High Wind Loads and Model Code for PV Arrays

Solar ABC's Project

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Solar America Board for Codes and Standards

Problems:

- Existing codes lack guidelines for PV systems

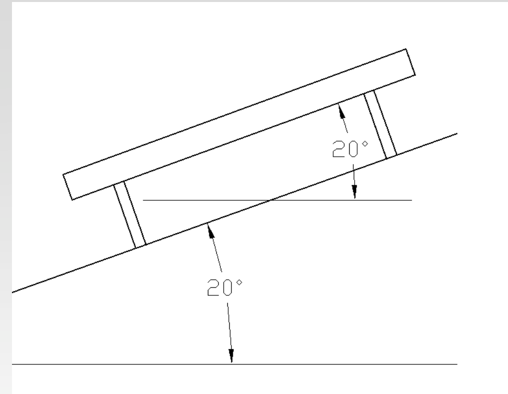
- Designers use codes intended for buildings; many interpretations are possible

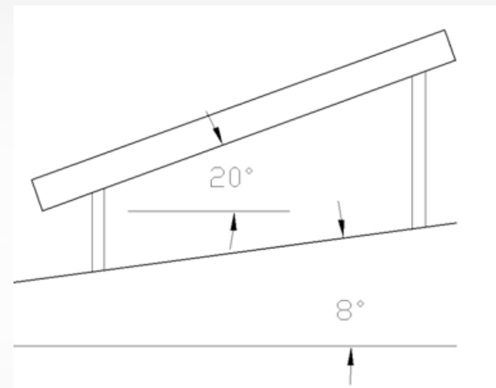
- Many PV systems are either over-designed or under-designed to withstand expected wind speeds.

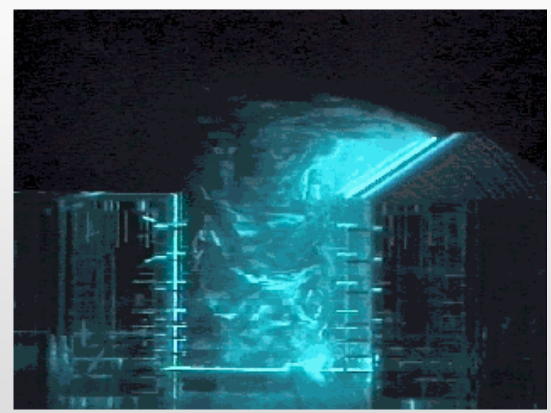
Approach

- Phase I (complete): Review the most widely used code (ASCE-7) to develop a recommended approach to calculate wind loads on PV modules mounted parallel to the roof surface.

- Phase II: Expand code based approach to sloped PV systems, and possibly conduct wind tunnel testing.

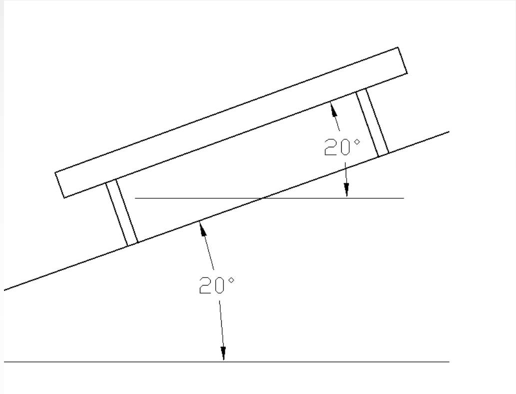






Results – PV Parallel to Roof Surface

- Numerous code-based approaches were studied; one was agreed upon



- Approach follows ASCE-7, Section 6
- Pressure on modules
  - Pressure = q*(GCp-GCpi)
  - q = velocity pressure; depends on building height and site specific factors; straightforward calculation described in ASCE, applicable to PV systems
  - GCp and GCpi are pressure coefficients – difficult to tell from code which, if any, are applicable to PV

Results – PV Parallel to Roof Surface

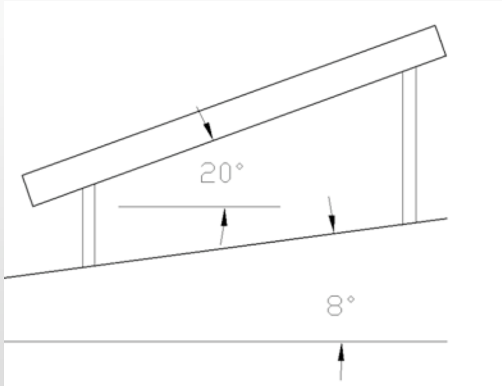
- External pressure coefficient (GCp)
  - Represents positive (downward force) or negative (uplift force) above a roof surface
  - Published values are suitable for PV parallel to the roof
  - Recommended values are in Figure 6-11, B, C, or D (depends on roof slope)

- Internal pressure coefficient (GCpi)
  - Represents positive or negative pressure below the roof surface
  - For roofs, depends on area of openings in the building walls
  - Open building (best case) = no pressurization under roof; wind flow not obstructed
  - Partially enclosed (worst case) = significant pressurization under roof due to imbalance of openings in walls
  - Published GCpi values NOT suitable for PV parallel to the roof because PV is inches away from roof while roof is 15’ or more above ground
  - Recommended values are in Figure 6-11, B, C, or D – not Figure 6-5

- Results are conservative because they don’t account for pressure equalization, which could reduce loads by ~80%; code acknowledges this but requires wind tunnel testing to demonstrate lower loads

Results – PV Sloped Relative to Roof

- ASCE tables and calculations are not recommended
- A hybrid approach was developed but requires further study
- Hybrid approach will also over-predict wind loads – need wind tunnel testing



Recommendations for Future Work

- Develop analytical approach for PV sloped relative to roof
- Wind tunnel testing is drastically needed:
  - Recommended analytical approaches will over-predict loads for most systems = *increased system cost*
  - Recommended analytical approaches may not be adopted in favor of alternatives that yield lower (but defensible) wind loads *= possible system failures*
- How to participate
  - Locate or share applicable wind tunnel data
  - Email suggestions to barkaszi@fsec.ucf.edu or colleen.obrien@bewengineering.com.