STRUCTURAL DESIGN REQUIREMENTS

This worksheet provides a process for evaluating the structural integrity of PV array installations on buildings, based on ASCE 7-10, 2014 FBC, NFPA 70 (NEC), AC428 and product manufacturers instructions.

Restrictions are intended to: 1) standardize requirements for typical residential installations, 2) facilitate the review, verification and approval process by AHJs, 3) reduce or eliminate the need for professional engineering review, and 4) reduce system soft-costs.

This process sets prescriptive requirements that apply to the majority of single and two-family residential structures in Florida. Designs that do not meet these requirements do not qualify for this expedited permitting process.

Designs that do not qualify for this process may be permitted through traditional methods, and additional structural verification may be required.

	Building Requirements	Comments
1	Buildings shall be Risk Category II structures, single-family or two-family residential buildings only.	Limits structural calculations, scope of analysis.
2	Mean roof height, h, shall be less than or equal to 30 ft.	To permit evaluation of component and cladding (C&C) pressures defined within Chapter 30 of ASCE 7-10, Parts 1 & 2.
3	The building shall be enclosed as defined in Section 26.2 and conforms to the wind-borne debris provisions of Section 26.10.3.	To permit evaluation of component and cladding (C&C) pressures defined in ASCE 7-10 Chapter 30 Parts 1 & 2. Openings must be protected for Wind-borne Debris Regions (WBDR). WBDR are areas located within 1 mile of the coastal mean high water line where the basic wind speed is 130 mph or greater; or in areas where the basic wind speed is 140 mph or greater. See ASCE7-10 Section 26.10.3.1. Hurricane prone regions are the U.S. Atlantic Ocean and Gulf of Mexico coasts where the basic wind speed for Risk Category II buildings is greater than 115 mph (includes all of Florida).
4	The building is a regular-shaped building or structure as defined in Section 26.2.	To permit evaluation of component and cladding (C&C) pressures defined in ASCE 7-10 Chapter 30 Part 2.
5	The building does not have response characteristics making it subject to across wind loading, vortex shedding, or instability due to galloping or flutter; and it does not have a site location for which channeling effects or buffeting in the wake of upwind obstructions warrant special consideration.	To permit evaluation of component and cladding (C&C) pressures defined in ASCE 7-10 Chapter 30 Part 2.
6	Buildings shall have minimum 2x4 pre-engineered (manufacturer plated) truss systems with 24" OC maximum spacing.	Limits the level of structural calculations required for verification of building roof load capability and point attachments. Manufacturer plated wood roof trusses are assumed to be code-compliant. Roofing systems using rafters are not addressed and may be permitted by traditional process.
7	The building shall have either a gable or hip roof with pitch between 2/12 and 6/12 ($7^{o} \leq \theta \leq 27^{o}$).	To permit evaluation of component and cladding (C&C) pressures defined within Chapter 30 of ASCE 7-10, Part 1. Flat, monoslope and other roof shapes are not addressed in this process.
8	Building roof structures shall have been permitted under requirements of the FBC or building code in effect at the time of construction.	Limits the level of structural calculations and details required for verification of building load capability and point attachments. Partial justification for not requiring further evaluation of the roof structure. Proving this for older structures may not be that easy unless local building department have records, or the installer may have to pay for a structural evaluation - they can alternatively submit that for the online system as evidence. The basis for this is that dead load provisions in prior building codes and lumber size/grading methods dating back to the early 1900's exceeded the standards used today (please see the attached CA reference for further details).
9	Roofs shall have no more than a single layer of roof covering or any additional equipment not factored in the roof structure design.	This restriction limits roof dead load to original design conditions. FBC Existing Building [B] 706.2 exempts the addition or replacement of roofing or replacement of equipment resulting in additional dead loads, from having to comply with the gravity load requirements of the FBC where the additional dead load from the roofing or equipment does not increase the force in a structural element by more than 5 percent. This exception also applies to a second layer of roof covering weighing 3 psf or less over an existing, single layer of roof covering.
10	Roof live load shall be assumed to be zero for PV array area.	From AC428 Section 3.1.3.5. Building officials may allow for all or a portion of the roof original live load design load to be removed/reduced for areas of PV array installation. The rationale is that live load or roof foot traffic is eliminated or reduced to designated paths; the PV array and live load foot traffic cannot occupy the same space. Roof live loads are typically designed for 20 psf, although reductions are permitted, design roof live load must always be greater than 12 psf. Concentrated roof design loads are 300 psf. See ASCE7-10 Table 4-1, FBC TABLE 1607.1.
11	The contractor shall submit digital images of roof structures with their permit package to help AHJs verify that the structural members are in good condition and have not been significantly weakened or compromised (i.e., no rot, termites, fire damage, cracking, sagging, holes, notches, modifications, etc.). At least 7 digital photos shall be attached, showing overall roof from interior and exterior, as well as truss depth, width, spacing, slope and span. (set tape measure alongside roof framing members for scale).	This requirement helps avoid the need for a professional structural evaluation. Contractors may require special training to assess the condition of roofing systems, to recognize unusual noncompliant conditions, and provide adequate photo documentation. Note that Florida certified solar contractors (CV) are required to have some knowledge of roofing systems and weathersealing practices in accordance with National Roofing Contractor's Association practices.
	Wind Load Calculations	
12	All structural elements shall be designed for component and cladding (C&C) pressures defined in ASCE 7-10 Chapter 30 and the FBC Chapter 16.	Rooftop mounted photovoltaic systems shall be designed for wind loads for component and cladding in accordance with FBC Chapter 16 using an effective wind area based on the dimensions of a single unit frame (FBC 1509.7.1/R905.17.1). This section does not specifically apply to HVHZ.
13	For High-Velocity Hurricane Zones (HVHZ), ASD wind pressures from RAS 127 for Exposure C shall be permitted to be used.	Roofing Application Standard (RAS) No. 127 is based on C&C ASD wind pressures for 175 mph, Exposure C and effective wind area of 10 sf.
14	The basic wind speed, V, used in the determination of design wind loads for Risk Category II buildings and structures shall be determined from ASCE7-10 Fig. 26.5-1A, or shall be the basic wind speed established by the load building department for Risk Category II buildings and structures, whichever is greater.	See ASCE7-10 Section 26.5.1 or FBC Section 1609. FBC wind speed maps are based on ultimate wind speed and consistent with the basic wind speed maps in ASCE7-10 Section 26.5.1 and for use with ASD load combinations in Section 2.4.
15	The basic wind speed for Miami-Dade and Broward counties shall be 175 mph and 170 mph, respectively for Risk Category II buildings and structures.	The High-Velocity Hurricane Zones (HVHZ) are specifically defined as Miami-Dade and Broward Counties per FBC Section 1620. The design wind speeds in the HVHZ are as follows: Miami-Dade County: Risk Category II Buildings and Structures: 175 mph Broward County: Risk Category II Buildings and Structures: 170 mph
16	The wind directionality factor, Kd, shall be 0.85 for building component and cladding loads.	See ASCE7-10 Section 26.6.1, Table 26.6-1. The wind directionality factor shall only be included in determining wind loads when the load combinations specified in Sections 2.3 and 2.4 are used for the design. Load combinations for this process are evaluated using Allowable Stress Design (ASD) methods in Section 2.4.
17	Exposure category shall be taken as Exposure C even if the location qualifies for Exposure B. Installations subjected to Exposure D shall be permitted for basic wind speed no greater than 140 mph, arrays must be installed only in Zone 1 with maximum spacing between attachment points no greater than 2 ft OC. Any locations greater than 140 mph in Exposure D shall not be permitted for this process, including Miami-Dade and Broward Counties.	Design wind pressures for components and cladding shall be based on the exposure category resulting in the highest wind loads for any wind direction at the site. See ASCE7-10 Section 26.7.4.4. Exposure D also qualify for this process with certain exceptions. Exposure D shall apply where the ground surface roughness, as defined by Surface Roughness D, prevails in the upwind direction for a distance greater than 5,000 ft or 20 times the building height, whichever is greater. Exposure D shall also apply where the ground surface roughness immediately upwind of the site is B or C, and the site is within a distance of 600 ft or 20 times the building height, whichever is greater, from an Exposure D condition. Surface Roughness D is defined as "flat, unobstructed areas and water surfaces".
18	The building shall not be subjected to any topographic effects resulting from wind speed-up over hills, ridges or escarpments; Kzt is assumed to be 1.0.	See ASCE7-10 Section 26.8.1. Generally, topographic effects do not apply to Florida's flat terrain with grade less than 5%. This assumption is not valid and topographic effects shall be considered if all of the following conditions are met: 1. The hill, ridge, or escarpment is isolated and unobstructed upwind by other similar topographic features of comparable height for 100 times the height of the topographic feature (100H) or 2 mi, whichever is less. This distance shall be measured horizontally from the point at which the height H of the hill, ridge, or escarpment is determined. 2. The hill, ridge, or escarpment protrudes above the height of upwind terrain features within a 2-mi radius in any quadrant by a factor of two or more. 3. The structure is located as shown in Fig. 26.8-1 in the upper one-half of a hill or ridge or near the crest of an escarpment. 4. H/Lh ≥ 0.2. 5. H is greater than or equal to 15 ft for Exposure C and D and 60 ft for Exposure B.
19	Velocity pressure exposure coefficient Kz shall be 0.98 for h = 30 ft in Exposure C.	To permit evaluation of component and cladding (C&C) pressures defined within Chapter 30 of ASCE 7-10, Part 1. Velocity pressure exposure coefficient Kz is taken as 0.98 for h = 30 ft in Exposure C. Minimum value of Kz allowed by ASCE7-10 is 0.85 for heights 15 ft and less for Exposure C.
20	Internal pressure coefficients GCpi shall be +/- 0.18 for enclosed buildings.	In the calculation of design wind loads for the MWFRS and for components and cladding for buildings, the algebraic sum of the pressures acting on opposite faces of each building surface shall be taken into account (Section 26.4.3). According to the ICC Acceptance Criteria for a Modular Framing System Used to Support Photovoltaic Panels (AC428), section 3.1.3.1.1 requires all elements for flush-mounted PV systems to be designed for C&C loads per ASCE 7-10 Chap 30, except that the internal pressure coefficient, GCpi, shall be equal to zero.
21	External pressure coefficients shall be based on an effective area of 10 sf.	Pressure coefficients in RAS 127 are also based on C&C pressures for an effective area of 10 sf. ASCE7-10 Section 30.2.3: Component and cladding elements with tributary areas greater than 700 ft2 shall be permitted to be designed using the provisions for MWFRS.
	PV Module and Racking System Requirements	

22	All PV modules shall be of the same make/model and be listed to UL 1703 Standard for Flat-Plate Photovoltaic Modules and Panels.	FBC 1509.7.4/R905.17.4, NEC 690.4
23	All PV modules shall be installed according to manufacturer's instructions.	NEC 110.3(B) and FBC 1509.7.4/R905.17.4.
24	All PV modules, racking systems and rail sections shall be approved by Florida Solar Energy Center.	Approvals based on meeting prescriptive requirements for this expedited permitting process.
25	All racking structural members shall be 6000 series aluminum alloy only, including rails (beams).	No exterior wood, steel or plastic supports are permitted. Aluminum alloys provide superior performance and corrosion resistance in Florida's hot and humid environment.
26	All racking clamps, L-feet and attachment points shall be aluminum or stainless steel alloys.	Stainless steel is typically used for mid clamps for equipment bonding.
27	All threaded fasteners shall be stainless steel alloys 304 or 316 series. Anti-seize compunds shall be used on all threaded fasteners to prevent galling and to esure proper torque.	No galvanized or zinc-plated fasteners are permitted.
28	PV array racking systems be listed to UL 2703 Standard for Mounting Systems, Mounting Devices, Clamping/Retention Devices, and Ground Lugs for Use with Flat-Plate Photovoltaic Modules and Panels.	Industry standard.
29	Rooftop mounted photovoltaic systems (racking and module assembly) shall have Class A fire rating using Type 1, 2, 3, or 10 fire rated modules.	1509.7.2/R905.17.2 Fire classification. Rooftop mounted photovoltaic systems shall have the same fire classification as the roof assembly required by Section 1505 (R902). Important to clarify that this requires PV arrays to have fire class rating at least equivalent to the minimum required by the FBC at the time of construction, not what class of roof is actually installed.
30	PV array racking system shall be installed according to manufacturer's instructions.	FBC 1509.7.3/R905.17.3 Installation. Rooftop mounted photovoltaic systems shall be installed in accordance with the manufacturer's installation instructions. NEC 110.3(B)
31	PV array shall be mounted in a standoff manner above and parallel to the roof surface. The distance between the roof surface and the PV module shall be between 2 and 10 inches.	Common practice, industry standard. Plane of the PV array shall be in plane of roof, no tilting of arrays on sloped roofs. From AC428 Acceptance Criteria for Modular Framing Systems Used to Support Photovoltaic (PV) Modules. Standoff heights are restricted to between 2 and 10 inches. This affects fire class rating per racking installation instructions.
32	PV modules shall not be installed within 10 inches of a roof edge or ridge.	From AC428 Acceptance Criteria for Modular Framing Systems Used to Support Photovoltaic (PV) Modules.
33	PV modules shall be installed in a portrait orientation, with the module long dimension parallel to the roof slope and perpendicular to support rails.	PV modules shall be installed with long dimension perpendicular to support rails (beams) per manufacturer's instructions and load data.
34	Support rails shall be installed perpendicular to trusses.	Support rails shall not be parallel to and supported by a single truss.
35	PV modules shall not be installed to cover plumbing vents, skylights or any other existing roof equipment or obstructions.	Assumption is that modules would be removed from obstruction locations interior to array from continuous rail sections, or array rows shifted (justified) left or right on roof surface to avoid obstructions.
36	PV arrays and racking shall have a distributed weight (dead load) of less than 4 psf and concentrated dead load less than 45 lbs per attachment point to roof.	Requirements from expedited permitting process, NY, CA. Partial justification for not requiring further evaluation of the roof structure. For typical commercial PV modules using rail spans of 4 ft OC have tributary area 11 sf, maximum dead load is 4 psf x 11 sf = 44 lbs per attachment; 22 lbs per attachment for 2 ft OC spacing.
37	A minimum gap of 0.75 inch shall exist between PV modules and adjacent rows of modules.	From AC428. Typical midclamp spacing between adjacent modules.
38	Maximum allowable design load per point attachment shall be limited to no greater than 250 lbs. All point attachments shall be made to the roof structure (not to decking) with minimum 5/16" diameter lag screws, 3-1/2" overall length and 2-1/2" threaded portion. Installation requirements shall include: 1. Screw thread must be embedded in the side grain of a truss or other structural member integral with the roof structure. 2. Screw must be located in the middle third of the structural member. 3. Pilot hole size shall be 7/32" for nominal 5/16" diameter standard lag screws. Alternatively, self-drilling lag screws may be used. 4. Lag screws shall be installed with flat washer flush to surface (no gap), and do not over-torque.	This requirement establishes a maximum allowable load of 250 lbs per point attachment, based on the lag screw allowable load as the limiting factor. All other racking system design elements exceed these allowable loads - see structural calculations. Additional blocking may be required for point attachments connection to the roof structure.
39	For regions with basic wind speed greater than 150 mph and Exposure B or C, installations are restricted to Zone 1 and maximum allowable spacing between point attachments shall be no greater than 2 ft OC.	Requirements based on structural analysis. This restriction limits the maximum C&C loads and requires a minimum 3 ft wide perimeter around PV arrays for hip and gable roofs. By default, this also satisfies the fire code requirements.
40	For regions with basic wind speed no greater than 150 mph and Exposure B or C, installations in Zone 1 shall have maximum allowable spacing between point attachments no greater than 4 ft OC.	Requirements based on structural analysis.
41	Where permitted, point attachments for 4 ft OC spacing shall be staggered or alternated between adjacent trusses.	This requirement ensures concentrated loads from point attachments are distributed among adjacent trusses.
42	Installations in Exposure D shall be permitted for basic wind speed no greater than 120 mph, arrays shall be installed only in Zone 1 with maximum spacing between attachment points no greater than 2 ft OC. Any locations greater than 120 mph in Exposure D shall not be permitted for this process, including Miami-Dade and Broward Counties.	
43	For regions with basic wind speed no greater than 140 mph in Exposure B or C, installations in Zone 2 are permitted and shall have maximum allowable spacing between point attachments no greater than 2 ft OC. Installations shall not interfere with fire code requirements for access pathways and ridge ventilation.	Requirements based on structural analysis. This allows installations in roof zones 2 for wind speeds no greater than 140 mph. Fire code requirements will restrict PV array installations within 3 ft of the ridge, and within 3 ft along one side (eave to ridge) of hip roof installations, and within 3 ft along both sides for gable roof installations.
44	PV modules shall have minimum uplift load rating at least 50 psf.	Design Load Rating = Applied Test Load / 1.5. Most PV modules must have maximum uplift load rating at least 64 psf.
45	PV modules shall be secured to support rails at a minimum of four (4) locations along the module frame using clamps or other methods/types of fasteners approved by the module manufacturer in their installation instructions. Location of attachments along modules frames shall conform to manufacturer's requirements to attain maximum allowable loads. All module clamps or fasteners must be rated for a minimum 400 lbs per attachment, and must used minimum size 1/4" x 20 fasteners.	Each PV module is typically secured to support rails using four clamps or other means at designated locations along module frame to support design loads. Two clamps are shared by adjacent modules, and maximum allowable loads are based on two attachments per module.
46	All roof attachments and building envelope penetrations shall be sealed and flashed with approved methods. Flashing products may be approved per AC286 or by accepted practice of the National Roofing Contractor's Association (NRCA) Roofing Manual latest edition. All structural attachments and installation of weathersealing provisions shall be done in dry conditions.	AC286: ACCEPTANCE CRITERIA FOR ROOF FLASHING FOR PIPE PENETRATIONS. FBC M2301.2.7 Roof and wall penetrations. Roof and wall penetrations shall be flashed and sealed in accordance with Chapter 9 (the HVHZ shall comply with Chapter 44) of the FBC to prevent entry of water, rodents and insects. R903.2 Flashing. Flashings shall be installed in a manner that prevents moisture from entering the wall and roof through joints in copings, through moisture permeable materials and at intersections with parapet walls and other penetrations through the roof plane.