panelclaw®
AN ENSTALL COMPANY

PANELCLAW, INC
1600 Osgood St. Suite 2023
North Andover, MA 01845

+1 (978) 688-4900
sales@panelclaw.com

EFFECTIVE WIND AREAS FOR LOW-SLOPE BALLASTED ROOFTOP PV SYSTEMS

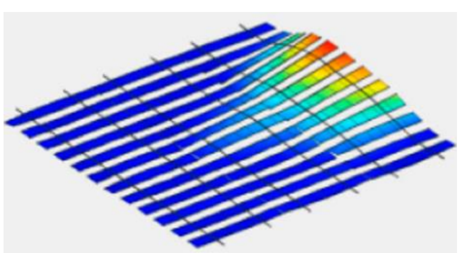
BACKGROUND

clawFR 10 Degree array

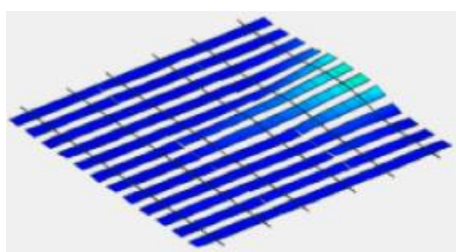
All leading vendors of ballasted rooftop racking systems conduct wind tunnel testing to measure the aerodynamics of their mounting products and determine wind pressure coefficients for use in their structural design tools. To apply these coefficients to real world scenarios, racking companies must evaluate the rigidity of their products by performing a series of tests on full scale systems built with production components and representative solar modules.

The wind load on a solar array is calculated by multiplying the wind pressure, determined through ASCE 7 and/or wind tunnel testing, by the area of the structure that contributes to resisting the load on each module[1]. Pressure coefficients defined in ASCE 7 or wind tunnel testing are partly determined by EWA (effective wind area, see Section 26.2 of ASCE 7). As EWAs increase, pressure coefficients and overall wind loads decrease. For ballasted solar arrays, EWAs typically depend on vertical deflection or lift and are highly dependent on the rigidity of the mounting structure.

There is currently no accepted standard methodology for measuring EWA's. So, racking vendors develop proprietary approaches based primarily on engineering judgement and guidance from wind tunnel experts. An array with low rigidity – read, very weak connections between adjacent modules – has relatively small EWA's and typically requires much more load resistance in the form of ballast and/or roof anchors than a high rigidity array with larger EWA's.



Low stiffness array



High stiffness array

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[1] Citation from IFI wind report for PanelClaw Polar Bear 10deg Gen III HD: The necessary ballast for the securement of the solar ballasted roof mount system depends on the stiffness of connecting members. Stiff members exploit the lack of the non-simultaneous action of building- or array-induced gusts on large effective wind areas. If wind forces on highly loaded zones of arrays can be largely redistributed by the interconnected substructure, the benefits of load sharing are applicable.

Thus, racking vendors are incentivized to overstate the rigidity of arrays constructed with their products since this practice reduces ballast and anchor requirements. Of course, **exaggerated EWA's can lead to hazardous designs that are not able to withstand the worst case expected wind loads at a project site and leave the system owner exposed to property damage**.

DETERMINING EWA

The general approach for measuring EWAs entails lifting each module of a suitably sized array while observing the displacement of surrounding modules to determine the amount of load sharing and how it helps resist the uplift forces on the module being lifted. Prior to testing, the following criteria must be established: maximum acceptable lift height, how to determine if surrounding modules are contributing, what size and shape array(s) to test and what module size(s) to use. All these criteria impact the results in some manner.

clawFR 10 Degree vertical load sharing test setup

Racking vendors should work closely with their wind tunnel laboratory to agree acceptable aerodynamic limits for various modules in an array. Modules at the array perimeter may be more aerodynamically sensitive than interior modules.

The structural behavior of the system must also be considered when determining acceptable lift height. The load used to lift a module should not cause structural failure or excessive deformation of any system component. Modules should also remain secure to the mounting structure after the load is removed. Furthermore, once a section of an array has been lifted, it should return to its original position upon removal of the lifting force. When lifted a second time to the same height, the load sharing should be unchanged.

Module size and array configuration used in the EWA test should be representative of actual deployed systems. EWAs are typically defined in terms of a number of modules. Larger modules require more rigid structures to justify the same load sharing contribution as modules with much smaller areas. For a given mounting platform, EWAs for a 30+ sq. ft. module are unlikely to match EWAs for a 22 sq. ft. module and thus adjustments may be necessary as module sizes continue to grow. Similarly, array configuration significantly impacts EWA validity. For example, it is illogical to use an EWA equivalent to 9 modules if an array has fewer than 9 modules. Attention should also be given to the direction of load sharing to ensure it is applicable to a given array.

PanelClaw's engineering team has many years of experience testing EWAs and has developed a comprehensive approach to accurately characterize its products in a way that is neither too aggressive nor too conservative.

Evidence suggests other companies have taken liberties in developing their approaches, sometimes resulting in grossly exaggerated EWAs.

While working with expert third parties including wind tunnel laboratories and engineering consulting firms, PanelClaw's methodology has been scrutinized by numerous wind and structural engineers with deep expertise in the rooftop PV domain. All of them have concluded the PanelClaw approach is best-in-class. The following excerpt is from the DNV Technology Assessment of the PanelClaw clawFR and clawFRplus mounting systems, *"DNV reviewed test reports for all three systems and agrees with the methodology used in determining EWAs."*

If your racking vendor has not submitted their wind design methodology, including how EWAs are determined, to an expert 3rd party for review, you should ask them to do so and review the report before using their products.