Best Practices

How engineering guidance for solar photovoltaic structures will reduce insurer risk

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By Jon Ness, P.E. | January 23, 2024 at 09:00 AM

Wind can cause photovoltaic systems to move in unanticipated, complex ways — simultaneously bending and twisting. (Shutterstock.com was provided by Jon Ness, P.E.)

Insurers are critical stakeholders in **the solar photovoltaic (PV) industry**. They have a compelling interest in robust and reliable solar PV systems with known risks, especially for utility-scale solar PV facilities that provide power to the grid.

Unfortunately, some risks related to solar PV structures are not widely recognized or understood.

The solar PV industry has grown, and practices have evolved for the last two decades. However, the industry still lacks uniform and specific design guidance for many aspects of solar PV structures. Without specific guidance, the engineering, procurement, installation, maintenance, and resulting reliability of solar PV systems can vary significantly from one solar facility to another. As a result, some solar installations suffer failures under lower-than-expected environmental loads.

Snow and ice can overload a structure. Impacts from hail do not usually damage the support structure but they significantly damage the glass of PV modules. Wind loading of PV structures is more complicated and is a leading contributor to structural instability and failure. Wind can cause PV systems to move in unanticipated, complex ways — simultaneously bending and twisting. Even at relatively low wind speeds, this movement and vibration can become extreme enough to cause the PV modules to come loose from the supporting structure or can cause the bolts securing the supports to loosen, break, or fall out. These failures can result in a single PV module breaking free or a whole row of modules becoming detached.

Example: The problem with wind loads

For reliable operation, PV module mounting methods must withstand conditions in the field, so test methods need to reflect the real-world environment.

“A weak link in the wind resistance of PV modules is often in their connection to their supports,” says Richard J. Davis, P.E., FSFPE, M.ASCE, staff vice president and senior engineering technical specialist at FM Global’s chief engineer’s group.

In common designs for mounting the modules, the aluminum frame holding the module around its edges is relatively shallow. The module glass is very thin compared to the width of the module, which makes the module much more flexible than one might expect, Davis says. Under wind pressure, the center of the module can bow upward a surprising amount; six times more than a stiffer material. Such a large deflection of the module can make its mounting frame try to rotate, and the module can slip out.

Some designers perform a pull test to measure the strength of the PV module attachment. The test results indicate the attachment is very strong. However, this does not reflect the reality of what happens under wind pressure. That test doesn't include vibration and rotation, only heavy stationary loading. The most realistic way to measure the wind resistance of PV modules and their attachments, Davis says, is to wind-pressure test them together to determine how well the structure controls module bending and frame rotation under realistic dynamic wind conditions.

The need for engineering guidance in the solar PV industry

The solar industry has adopted some technological improvements for environmental load scenarios. However, without specific guidance documents, structural engineers have to fall back on the "standard of care" concept to guide their decision-making. Under this concept, they apply engineering judgment to interpret existing building codes, standards, and practices from established industries to inform their design decisions about solar PV structures. Engineers have sometimes prioritized low cost in designing solar PV supports, resulting in flexible structures made of lightweight members. Although these structures may meet existing static design and testing guidelines, they sometimes fail even when exposed to wind speeds lower than their rated values.

Existing building codes will not likely be changed to incorporate guidance for solar structures. However, as the solar PV industry increases its understanding of the technology, it is developing solar-specific guidance documents, and eventually will provide the needed industry codes and standards.

Help is on the way

Because industries develop design guidance through a consensus process, it takes many years to produce an industry standard. Guidelines and manuals of practice are typically issued first. Only after a lengthy review and refinement process do guidelines and manuals of practice become industry standards.

The Structural Engineering Institute, through the Solar PV Structures Committee of the American Society of Civil Engineers, is developing a guideline (**called a manual of practice**) to provide a more reliable and consistent approach to the design of solar PV structures. This manual will guide engineers to design solar PV structures for ground-mounted, elevated, rooftop, and floating PV systems. The ASCE Committee developing this manual includes experienced solar structural engineers, contractors, wind specialists, solar developers, solar facility owners, and manufacturers of solar structures and trackers.

An ongoing **research project funded by the Solar Energy Technology Office at the U.S. Department of Energy** is developing a guidance document focused on critical fastened joints in solar PV systems. This document will address a wide range of topics, including gaps in the current industry codes and standards, results from interviews focused on structural failures, transferable knowledge, and new methods of modeling and testing solar PV structures. The research team will seek industry input starting in September of 2024, and the final document is due to be released in early 2025.

When the guidance document and manual of practice become available, the design, procurement, installation, maintenance, and resulting reliability of solar PV systems can begin to coalesce around a more mature design basis for solar PV structures. Insurers can use those documents to better understand the risks related to solar PV structures and reflect those risks in their underwriting.

Until then, underwriting, risk management, and loss prevention professionals can educate themselves on how the guidance documents and standards are progressing. Insurance industry professionals who have experience with utility-scale solar facilities can share their knowledge by **taking a survey** about the failure of solar structural components.

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