)



Temperature Dependence of Isc, Voc, Pmax



BUSD - ARTS MAGNET 2010-004.01 4 OF A

Seismic (IBC / ASCE 7) Seismic Design Category - D (CBC 1613.5.6 & ASCE 7-05, Sect. 11.6)

Building Category - II (ASCE 7-05 Table 1-1)
Seismic Importance Factor, I - 1.00 (ASCE 7-05 Table 11.5-1)
Soil Site Class - D (ASCE 7-05 Chapter 20)

Site Location		
Latitude	37.887°	N
Longitude	122.270°	W

S_s = 1.970
S_1 = 0.764 } See next Page

$S_{MS} = F_a S_s =$ 1.97 $F_a = 1$
$S_{M1} = F_v S_1 =$ 1.146 $F_v = 1.5$

$S_{DS} = 2/3\ S_{MS} =$ 1.313 $T_0 = 0.2\ S_{D1}/S_{DS} =$ 0.116
$S_{D1} = 2/3\ S_{M1} =$ 0.764 $T_s = S_{D1}/S_{DS} =$ 0.582

for $T < T_0$, $S_a = S_{DS}(0.4 + 0.6\ T/T_0)$

for $T_0 < T < T_s$, $S_a = S_{DS}$

for $T_s < T$, $S_a = S_{D1}/T$

$T = C_t h_n^x =$ 0.22 (ASCE Eq. 12.8-7)
$C_t =$ 0.020 (ASCE Table 12.8-2)
$h_n =$ 25.00
$x =$ 0.75 (ASCE Table 12.8-2)

Component Force (ASCE Section 13.3.1)

ASCE Eq. 13.3-1

$$F_p = \frac{0.4\ a_p S_{DS} W_p}{R_p / I_p}\left(1 + 2\frac{z}{h}\right) =$$ 0.630 Wp ***Controls*** z = h h = roof elev.

ASCE Eq. 13.3-2

$F_p\ max = 1.6\ S_{DS} I_p W_p =$ 2.101 Wp

ASCE Eq. 13.3-3

$F_p\ min = 0.3\ S_{DS} I_p W_p =$ 0.394 Wp

$I_p =$ 1.0 $a_p =$ 1.0 $R_p =$ 2.5

W_p = 80 # $\therefore F_p$ = 51 # for ASD, USE 0.7 * F_p = 35 #

2010-004-01 10 Solar Design.xls, ASCE Seis

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NREL Structural Evaluation
BUSD - Berkeley Arts Magnet

rev.	description	date	by	drawn	job
				PMW	2010-004.01
				scale	
				date 10/8/10	page 5 of A

Berkeley Unified School District
Berkeley Arts Magnet

Conterminous 48 States
2005 ASCE 7 Standard / 2007 California Building Code
Latitude = 37.877
Longitude = -122.27
Spectral Response Accelerations Ss and S1
Ss and S1 = Mapped Spectral Acceleration Values
Site Class B - Fa = 1.0 ,Fv = 1.0
Data are based on a 0.009999999776482582 deg grid spacing

Period (sec)	Sa (g)
0.2	1.970 (Ss, Site Class B)
1.0	0.764 (S1, Site Class B)

Conterminous 48 States
2005 ASCE 7 Standard / 2007 California Building Code
Latitude = 37.877
Longitude = -122.27
Spectral Response Accelerations SMs and SM1
SMs = Fa x Ss and SM1 = Fv x S1
Site Class D - Fa = 1.0 ,Fv = 1.5

Period (sec)	Sa (g)
0.2	1.970 (SMs, Site Class D)
1.0	1.147 (SM1, Site Class D)

Conterminous 48 States
2005 ASCE 7 Standard / 2007 California Building Code
Latitude = 37.877
Longitude = -122.27
Design Spectral Response Accelerations SDs and SD1
SDs = 2/3 x SMs and SD1 = 2/3 x SM1
Site Class D - Fa = 1.0 ,Fv = 1.5

Period (sec)	Sa (g)
0.2	1.313 (SDs, Site Class D)
1.0	0.764 (SD1, Site Class D)

Reference: "USGS Seismic Hazard Curves and Uniform Hazard Response Spectra", **NSHMP_HazardApp.jar** application

Berkeley Arts Magnet at Whittier

Location		Gross Available Area (ft^2)	Estimated PV Capacity		
			Rooftop (kWp)	Parking (kWp)	Total (kWp)
Berkeley Arts Magnet at Whittier					
2	Roofs (total)	22,000	140	0	140
	Building A	22,000			
Totals		**22,000**	**140**	**0**	**140**

Questions/Comments for District

1. Need PG&E billing information
2. What is age & condition of roofs?
3. Are there roof structural concerns?
4. Roof obstructions: ***significant***

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October 8, 2010

Mr. Dan Olis
National Renewable Energy Laboratories
1617 Cole Blvd.
Golden, CO 80401

Subject: **NREL Structural Evaluation** **2010-004.01**
BUSD – Jefferson Elementary
Evaluation of Existing Framing

Dear Mr. Olis:

In accordance with the provisions of our agreement, we have completed our preliminary structural investigation of the existing roof framing for the Jefferson Elementary School Facility located in Berkeley, CA. The purpose of the evaluation is to rapidly assess if the existing framing can support a solar array and determine if there are potential structural deficiencies that may preclude the addition of a solar array.

The evaluation is based on an in-house review of the available "as-built" drawings furnished by the Berkeley Unified School District. No site visit has been performed as part of this phase of the work; however, should the project move forward, a site visit during a subsequent phase is planned to confirm that the structure, in general, conforms to the "as-built" drawings. At that time the results presented in this rapid evaluation should be reviewed and any refinement prepared as necessary.

This letter summarizes the results of our preliminary evaluation.

Existing Conditions

The existing structure is located at 1400 Ada Street in Berkeley, California. It is comprised of 3 "Wings"; two 2-story Wings with classrooms and a final single story Wing with the Multi-Use and Kitchen facilities. Solar has been identified for potential installation on each of the "Wings". The year of construction is 1950.

The roof of the existing structure is a specified as a composition roof over concrete joist construction on Wings 1 and 2 and a composition roof over metal deck and steel framing at the Multi-Use at Wing 3. The roof framing at the Classroom wings is supported by concrete columns and concrete shear walls. Resistance to lateral loads due to wind or earthquake forces is provided by the horizontal concrete diaphragm and the vertical concrete shear walls.

The roof framing over the Multi-Use building is supported by steel columns and perimeter concrete shear walls. Resistance to lateral loads due to wind or earthquake forces is provided by the horizontal metal deck diaphragm and the vertical concrete shear walls.

Preliminary Structural Evaluation

The evaluation involves investigating two distinct aspects of the framing. First, can the framing support the added gravity loads to be imposed by the proposed solar array and second, can the existing lateral force resisting system support the added wind and/or seismic horizontal forces without triggering a code required upgrade of the structure? The latter is limited to a maximum of 10% of the existing tributary structural dead load as permitted by ASCE 7-05 Section 11B.3 and the California Building Code (CBC) Section 3403A.2.3.1, Exception 2. The analysis assumes that there is only one roof membrane present and that should a re-roof be performed either prior to installation of the solar array or during the life of the array that the existing will be removed and not roofed over. For the purposes of this analysis, a second roof membrane over the existing has been excluded to maximize the potential size of the solar array.

Where the racking system keeps the array close to the roof, wind loads generally do not represent a significant increase in forces to the existing main lateral force resisting elements. There are no parapets to prevent the array from sliding off of the roof, therefore, the proposed array used in the analysis is planned to be positively anchored to the structure without the use of any ballast. The design wind speed for this site is 85 MPH (3-second gust), Exposure C. A Suntech STP 260 solar module has been selected for use in the framing evaluations. To support the modules and provide a 20° tilt to the array, a SunLink racking system has been used. The anticipated weight of the array (module + racking system) use in the analysis is estimated to be 80.5# per module. A breakdown of the design loads used in the evaluation of the existing framing is shown in the Table at the end of this report.

1) Evaluation of Gravity Loads:

The existing roof deck at the classrooms is shown as 2 ½" concrete slab over 4x14 concrete joists spaced at 24 inches on center. At this time an array layout has not been determined. In order to perform an evaluation of the gravity loads on the existing framing, we used a 4x1 panel arrangement as manufactured by SunLink with the north-south axis parallel to existing concrete joists. This orientation results in the maximum concentration of loads to the least number of concrete joists. Our evaluation shows that the existing framing is adequate to support the anticipated loads and that, therefore, the existing framing is acceptable for any orientation or distribution of modules in the array(s). Attached for your reference are our preliminary calculations.

At the Multi-Use, the existing deck is not readily identified on the available "as-built" drawings. However, the proposed array has a dead load based on its plan area of approximately 3 psf. Per DSA IR 16-8, the design roof live load based on the array racking system selected may be taken as zero (racking system is low to the roof preventing storage beneath it). The existing deck (and supporting framing) can, therefore, be seen as adequate to support the proposed array.

2) Evaluation of Lateral Loads:

The total existing roof area where placement of arrays has been proposed is approximately 21,340 sq. ft. At the two story classroom wings, the roof area is 7,969 sq. ft. and 7,227 sq. ft. respectively with an estimated dead load of 72 psf. The exterior walls are 8" concrete with an estimated dead load of 100 psf. Combined together the total effective existing roof dead load at the @ Wing 1 is 697,007 lbs. and 639,873 lbs. @ Wing 2. At the Multi-Use, Wing 3, the roof area is 6,144 sq. ft. with an estimated dead load, including the exterior concrete walls, of 299,520 lbs.

In order to avoid triggering a code required upgrade, the weight of any added solar array should not exceed 10% (Total Dead Load) or 69,701# (Wing 1), 63,987# (Wing 2) and 29,952# (Wing 3). Dividing these weights by the combined weight per module of the proposed array (59.5+21) the maximum number of permissible modules for the array can be determined as 866+795+372 respectively. However, checking the available roof area against the plan area of each module, the actual number of modules that can be used is significantly less than that based on 10% of the existing mass. These module counts are 256+232+198 respectively. Please note these module quantities do not account for any setbacks that may be required or aisle ways, shading restrictions or any other roof obstructions that may affect the final array layout.

<u>Conclusions</u>

In conclusion, we believe that positively anchored solar (PV) arrays can be supported on the existing structures. They should not exceed either the Maximum Array Weight or the Maximum Number of Modules shown below. Either the SunLink 4x1 or 3x1 panel system is acceptable for this project.

Design Parameters	
Existing roof dead load	72 psf (Wings 1 & 2) 30 psf (Wing 3, Multi-Use)
Basic Wind Speed (3-second gust)	85 MPH (Exposure C)
Seismic force (Allowable Stress Design)	0.425 $W_p \simeq$ 34# per module
Module	Suntech STP 260
Module weight	Approximately 59.5# each
Module Area	20.9 square feet
Module Mounting System	By SunLink Corporation
System weight	Approximately 21# per module
System tilt angle	20º
Maximum PV Array	
Maximum Array Weight (10% Total Est. Roof DL)	69,701# (Wing 1) 63,987# (Wing 2) 29,952# (Wing 3)
Maximum Number of Modules (Limited by the available roof area)	256 (Wing 1) 232 (Wing 2) 198 (Wing 3)

If you have any questions regarding this letter, please call me at (209) 736-2079.

Sincerely,
Interactive Resources

Paul M. Westermann, P.E., S.E.
Principal

REGISTERED PROFESSIONAL ENGINEER
PAUL M. WESTERMANN
NO. S 003097
REN. 9-30-11
STRUCTURAL
STATE OF CALIFORNIA

Enclosure

Design Criteria

Roof Framing

Roof Live Load	20 psf	Slope 1/4:12 Reducible
Live Load at Solar Modules	10	(Special roof load, greenhouse)

Classrooms (Wings 1 & 2)

Roof Dead Load

Built-up Roof	6.0 psf	
4x14 Concrete Joists @ 24" o.c.	62.5	
w/ 2 1/2" concrete slab	0.0	
Acoustical Tile Ceiling	1.5	
Mech/Elec/Misc	2.0	
	72.0 psf	USE 72 psf

Multi-Use (Wing 3)

Roof Dead Load

Built-up Roof	6.0 psf	
Metal Deck	2.1	
Steel Framing	6.7	
Plaster Ceiling	10.0	
Mech/Elec/Misc	5.2	
	30 psf	USE 30 psf

Existing Exterior Walls DL

8" CMU Solid Grouted 100 psf

Parapet Height ~ 0.0 ft

Trib Ht. at Classrooms - 9.0' @ Multi-Use - 9.0'

Interior Partitions

USE 5.0 psf for seismic loads at roof at Classrooms only

Determine Allowable Solar Array Size

Determine allowable loads as a percent of the exisitng tributary DL so as not to trigger a Code reqired Seismic Upgrade

Per ASCE 7-05, Section11B.3 & CBC 3403A.2.3 - a seismic upgrade is not required if the addition does not increase the seismic forces by 10%

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Structural Engineers
117 Park Place
Point Richmond, CA 94801
510.236.7435
510.232.5325 (FAX)

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(E) Building Dimensions - Classroom Wing 1

B = 172.00' D = 46.33'

Existing Roof Area - 7,969 sf (per original construction documents)

(E) DL = 697,007 (= Roof Area * DL + Trib Wall DL * Trib Wall Area)
Trib Wall DL = 100 psf*min(172, 46.33')*2*(9+0' Parapet)

10% DL = 69701

Prposed Solar Array

Module - Suntech STP260 Titl-angle - 20°
Module Area - 20.9 sf Plan Area ~ 1.49 * Module Area = 31.1 sf
Module Wt. - 59.5 # Frmg per Module - 21

Basic Wind Speed = 85 mph
Exposure - C (ASCE 7-05 Section 6.5.6.2)

Allowable number of Modules

$$\text{No. Modules Allowed} = \frac{10\%\ (E)\ DL}{\text{Array Wt}} = 866 \text{ modules}$$

Array Wt = 80.5 #/module

$$\text{No. Mod. based on roof area} = \frac{\text{Roof Area}}{\text{Plan Area}} = 256 \text{ modules}$$

Check (E) Framing

(E) D+L = 697007+7969*20 psf = 856,387
(E) D+L+ array = 697007+7969*10 psf +256*80.5 = 797,305

$$\Delta = \frac{797{,}305}{856{,}387} - 1 = -0.069$$ Ok

Change in load on deck

(E) D+L = 92 psf
(E) D+L+ array = 84.6 psf

$$\Delta = \frac{84.6}{92} - 1 = -0.08$$ Ok

Racking Point Loads

for SunlLink System

No. Modules per Support ~ 2

P = 2 * (59.5+21) = 161

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SUNTECH

Solar powering a green future

STP280 - 24/Vb-1
STP270 - 24/Vb-1
STP260 - 24/Vb-1

270 Watt

POLY-CRYSTALLINE SOLAR PANEL

Features

- High conversion eff ciency based on innovative photovoltaic technologies
- High reliability with guaranteed +/-3% power output tolerance
- Withstands high wind-pressure and snow load, and extreme temperature variations

Quality and Safety

- Industry-leading, transferable 25-year power output warranty
- Rigorous quality control meeting the highest international standards
- ISO 9001:2000 (Quality Management System) and ISO 14001:2004 (Environmental Management System) certified factories deliver world class products
- UL listing:UL1703, CULus, Class C fire rating, conformity to CE

Recommended Applications

- On-grid utility systems
- On-grid commercial systems
- Off-grid ground mounted systems

Suntech's technology yields improvements to BSF structure and anti-reflective coating to increase conversion efficiency

Unique design on drainage holes and rigid construction prevents frame from deforming or breaking due to freezing weather and other forces

Suntech was named Frost and Sullivan's 2008 Solar Energy Development Company of the Year

The panel provides more field power output through an advanced cell texturing and isolation process, which improves low irradiance performance

SUNTECH

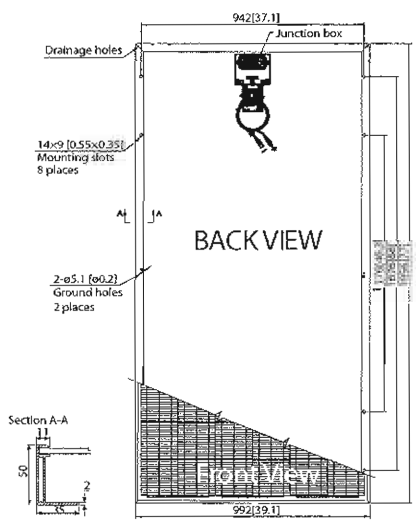
Solar powering a green future™

STP280 - 24/Vb-1
STP270 - 24/Vb-1
STP260 - 24/Vb-1

Electrical Characteristics

Characteristics	STP280-24/Vb-1	STP270-24/Vb-1	STP260-24/Vb-1
Open - Circuit Voltage (Voc)	44.8V	44.5V	44V
Optimum Operating Voltage (Vmp)	35.2V	35V	34.8V
Short - Circuit Current (Isc)	8.33A	8.2A	8.09A
Optimum Operating Current (Imp)	7.95A	7.71A	7.47A
Maximum Power at STC (Pmax)	280Wp	270Wp	260Wp
Operating Temperature	-40°C to +85°C	-40°C to +85°C	-40°C to +85°C
Maximum System Voltage	600V DC	600V DC	600V DC
Maximum Series Fuse Rating	20A	20A	20A
Power Tolerance	±3 %	±3 %	±3 %

STC: Irradiance 1000W/m², Module temperature 25°C, AM=1.5



Note: mm [inch]

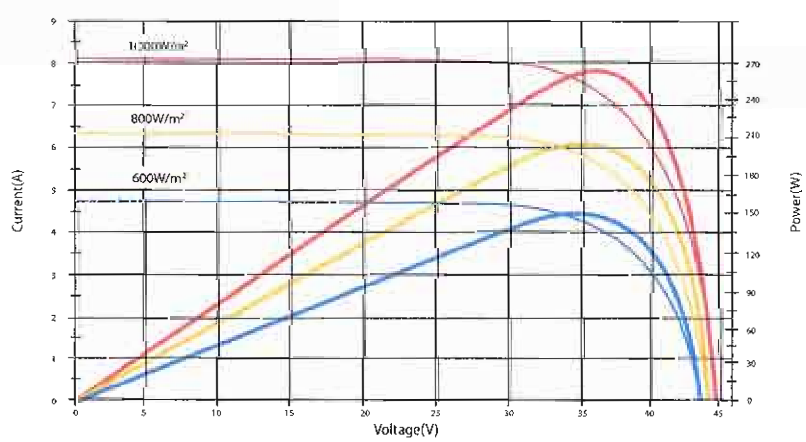
Mechanical Characteristics

Solar Cell	Poly-crystalline 156×156mm (6 inch)
No. of Cells	72 (6×12)
Dimensions	1956×992×50mm (77.0×39.1×2.0 inch)
Weight	27 kg (59.5 lbs.)
Front Glass	4mm(0.16 inch) tempered glass
Frame	Anodized aluminium alloy
Junction Box	IP65 rated
Output Cables	AIW(12AWG), asymmetrical lengths (-) 1200mm (47.2 inch) and (+) 800mm (31.5 inch), MC Plug Type IV connectors

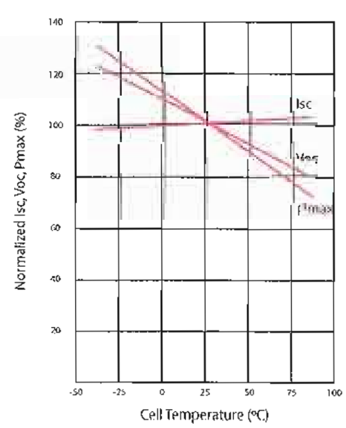
Temperature Coefficients

Nominal Operating Cell Temperature (NOCT)	45±2°C
Temperature Coefficient of Pmax	-(0.47 ± 0.05) %/°C
Temperature Coefficient of Voc	-(0.34 ± 0.01) %/°C
Temperature Coefficient of Isc	(0.055 ± 0.01) %/°C

Current-Voltage & Power-Voltage Curve (260W)



Temperature Dependence of Isc, Voc, Pmax



(E) Building Dimensions - Classroom Wing 2

B = 156.00' D = 46.33'

Existing Roof Area - 7,227 sf (per original construction documents)

(E) DL = 639,873 (= Roof Area * DL + Trib Wall DL * Trib Wall Area)
Trib Wall DL = 100 psf*min(156, 46.33')*2*(9+0' Parapet)

10% DL = 63987

Prposed Solar Array

Module - Suntech STP260 Titl-angle - 20°
Module Area - 20.9 sf Plan Area ~ 1.49 * Module Area = 31.1 sf
Module Wt. - 59.5 # Frmg per Module - 21

Basic Wind Speed = 85 mph
Exposure - C (ASCE 7-05 Section 6.5.6.2)

Allowable number of Modules

$$\text{No. Modules Allowed} = \frac{10\%\ (E)\ DL}{\text{Array Wt}} = 795 \text{ modules}$$

Array Wt = 80.5 #/module

$$\text{No. Mod. based on roof area} = \frac{\text{Roof Area}}{\text{Plan Area}} = 232 \text{ modules}$$

Check (E) Framing

(E) D+L = 639873+7227*20 psf = 784,413
(E) D+L+ array = 639873+7227*10 psf +232*80.5 = 730,819

$$\Delta = \frac{730{,}819}{784{,}413} - 1 = -0.068 \quad \text{Ok}$$

Change in load on deck

(E) D+L = 92 psf
(E) D+L+ array = 84.6 psf

$$\Delta = \frac{84.6}{92} - 1 = -0.08 \quad \text{Ok}$$

Racking Point Loads

for SunlLink System

No. Modules per Support ~ 2

P = 2 * (59.5+21) = 161

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(E) Building Dimensions - Multi-Use Wing 3

B = 96.00'   D = 64.00'

Existing Roof Area - 6,144 sf   (per original construction documents)

(E) DL = 299,520   (= Roof Area * DL + Trib Wall DL * Trib Wall Area)
Trib Wall DL = 100 psf*min(96, 64')*2*(9+0' Parapet)

10% DL = 29952

Prposed Solar Array

Module - Suntech STP260   Titl-angle - 20°
Module Area - 20.9 sf   Plan Area ~ 1.49 * Module Area = 31.1 sf
Module Wt. - 59.5 #   Frmg per Module - 21

Basic Wind Speed = 85 mph
Exposure - C   (ASCE 7-05 Section 6.5.6.2)

Allowable number of Modules

$$\text{No. Modules Allowed} = \frac{10\%\ (E)\ DL}{\text{Array Wt}} = 372 \text{ modules}$$

Array Wt = 80.5 #/module

$$\text{No. Mod. based on roof area} = \frac{\text{Roof Area}}{\text{Plan Area}} = 198 \text{ modules}$$

Check (E) Framing

(E) D+L = 299520+6144*20 psf = 422,400
(E) D+L+ array = 299520+6144*10 psf +198*80.5 = 376,899

$$\Delta = \frac{376{,}899}{422{,}400} - 1 = -0.108 \quad \underline{\text{Ok}}$$

Change in load on deck

(E) D+L = 50 psf
(E) D+L+ array = 42.6 psf

$$\Delta = \frac{42.6}{50} - 1 = -0.15 \quad \underline{\text{Ok}}$$

Racking Point Loads

for SunlLink System

No. Modules per Support ~ 2

P = 2 * (59.5+21) = 161

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Structural Engineers
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Seismic (IBC / ASCE 7)

Seismic Design Category - D (CBC 1613.5.6 & ASCE 7-05, Sect. 11.6)

Building Category - II (ASCE 7-05 Table 1-1)
Seismic Importance Factor, I - 1.00 (ASCE 7-05 Table 11.5-1)
Soil Site Class - D (ASCE 7-05 Chapter 20)

Site Location				
Latitude	37°	52'	43.54"	N
Longitude	122°	17'	4.07"	W

S_s = 1.879
S_1 = 0.714
} See next Page

$S_{MS} = F_a S_s$ = 1.879 F_a = 1
$S_{M1} = F_v S_1$ = 1.071 F_v = 1.5

$S_{DS} = 2/3\ S_{MS}$ = 1.253 $T_0 = 0.2\ S_{D1}/S_{DS}$ = 0.114
$S_{D1} = 2/3\ S_{M1}$ = 0.714 $T_s = S_{D1}/S_{DS}$ = 0.57

for $T < T_0$, $S_a = S_{DS}(0.4 + 0.6\ T/T_0)$

for $T_0 < T < T_s$, $S_a = S_{DS}$

for $T_s < T$, $S_a = S_{D1}/T$

$T = C_t h_n^x$ = 0.29 (ASCE Eq. 12.8-7)

C_t = 0.020 (ASCE Table 12.8-2)
h_n = 36.00
x = 0.75 (ASCE Table 12.8-2)

Component Force (ASCE Section 13.3.1)

ASCE Eq. 13.3-1

$$F_p = \frac{0.4\ a_p S_{DS} W_p}{R_p / I_p}\left(1 + 2\frac{z}{h}\right) = 0.601\ Wp$$

Controls z = h h = roof elev.

ASCE Eq. 13.3-2

$F_p\ max = 1.6\ S_{DS} I_p W_p$ = 2.005 Wp

ASCE Eq. 13.3-3

$F_p\ min = 0.3\ S_{DS} I_p W_p$ = 0.376 Wp

I_p = 1 a_p = 1 R_p = 2.5

W_p = 81 # ∴ F_p = 48 # for ASD, USE 0.7 * F_p = 34 #

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Structural Engineers
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Point Richmond, CA 94801
510.236.7435
510.232.5325 (FAX)

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Berkeley Unified School District
Jefferson Elementary

Conterminous 48 States
2005 ASCE 7 Standard / 2007 California Building Code
Latitude = 37.879
Longitude = -122.284
Spectral Response Accelerations Ss and S1
Ss and S1 = Mapped Spectral Acceleration Values
Site Class B - Fa = 1.0 ,Fv = 1.0
Data are based on a 0.009999999776482582 deg grid spacing

Period (sec)	Sa (g)
0.2	1.879 (Ss, Site Class B)
1.0	0.714 (S1, Site Class B)

Conterminous 48 States
2005 ASCE 7 Standard / 2007 California Building Code
Latitude = 37.879
Longitude = -122.284
Spectral Response Accelerations SMs and SM1
SMs = Fa x Ss and SM1 = Fv x S1
Site Class D - Fa = 1.0 ,Fv = 1.5

Period (sec)	Sa (g)
0.2	1.879 (SMs, Site Class D)
1.0	1.071 (SM1, Site Class D)

Conterminous 48 States
2005 ASCE 7 Standard / 2007 California Building Code
Latitude = 37.879
Longitude = -122.284
Design Spectral Response Accelerations SDs and SD1
SDs = 2/3 x SMs and SD1 = 2/3 x SM1
Site Class D - Fa = 1.0 ,Fv = 1.5

Period (sec)	Sa (g)
0.2	1.252 (SDs, Site Class D)
1.0	0.714 (SD1, Site Class D)

Reference: "USGS Seismic Hazard Curves and Uniform Hazard Response Spectra", **NSHMP_HazardApp.jar** application

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Structural Engineers
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Point Richmond, CA 94801
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Jefferson Elementary

Location		Gross Available Area (ft^2)	Estimated PV Capacity		
			Rooftop (kWp)	Parking (kWp)	Total (kWp)
2	Roofs	19,800	210	0	210
	Building A	7,650			
	Building B	6,750			
	Building C	5,400			
Totals		**19,800**	**210**	**0**	**210**

Questions/Comments for District

1. Need PG&E billing information
2. What is age & condition of roofs?
3. Are there roof structural concerns?
4. Roof obstructions: ***minimal***