Penn FUSION Engineering

152 S. Broad St.
Lansdale, PA 19446
(215)361-8040

January 2, 2020

PowerHome Solar
919 N. Main St
Mooresville, NC 28115

RE: **Blakey Residence**
15024 Ashton Road, Detroit, MI 48223
Client Project #: 15024BLAK
PFE Project #: 201002

On behalf of PowerHome Solar, Penn Fusion Engineering LLC (PFE) performed a structural analysis of the roof at the above referenced location. The purpose of our analysis was to determine if the existing roof system is structurally sufficient to support the new photovoltaic moudles in addition to the code required design loads. Information used for this analysis was determined by a site survey performed by a representative of PFE and is isolated only to the areas where the modules are intended to be placed. If any discrepancies are found by the contractor during installation, please contact PFE.

System Specifications:
Panel Specs: (22) Silfab Solar - SLA-M
Racking System: Quick Mount PV - QRail Light

The modules are to be located on the following roof planes:

Mounting Plane	Rafter Size	Rafter Spacing	Horizontal Span	Collar Ties	Collar Tie Spacing	Sheathing	Shingle Type	Number of Shingle Layers	Ceiling Profile
1	2x6	16"	13ft. 11in.	N/A	0"	CDX 1/2"	Asphalt Shingles	1	Flat
2	2x6	16"	12ft. 0in.	N/A	0"	CDX 1/2"	Asphalt Shingles	1	Flat

The roof design has been analyzed in accordance with the 2015 Michigan Residential Code with design loads as follows:

Ground Snow (Pg): 20 psf
Wind Speed (V): 115 mph

Mounting Plane 1
The calculations for these structural members are attached. It has been determined by this office that the roof, as specified above, is adequate to support the new PV modules in addition to the code required design loading.

Attach the module rail brackets to the roof with 5/16" lag bolts at 48 on center maximum with staggered penetration such that load is distributed evenly among roof members. Provide a minimum of 2" of penetration into the wood members.

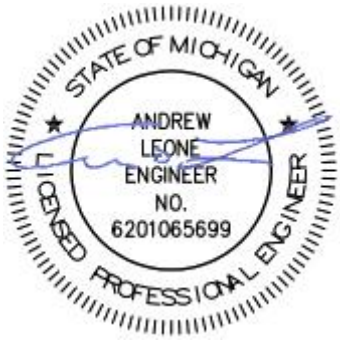
Mounting Plane 2
The calculations for these structural members are attached. It has been determined by this office that the roof, as specified above, is adequate to support the new PV modules in addition to the code required design loading.

Attach the module rail brackets to the roof with 5/16" lag bolts at 48 on center maximum with staggered penetration such that load is distributed evenly among roof members. Provide a minimum of 2" of penetration into the wood members.

This office has determined that the installation of the PV System as specified above will meet the structural requirements of the 2015 Michigan Residential Code and ASCE7-10 when installed in accordance with the manufacture's instructions.

If you have any questions regarding this analysis, please feel free to contact us.

Best Regards,
Penn Fusion Engineering LLC



Andrew D. Leone, P.E.
Principal

152 S. Broad St.
Lansdale, PA 19446
(267)640-2758

Client Name: PowerHome Solar
PFE Project Number: 201002
Client Project Number: 15024BLAK
Project: Blakey Residence
Address: 15024 Ashton Road
Detroit, MI 48223
Description: Mounting Plane 1
Calculations By: ADL
Date: January 2, 2020

Roof Construction

2x6 Rafters at 16" on center

A=	8.25 in^2
Ix=	20.8 in^4
Sx=	7.56 in^3
Wood Species=	Doug-Fir Larch #2
Fb=	900 psi
Fv=	180 psi
E=	1600000 psi
Roof Slope=	34 °
Rafter Span=	13.92 ft
Ceiling Attached to Rafters?:	No

Design Criteria

Ground Snow (P_g):	20 psf
Design Wind Speed:	115 mph
Live Load:	20 psf
Dead Load:	4.91 psf
PV Modules:	3.62 psf

Wind Calculations

Directionality Factor (K_d):	0.85
Topographic Factor (K_{zt}):	1
Velocity Pressure Exposure Coefficient (K_z):	0.7
Importance Factor (I):	1
Velocity Pressure (q_z):	20.14 psf
Tributary Square Footage on Component:	10.83 ft^2
Component Roof Pressures:	21.69 / -27.66 psf

Snow Load Calculations

Exposure Factor (C_e):	1
Thermal Factor (C_t):	1
Importance Factor (I):	1
Flat Roof Snow Loads (P_f):	14 psf
Roof Slope Factor (C_s):	0.9
Sloped Snow Loads (P_s):	12.6 psf
Unbalanced Snow Load:	0 psf

Member Calculations

Bending

M_d:	921.81	ft*lb		
f_b:	1462.71	psi		
Load Duration Factor (C_d):	1.15			
Stability Factor (C_L):	1			
Wet Service Factor (C_M):	1			
Temperature Factor (C_T):	1			
Size Factor (C_F):	1.3			
Flat Use Factor (C_{fu}):	1			
Incising Factor (C_i):	1			
Repetitive Member Factor (C_r):	1.15			
F_b:	900	psi		
F'_b:	1547.33	psi	**1462.71<=1547.33**	**OK in Bending**

Shear

V_d:	264.84	lb		
f_v:	48.15	psi		
Load Duration Factor (C_d):	1.15			
Wet Service Factor (C_M):	1			
Temperature Factor (C_T):	1			
Size Factor (C_F):	1.3			
Flat Use Factor (C_{fu}):	1			
Incising Factor (C_i):	1			
F_v:	180	psi		
F'_v):	207	psi	**48.15<=207**	**OK in Shear**

Deflection

Live Load Deflection (Δ_L):	0.68	in	**L/247**	**OK in Live Load Deflection**
Total Load Deflection (Δ_T):	0.97	in	**L/173**	**OK in Total Load Deflection**

Uplift Calculation

Tributary Square Footage on Component:	10.83	ft^2
Uplift Pressure:	-27.66	psf
Uplift per Lag:	-299.64	lbs
Lag Screw Diameter:	5/16	in
Allowable Withdrawal per Inch:	490.99	lbs/in
Minimal Screw Penetration:	0.61	in

Install 5/16" diameter lag screws @ 48 on center with minimum penetration of 2" into rafter.

152 S. Broad St.
Lansdale, PA 19446
(267)640-2758

Client Name: PowerHome Solar
PFE Project Number: 201002
Client Project Number: 15024BLAK
Project: Blakey Residence
Address: 15024 Ashton Road
Detroit, MI 48223
Description: Mounting Plane 2
Calculations By: ADL
Date: January 2, 2020

Roof Construction

2x6 Rafters at 16" on center

A=	8.25 in^2
Ix=	20.8 in^4
Sx=	7.56 in^3
Wood Species=	Doug-Fir Larch #2
Fb=	900 psi
Fv=	180 psi
E=	1600000 psi
Roof Slope=	34 °
Rafter Span=	12.01 ft
Ceiling Attached to Rafters?:	No

Design Criteria

Ground Snow (P_g):	20 psf
Design Wind Speed:	115 mph
Live Load:	20 psf
Dead Load:	4.91 psf
PV Modules:	3.62 psf

Wind Calculations

Directionality Factor (K_d):	0.85
Topographic Factor (K_{zt}):	1
Velocity Pressure Exposure Coefficient (K_z):	0.7
Importance Factor (I):	1
Velocity Pressure (q_z):	20.14 psf
Tributary Square Footage on Component:	10.83 ft^2
Component Roof Pressures:	21.69 / -27.66 psf

Snow Load Calculations

Exposure Factor (C_e):	1
Thermal Factor (C_t):	1
Importance Factor (I):	1
Flat Roof Snow Loads (P_f):	14 psf
Roof Slope Factor (C_s):	0.9
Sloped Snow Loads (P_s):	12.6 psf
Unbalanced Snow Load:	0 psf

Member Calculations

Bending

M_d:	685.48 ft*lb		
f_b:	1087.7 psi		
Load Duration Factor (C_d):	1.15		
Stability Factor (C_L):	1		
Wet Service Factor (C_M):	1		
Temperature Factor (C_T):	1		
Size Factor (C_F):	1.3		
Flat Use Factor (C_{fu}):	1		
Incising Factor (C_i):	1		
Repetitive Member Factor (C_r):	1.15		
F_b:	900 psi		
F'_b:	1547.33 psi	**1087.7<=1547.33**	**OK in Bending**

Shear

V_d:	228.38 lb		
f_v:	41.52 psi		
Load Duration Factor (C_d):	1.15		
Wet Service Factor (C_M):	1		
Temperature Factor (C_T):	1		
Size Factor (C_F):	1.3		
Flat Use Factor (C_{fu}):	1		
Incising Factor (C_i):	1		
F_v:	180 psi		
F'_v):	207 psi	**41.52<=207**	**OK in Shear**

Deflection

Live Load Deflection (Δ_L):	0.37 in	**L/385**	**OK in Live Load Deflection**
Total Load Deflection (Δ_T):	0.53 in	**L/270**	**OK in Total Load Deflection**

Uplift Calculation

Tributary Square Footage on Component:	10.83 ft^2
Uplift Pressure:	-27.66 psf
Uplift per Lag:	-299.64 lbs
Lag Screw Diameter:	5/16 in
Allowable Withdrawal per Inch:	490.99 lbs/in
Minimal Screw Penetration:	0.61 in

Install 5/16" diameter lag screws @ 48 on center with minimum penetration of 2" into rafter.