

Why Leeward Surfaces Can Experience Higher Wind Loads Than Windward Surfaces

When wind strikes a building, the most apparent pressure occurs on the windward side, where air presses directly against the exterior. This creates positive pressure that pushes windows, doors, curtain walls, cladding, and other building-envelope components inward.

Surfaces on the opposite side can experience a different and sometimes greater net pressure.

As air moves over the roof and around the sides of a building, it separates from the exterior surfaces and creates areas of lower pressure. This negative pressure, commonly called suction, pulls outward on leeward walls, side walls, roofs, corners, and edges.

Under some conditions, the outward pressure on a leeward surface can exceed the inward pressure on a windward surface. The controlling pressure, however, may occur at a roof corner, roof edge, wall corner, or side-wall zone rather than across the entire leeward wall.

These pressure differences affect how windows, doors, curtain walls, roofing, wall systems, and their connections are designed, specified, and tested.

Positive Pressure Versus Negative Pressure

Positive and negative pressure describe the direction of a force.

- **Positive pressure** pushes toward the building. It generally occurs where wind first strikes the structure.

"The highest wind load does not always occur where the wind first hits. Suction at leeward surfaces, corners, and roof edges can create greater outward pressure than windward loads."

- **Negative pressure** pulls away from the building. It develops where airflow accelerates, changes direction, or separates from an exterior surface.

A negative pressure does not necessarily represent a lower load. The minus sign indicates direction, not severity. A negative pressure with a greater absolute value can place more demand on an assembly than a smaller positive pressure.

Negative pressures commonly affect:

- Leeward and side walls
- Roof surfaces
- Wall and roof corners
- Roof perimeters
- Parapets and overhangs

The pressure at each location depends on factors that include building height and geometry, wind speed and

direction, exposure, internal pressure, surrounding terrain, and the component's location on the building.

Why the Leeward Load Can Be Higher

Air accumulates against the windward face before moving over and around the structure. Once it passes the building edges, the airflow separates and forms a turbulent wake with lower exterior pressure.

That lower pressure creates suction on the leeward side.

The net load on an assembly also accounts for pressure inside the building. If exterior suction pulls outward while positive internal pressure pushes from within, the forces act in the same direction.

This combination can cause the net outward load on a leeward surface to exceed the inward pressure on a windward surface. It can become especially significant if wind enters through a large opening created by a damaged door, window, or other building-envelope component.

Corners and edges may experience even higher localized suction because airflow accelerates and separates as it moves around the building. Roof corners and perimeters, for example, often face greater uplift demands than interior roof areas.

The same product may therefore require stronger attachments, closer fastener spacing, or a higher pressure rating depending on where it is installed.

Wind Direction Can Change

Windward and leeward are not fixed sides of a building. Their locations change with wind direction.

During a hurricane, wind can approach from multiple directions as the storm circulates and passes a site. A wall that begins on the leeward side may later become the windward wall.

Tornadoes can also produce rapidly changing and turbulent airflow. ASCE 7-22 introduced a dedicated tornado-load chapter, with provisions that apply under specified conditions.

Project teams must evaluate the wind directions and loading cases required by the applicable building code and referenced standard.

How Standards Address Suction Loads

Building codes commonly reference ASCE/SEI 7 for determining wind loads.

The standard considers factors such as:

- Wind speed
- Building height and geometry
- Exposure and risk categories
- Enclosure classification
- Internal and external pressure
- Effective wind area
- Component location

ASCE 7 divides walls and roofs into pressure zones to account for localized loading differences, including higher suction that can occur near corners and edges.

It also distinguishes between the main wind-force-resisting system and components, and the cladding. Windows, doors, curtain walls, wall panels, roof coverings, fasteners, anchors, and attachments generally fall under the components-and-cladding provisions.

Design professionals use positive and negative pressure coefficients to calculate the net load acting across an assembly. Project documents should identify pressures in both directions, so product selection and testing reflect the applicable design conditions.

Testing Windows, Doors, and Curtain Walls

Structural testing evaluates how an assembly responds to controlled pressure differences.

ASTM E330/E330M is commonly used to determine the structural performance of exterior windows, doors, skylights, and curtain walls under uniform static air-pressure differences. The specimen is installed in or against a test chamber, and pressure can be applied in positive and negative directions.

Positive pressure pushes the specimen inward. Negative pressure pulls it outward.

Depending on the test program and specification, testing may evaluate:

- Deflection and permanent deformation
- Glass breakage

- Frame and mullion performance
- Anchor and fastener capacity
- Hardware performance
- Panel or glazing disengagement

Testing in the required directions is important because an assembly may respond differently under inward and outward loads. Negative pressure may place greater demand on glazing retainers, pressure plates, anchors, clips, fasteners, hardware, and perimeter connections.

For some hurricane-related evaluations, test programs may also include impact testing followed by repeated positive and negative pressure cycles. ASTM E1233/E1233M provides a procedure for evaluating structural performance under cyclic air-pressure differentials.

Testing Roofing and Wall Systems

Roofing systems are particularly sensitive to suction.

Wind moving over a roof can create uplift that pulls membranes, panels, insulation, fasteners, and edge systems away from the deck. The highest design pressures often occur at roof corners and perimeters.

- Applicable test methods may evaluate the entire assembly, including:
- Roof covering
- Insulation and adhesives
- Fasteners and plates
- Seams
- Edge securement
- Roof deck

Wall and cladding systems may also be tested under positive and negative pressure to evaluate panels, clips, rails, fasteners, joints, substrates, and supporting framing.

A strong exterior panel cannot provide adequate system performance if its attachments or supporting components cannot transfer the load back to the building structure.

Matching Test Results to Project Conditions

A product described as "wind tested" is not automatically suitable for every project or every location on a building.

Project teams should compare the required design pressures with the conditions represented in the test report, including:

- Positive and negative pressure ratings
- Product dimensions and support spacing
- Glass or panel configuration
- Anchor and fastener spacing
- Substrate and installation method
- Tested pressure direction
- Wall or roof zone

Changes in size, spacing, materials, substrates, or attachment methods can affect performance.

The test specimen should represent the proposed installation as closely as possible. The complete load path should also be reviewed, from the exterior surface through the connections and supporting structure.

Account for the Push and the Pull

Negative pressure may control the design at roof edges, roof corners, wall corners, and leeward or side-wall zones. Testing assemblies in the required directions helps project teams assess how the complete system, including its fasteners, anchors, supports, and connections, responds to those loads.

Intertek provides laboratory and field testing for windows, doors, curtain walls, roofing, cladding, and other building-envelope systems. Its fenestration services address structural, air, water, energy, and other performance requirements.

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