VSE Project Number: U1867.0279.211

May 24, 2021

New England Clean Energy
43 Broad Street
Hudson, MA 01749

REFERENCE: Ockene - Harvard Residence: 24 Fairbank Street, Harvard, MA 01451
New England Clean Energy Project: PRJ2467
Solar Array Installation

To Whom It May Concern:

Per your request, we have reviewed the existing structure at the above referenced site. The purpose of our review was to determine the adequacy of the existing structure to support the proposed installation of solar panels on the roof as shown on the panel layout plan.

Based upon our review, we conclude that the existing structure is adequate to support the proposed solar panel installation.

Design Parameters

Code: Massachusetts State Residential Code (780 CMR Chapter 51, 9th Edition (2015 IRC))
Risk Category: II
Design wind speed: 123 mph (3-sec gust) per ASCE 7-10
Wind exposure category: C
Ground snow load, Pg: 50 psf
Flat roof snow load, Pf: 35 psf

Existing Roof Structure

Roof structure: 2x6 rafters @ 16" o.c.
Roofing material: composite shingles
Roof 1: roof slope of 25°
Roof 2: roof slope of 45°

Connection to Roof

Mounting connection: (1) 5/16" lag screw w/ min. 2.5" threaded embedment into framing at max. 48" o.c. at panel seams
This installation uses a rail-less system. Panel Orientation: Portrait.
Maximum panel dimension: 67x40 in

Conclusions

Based upon our review, we conclude that the existing structure is adequate to support the proposed solar panel installation. The glass surface of the solar panels allows for a lower slope factor per ASCE 7, resulting in reduced design snow load on the panels. The gravity loads, and thus the stresses of the structural elements, in the area of the solar array are either decreased or increased by no more than 5%. Therefore, the requirements of Section 807.4 of the 2015 IEBC as referenced in 780 CMR Chapter 34, 9th Edition are met and the structure is permitted to remain unaltered.

The solar array will be flush-mounted (no more than 10" above the roof surface) and parallel to the roof surface. Thus, we conclude that any additional wind loading on the structure related to the addition of the proposed solar array is negligible. The attached calculations verify the capacity of the connections of the solar array to the existing roof against wind (uplift), the governing load case. Because the increase in lateral forces is less than 10%, this addition meets the requirements of the exception in Section 807.5 of the 2015 IEBC as referenced in 780 CMR Chapter 34, 9th Edition. Thus the existing lateral force resisting system is permitted to remain unaltered.

Limitations

Installation of the solar panels must be performed in accordance with manufacturer recommendations. All work performed must be in accordance with accepted industry-wide methods and applicable safety standards. The contractor must notify Vector Structural Engineering, LLC should any damage, deterioration or discrepancies between the as-built condition of the structure and the condition described in this letter be found. Connections to existing roof framing must be staggered, except at array ends, so as not to overload any existing structural member. The use of solar panel support span tables provided by others is allowed only where the building type, site conditions, site-specific design parameters, and solar panel configuration match the description of the span tables. The design of the solar panel racking (mounts, rails, etc.) and electrical engineering is the responsibility of others. Waterproofing around the roof penetrations is the responsibility of others. Vector Structural Engineering assumes no responsibility for improper installation of the solar array.

VECTOR STRUCTURAL ENGINEERING, LLC

Wells Holmes

Digitally signed by Wells Holmes
Date: 2021.05.24 14:23:23 -06'00'

05/24/2021

Wells Holmes, S.E.
MA License: 54240 - Expires: 06/30/2022
Project Engineer

Enclosures

WLH/anc

JOB NO.: U1867.0279.211
SUBJECT: WIND PRESSURE

PROJECT: Ockene - Harvard Residence

Components and Cladding Wind Calculations

Label: Solar Panel Array

Note: Calculations per ASCE 7-10

SITE-SPECIFIC WIND PARAMETERS:

Basic Wind Speed [mph]:	123
Exposure Category:	C
Risk Category:	II

Notes:

ADDITIONAL INPUT & CALCULATIONS:

Height of Roof, h [ft]:	25	(Approximate)	Hip?
Comp/Cladding Location:	Gable/Hip Roofs 7° < θ ≤ 27°		No
Enclosure Classification:	Enclosed Buildings		
Zone 1 GC_p:	0.9	Figure 30.4-2B	(enter negative pressure coefficients)
Zone 2 GC_p:	1.7		
Zone 3 GC_p:	2.6		
α:	9.5	Table 26.9-1	
z_g [ft]:	900	Table 26.9-1	
K_h:	0.95	Table 30.3-1	
K_{zt}:	1	Equation 26.8-1	
K_d:	0.85	Table 26.6-1	
Velocity Pressure, q_h [psf]:	31.1	Equation 30.3-1	
GC_{pi}:	0	Table 26.11-1	

PRESSURES:

$$p = q_h\left[(GC_p) - (GC_{pi})\right]$$ Equation 30.9-1

Zone 1, p [psf]:	27.0	psf (1.0 W, Interior Zones, beyond 'a' from roof edge)
Zone 2, p [psf]:	52.2	psf (1.0 W, End Zones, within 'a' from roof edge)
Zone 3, p [psf]:	80.0	psf (1.0 W, Corner Zones, within 'a' from roof corner) (a= 3 ft)

JOB NO.: U1867.0279.211
SUBJECT: CONNECTION

PROJECT: Ockene - Harvard Residence

Calculate Uplift Forces on Connection

	Pressure (0.6 Dead -0.6 Wind) (psf)	Max Trib. Width[1] (ft)	Max Trib. Area[2] (ft^2)	Max Uplift Force (lbs)
Zone 1	14.4	4.0	22.3	321
Zone 2	29.5	4.0	11.2	329
Zone 3	46.2	4.0	11.2	516

Calculate Connection Capacity

Lag Screw Size [in]:	5/16	
C_d:	1.6	NDS Table 2.3.2
Embedment[3] [in]:	2.5	
Grade:	SPF (G = 0.42)	
Nominal Capacity [lbs/in]:	205	NDS Table 12.2A
Number of Screws:	1	
Prying Coefficient:	1.4	
Total Capacity [lbs]:	586	

Determine Result

Maximum Demand [lbs]:	516
Lag Screw Capacity [lbs]:	586

Result: **Capacity > Demand, Connection is adequate.**

Notes

1. 'Max Trib. Width' is the width along the panel seams tributary to the connection.
2. 'Max Trib Area' is the product of the 'Max. Trib Width' and the panel width/height perpendicular to the direction of the connection spacing. Tributary area on connections at array edges are reduced by 50% as they
3. Embedment is measured from the top of the framing member to the beginning of the tapered tip of the lag screw. Embedment in sheathing or other material is not effective. The length of the tapered tip is not part of the embedment length.

JOB NO.: U1867.0279.211
SUBJECT: GRAVITY LOADS

PROJECT: Ockene - Harvard Residence

GRAVITY LOADS

Roof Pitch: 5.6 :12

ROOF DEAD LOAD (D)	Design material weight [psf]	Increase due to pitch	Material weight [psf]
Composite Shingles	2.2	1.10	2.0
1/2" Plywood	1.1	1.10	1.0
Framing	3.0		3.0
Insulation	0.0		0.0
1/2" Gypsum Clg.	0.0	1.10	0.0
M, E & Misc	0.0		0.0
Total Existing Roof DL	6.3		
PV Array DL	3.3	1.10	3

ROOF LIVE LOAD (Lr)

Existing Design Roof Live Load [psf]	20	ASCE 7-10 Table 4-1
Roof Live Load With PV Array [psf]	0	Massachusetts State Building Code (780 CMR Chapter 16, 9th Edition (2015 IBC)), Section 1607.12.5

SNOW LOAD (S):

	Existing	w/ Solar Array	
Roof Slope [x:12]:	5.6	5.6	
Roof Slope [°]:	25	25	
Ground Snow Load, p_g [psf]:	50	50	ASCE 7-10, Section 7.2
Terrain Category:	C	C	ASCE 7-10, Table 7-2
Exposure of Roof:	Fully Exposed	Fully Exposed	ASCE 7-10, Table 7-2
Exposure Factor, C_e:	0.9	0.9	ASCE 7-10, Table 7-2
Thermal Factor, C_t:	1.1	1.1	ASCE 7-10, Table 7-3
Risk Category:	II	II	ASCE 7-10, Table 1.5-1
Importance Factor, I_s:	1.0	1.0	ASCE 7-10, Table 1.5-2
Flat Roof Snow Load, p_f [psf]:	35	35	ASCE 7-10, Equation 7.3-1
Minimum Roof Snow Load, p_m [psf]:	0	0	ASCE 7-10, Section 7.3.4
Unobstructed Slippery Surface?	No	Yes	ASCE 7-10, Section 7.4
Slope Factor Figure:	Figure 7-2b	Figure 7-2b	ASCE 7-10, Section 7.4
Roof Slope Factor, C_s:	1.00	0.75	ASCE 7-10, Figure 7-2
Sloped Roof Snow Load, p_s [psf]:	35	26	ASCE 7-10, Equation 7.4-1
Design Snow Load, S [psf]:	35	26	

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SUBJECT: LOAD COMPARISON

PROJECT: Ockene - Harvard Residence

Summary of Loads

	Existing	With PV Array
D [psf]	6	10
Lr [psf]	20	0
S [psf]	35	26

Maximum Gravity Loads:

	Existing	With PV Array	
(D + Lr) / Cd [psf]	21	11	ASCE 7-10, Section 2.4.1
(D + S) / Cd [psf]	36	31	ASCE 7-10, Section 2.4.1

(Cd = Load Duration Factor = 0.9 for D, 1.15 for S, and 1.25 for Lr)

Maximum Gravity Load [psf]:	36	31

Ratio Proposed Loading to Current Loading: **87%** **OK**

The gravity loads, and thus the stresses of the structural elements, in the area of the solar array are either decreased or increased by no more than 5%. Therefore, the requirements of Section 807.4 of the 2015 IEBC as referenced in 780 CMR Chapter 34, 9th Edition are met and the structure is permitted to remain unaltered.