TECH TIPS

WIND UPLIFT

Forces Caused by the Wind

Designing structures and components, such as roofing, to withstand the damaging effects of the wind is an important aspect of engineering. During recent years, many research studies were conducted using wind tunnels and full-scale modeling to measure the forces of the wind on various types of structures.

Wind Uplift Resistance

Just as a model was developed to simplify the determination of pressures exerted by the wind, simple standardized tests were needed to measure the wind resistance of various roofing systems. Three of the principle tests are described below. All are performed on a mockup, with a minimum size of 10 ft by 10 ft, which is placed in a chamber that is capable of exerting suction from above, pressure from beneath, or both.

UL 1897 - Standard for Uplift Tests for Roof Covering Systems

This test evaluates the attachment of the roof covering systems to the roof decks. It is conducted by either pulling a vacuum above the assembly or by pressurizing an air bag placed loosely between the deck and the roof covering. The second method is more common. This test does not consider the strength of the roof deck, and the test is run to failure. The results are reported as the highest uplift pressure achieved prior to failure, commonly in pounds per square foot. The method does not necessarily simulate the actual dynamic uplift pressures encountered by roofing systems. This test is often incorporated into the UL 580 test to provide a point of failure after conclusion of the class 90 test procedure.

UL 580 - Standard for Tests for Uplift Resistance of Roof Assemblies

This test is appropriate when the roofing product is a structural panel installed over open framing without the need for a solid deck. It is also conducted on a roof covering attached to a solid substrate when the two are specified as a system. This test incorporates both pressure beneath the system and a vacuum above in an oscillating manner according to a specific test protocol. To achieve a UL Class 90 rating, the system must withstand a maximum positive pressure (pressure from below) of 48.5 psf combined with a maximum negative pressure (vacuum from above) of 56.5 psf, yielding a combined pressure differential of 105 psf. For Class 60 and Class 30 ratings, the maximum total pressures are 75 psf and 45 psf, respectively. Two points are particularly significant. First, the test is not run to failure, only to the specified limit. Second, when testing a roof covering fastened to a solid deck, the deck resists the pressure from below, and the roof covering may only resist the vacuum from above of 56.5 psf. An air bag system is used between the panel and roof deck and or purlins to aid in capturing the positive pressure below and transferring it to the metal panel itself. Due to the requirement, and to distribute pressure to underside of panel, underlayments are not to be used within the test assembly.

ATAS International, Inc.
Allentown, PA | Mesa, AZ
800.468.1441
www.atas.com
info@atas.com

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ASTM E1592 - Standard Test Method for Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference

The purpose of this test is to measure the bending capacity and attachment strength when a system is subjected to a uniform static pressure. Use of this test method is restricted to standing seam, trapezoidal, ribbed or corrugated metal panels in the thickness range of 0.012 to 0.050 inch. When considering wind uplift resistance, air pressure is applied beneath the panels and attachments, frequently using a loosely installed plastic bag beneath the panels to maintain the pressure. Unlike the other two tests, deflections in the test panels are measured at no less than six locations. Baseline measurements are taken at a nominal pressure and then at each of the specified test pressures or until failure. The test pressure is relieved before progressing to the next higher pressure to determine whether there has been any permanent deformation. Test results are used in conjunction with wind design standard to determine required spacing of supports or attachments.

Continued Evolution of Test Methods

An “Allowable Uplift Pressure” is calculated by applying an appropriate safety factor to the “Test Uplift Pressure” and then comparing it to the predicted “Design Wind Pressure”. Roofing and siding products are available in so many different materials and sizes, installed over a variety of deck substrate materials and support spacing, etc., that it is impossible to test every combination. Engineering analyses are sometimes required to determine the suitability of products for specific projects. In many cases it may be possible to increase the allowable uplift pressure by increasing the number of fasteners (reducing clip spacing) and/or increasing additional fastening points.

Test methods continue to evolve as our understanding of wind and its effects improves. As an example, the commentary in ASCE 7 admits that air permeable roof coverings are unfairly penalized. Research is being performed to address this condition and potentially modify the actual tested values and safety factors.