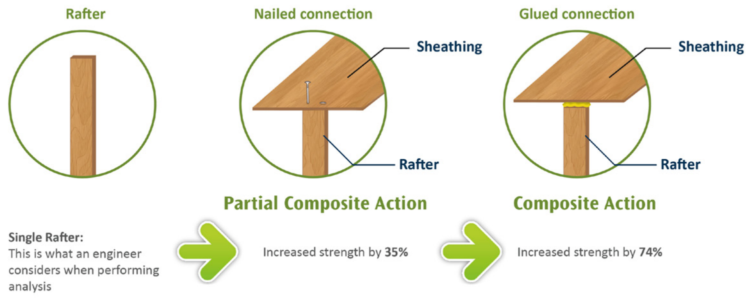
Reducing Soft Costs of Rooftop Solar Installations by Demonstrating Structural Strength

The costs of solar photovoltaic (PV) panels and system hardware such as inverters have dropped significantly. Non-hardware costs such as permitting, installation, and interconnection, however, remain a major hindrance to solar deployment. According to the U.S. Department of Energy, these "soft costs" can account for up to 64 percent of total system cost.[1]

One identified market barrier to rooftop solar PV installations is permitting delays and costs related to rooftop structural issues. A sufficiently strong rooftop structure is necessary to support the actual load created by solar PV installations. In many locations across the United States, however, misperceptions about the load-bearing capacity of existing roofs result in decisions to conduct structural analyses prior to solar permitting. Such analyses are often completed using an overly conservative methodology that underestimates the roof's load-carrying capacity, thus delaying or even blocking the PV installation. This conservatism is exacerbated by already stringent national structural codes.

To address this issue, Sandia National Laboratories (Sandia) conducted a first-of-its-kind study to stress wood rooftop structures to failure. The research team used a series of tests to collect actual rooftop load capacity data and compare it to the perceived load-carrying capacity in building codes. Test results indicate that the actual load-bearing capacity for residential rooftop structural systems is several times higher than the calculated values. These results provide a new tool and set of data for consideration in evaluating rooftops for solar PV installations. The work was funded by the SunShot Initiative of the U.S. Department of Energy's Solar Energy Technologies Office and conducted in partnership with the University of New Mexico.



A roof structure is made stronger by the system elements working together—much stronger than its main load-bearing element, the rafter, is alone. Current engineering analysis methods do not take this composite action into account when evaluating rooftop strength.

A Barrier of Perception More than Fact

Study results demonstrate that conservatism in the existing building code and the engineering analysis methodology significantly underestimates the actual load-carrying capacity of residential roof structures.

When engineers conduct the structural analysis on a rooftop, they often calculate stresses on an individual beam, rafter, or truss and then extrapolate that strength across the roof. This analysis assumes each component of the structure acts alone, a simplistic view that fails to consider the rooftop system as a whole or consider the load-sharing or load redistribution effects of a roof system. The result is a conservative analysis that does not accurately represent the roof's ability to support a PV installation.

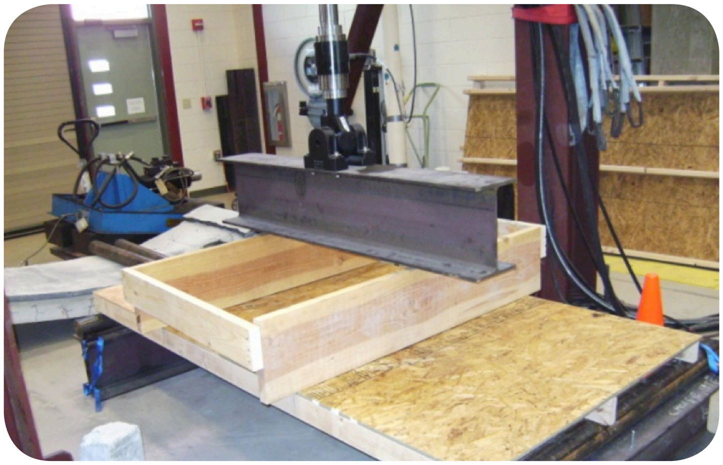
[1] *http://energy.gov/eere/sunshot/reducing-non-hardware-costs*

Roof Structures are Stronger than Believed

In order to evaluate rooftop strength, the Sandia research team developed and executed a series of tests on simulated scaled roof structures that used historical construction practices and materials. Testing was conducted at the structures laboratory in the Civil Engineering Department at the University of New Mexico.

The team's initial testing focused on individual wood beams and the potential strength increase in an individual beam given composite or partial composite action offered by connection of the overlying sheathing to the beam either by nails or glue. The team then tested several rafter-supported roof designs of varying size and span lengths, conducting 36 tests of various roof-assembly categories. Configurations included rafter-supported roof designs as well as open- and closed-web trusses.

The tests resulted in empirical 'actual' load-carrying capacity data that were compared to the code-defined allowable loads.



Sandia tested numerous rooftop structure configurations at UNM's structures laboratory.

For all sample configurations evaluated, empirical testing revealed a greater ultimate capacity than the prescribed allowable capacity. On average, rafter-based tests demonstrated a 330% excess load-bearing capacity, as compared to values computed in the National Design Standard, while composite action increased strength by as much as 74%.

Sandia's study findings provide evidence that the strength of rooftop structures may be sufficient to support any additional loading that occurs due to installing PV arrays. This conclusion suggests that current rooftop structural evaluations are overly conservative in evaluating the ability of roofs to support additional loading from solar PV installations. Code officials, permitting officials, and engineers can use this Sandia report as a tool in decisions about rooftop structural analyses and solar PV permitting applications, ultimately helping to support safe, cost-effective solar rooftop installations.

Download the full reports:

[Empirically Derived Strength of Residential Roof Structures for Solar Installations]

[Structural Code Considerations of Solar Rooftop Installations]

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