Targets for Building Performance: Selecting Windows that Work

Building performance is affected by wind and water pressures — high-performance windows are chosen through the application of best practice calculations.

May 2008 - By Celeste Allen Novak, AIA, LEED AP

Architects are aware of the importance of the impact of the local environment. They review building location and the building site to orient their buildings toward the sun and important views, as well as respond to local weather conditions. Specifying the correct cladding system for a regional location is based on numerous factors, among which are the average amounts of wind and water pressures found at the site. Architects can be proactive in their specifications of cladding systems, particularly windows if they understand and design to performance factors for the building location.

Sometimes, an architect will rely on a manufacturer's data for performance criteria, which may exceed the actual criteria for performance in a particular location. This reliance does not remove the architect's liability for performance design and may lead to specifying materials that are more costly and not more effective than designing to actual performance data based on the requirements of the local building code.
Often, structural engineers are asked to provide wind pressure data for a designer's buildings. The designer then provides this wind pressure data to the window supplier, who will supply a window that meets the specified design criteria. However, as stated in the 2006 International Building Code, structural design section 1603.1.4 — the design professional is responsible for determining design wind pressures for components and cladding.

In projects with curtain walls, architectural specifiers often defer to "delegated design." This is the practice of requiring a window manufacturer to provide the analysis for structural performance based on calculations from a qualified professional engineer, licensed to practice in the jurisdiction of the project. Even with delegated design clauses, the professional must provide performance requirements and design criteria for wind loading in the construction documents and specification package.

Greensboro Public Library, Greensboro, NC
Architect: J. Hyatt Hammond & Associates

One of the primary goals in the design of the new Central Library facility for the Greensboro Public Library was to have an abundance of natural light, and views both into and out of the building.

Another common practice is that designers rely on multiple choice solutions in prepackaged specification formats. This may create confusion regarding which performance class to use for different projects and can lead to specifying windows that do not meet the needs of the owner. Owners want windows that work and are easy to maintain.

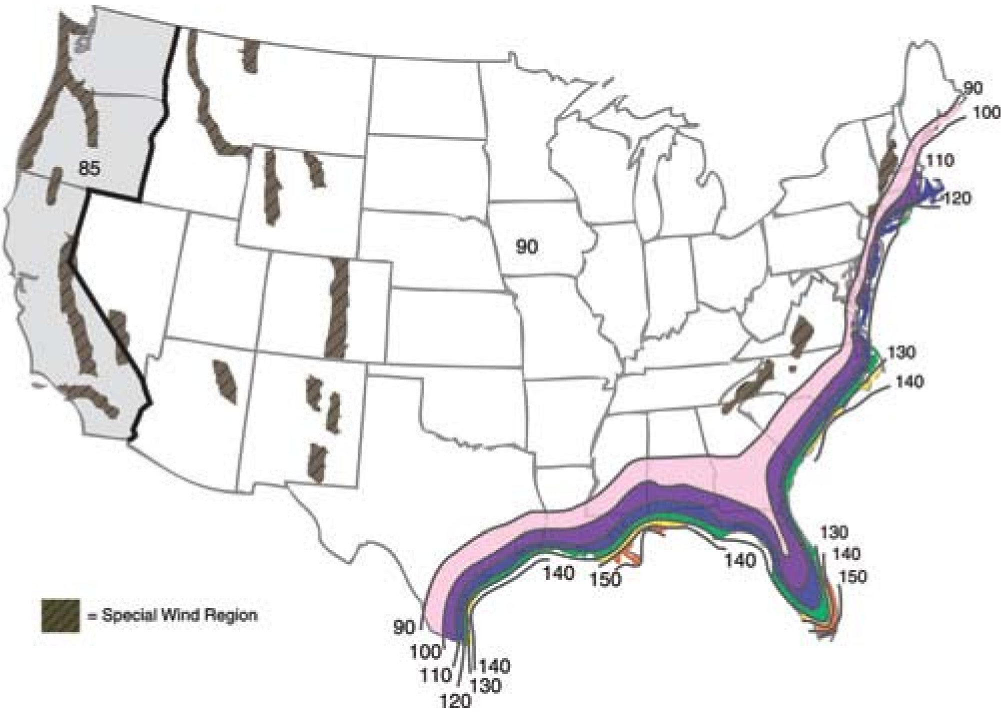
High-performance windows allow architects to seal the building envelope for maximum energy efficiency. Window performance is impacted by location, size and height of the building enclosure, as well as through proper installation. More designers are choosing to select windows that allow the building occupants to open the windows and let in fresh air. The operability of windows is related to the testing and rating of window performance class. Designers are challenged with identifying how to make the window system work as part of the building envelope, particularly in conjunction with different wind and water pressures, which can vary by location.

This article explores how to specify the right window for the project location based on the performance values for buildings. The impact of wind and water on window performance are discussed, along with a case study demonstrating the changes in wind and water pressure on the same building in different locations. The calculations required for determining performance values for windows are reviewed to educate the design professional in how to select the right window for the project location. Performance class and grades are explained, as well as the basis for the nomenclature used by the fenestration industry for window and door types. Choosing the right windows will optimize building performance and cost.

WEATHER AND WINDOWS: WIND DESIGN PRESSURE

Buildings stand up because of an architect’s ability to design structures that can withstand a variety of forces. Some forces are static, for example, the weight of the building structure; some forces are dynamic, such as the pressure of wind on the many sides of a building. The exterior face of a building is comprised of a number of separate design elements, including windows, flashings, wall panels, and decorative extrusions. The designer converts wind forces into units of pressure measured in pounds per square foot (psf). The wind load on a building is determined by the basic wind speed at the proposed construction site. For the most part, wind speeds have been found to be measurable and have been mapped by the National Weather Service.

Wind Speed Map



Wind speed values are nominal design 3-second gust wind speeds in miles per hour at 33 feet above ground for Exposure C category.

Image courtesy ASCE

Chapter 16, Structural Design of the 2006 International Building Code (IBC) requires designers to calculate the design wind pressures for a building, as well as for components and cladding based on local conditions. The main reference for wind design is the American Society of Civil Engineers (ASCE 7),*Minimum Design Loads for Buildings and Other Structures.*This standard provides guidelines for calculating minimum loads on buildings from a variety of sources, live loads, dead loads, service loads, seismic loads, as well as wind loads. The ASCE is not a building code, but the 16th Chapter of the IBC requires that the wind loads on every building be determined in accordance with Chapter 6 of ASCE 7. Local building codes may have other referenced material for the design professional to use or require the use of a particular version of the ASCE standard. Designers should contact the local building officials to determine which local codes and standards apply for their project.

Wind design pressures are impacted by building size, height, geometry, wind exposure as well as wind speed. Calculations for wind design pressure include a variety of other factors such as the intended occupancy and importance of a structure. ASCE 7 includes three different methods for determining wind design pressures for buildings. Method 1 — Simplified Procedure uses the following formula for calculating design wind pressure (P_{net}) for components and cladding: $P_{net} = \lambda x\ K_{zt}\ x\ I\ x\ P_{net30}$

Where:

λ = adjustment factor for building height and exposure
K_{zt} = topographic factor evaluated at mean roof height
I = importance factor based on building occupancy
P_{net30} = net design wind pressure for exposure B, at h = 30 ft,
and for I = 1.0

BUILDING HEIGHT AND EXPOSURE TO WIND

λ = Adjustment factor for building height & exposure

To solve for the adjustment factor for building height and expo-sure, the designer selects the appropriate value from Figure 6-3 in ASCE 7 Chapter 6 based on the mean roof height of the building and the exposure of the building to wind.

The mean roof height is simply the average of the roof eave height and the height to the highest point on the roof surface, except that, for roof angles of less than or equal to 10¡, the mean roof height shall be the roof eave height.

Determining the building exposure to wind requires a little more explanation. As wind flows to a building it is modified, strengthened or decreased by the path it takes, around, over or above other buildings. Building exposure (B, C, or D) is based on the context of the building location.

Exposure B is the least severe exposure and includes urban and suburban areas, wooded areas, or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger.

Exposure C includes open terrain with scattered obstructions having heights generally less than 30 feet. This category includes flat open country, grasslands, and all water surfaces in hurricane prone regions. Although a building might be in an urban area, the designer should be careful to evaluate the exposure to wind forces, based on the context of the building location in the city. For example, the designer may choose exposure C if the building location is at the edge of the city adjacent to farmlands, not Exposure B.

Exposure D is the most severe exposure and includes flat, unobstructed areas and water surfaces outside hurricane prone regions. This category includes the Pacific coastline, smooth mud flats, salt flats, unbroken ice, and inland waterways like the Great Lakes and Mississippi River.

As the building height increases and/or the exposure to wind increases, the design wind pressure also increases. Exposure factors are important with relationship to topographic features and building height as variables in solving for design wind pressure.

TOPOGRAPHIC FACTORS — K_{ZT}

Frank Lloyd Wright recommended that houses be constructed at the brow of the hill. He encouraged designs for nature and understood the effects of increasing wind speed as it blows across a hill. Topographic features such as hills, escarpments, or ridges may increase the design wind pressure for the building when the following conditions are present.

1. The hill, ridge, or escarpment that the building sits on is isolated.
2. The hill, ridge, or escarpment that the building sits on rises above the height of the surrounding terrain by a factor of two or more.
3. The structure is located in the upper one-half of a hill or ridge or near the crest of an escarpment.

Instructions for calculating the topographic factor, if needed, are shown in Figure 6-4 of ASCE 7. If all three of the site conditions noted above are not applicable, the topographic factor Kzt is equal to 1.00.

BUILDING OCCUPANCY

I= *Importance Factor*

Not all buildings are required to be designed to withstand the highest wind loads. The code is designed to save lives, and buildings are rated as to the importance of their occupancy. The ASCE*Table 1-1: Occupancy Category of Buildings and Other Structures for Flood, Wind, Snow, Earthquake, and Ice Loads*, lists occupancy categories which are used to determine an importance factor. The use of a building is considered by the code and rated according to whether the loss of that structure would represent a substantial hazard to human life.

Occupancy categories range from IV, the most important, to I, the least important. Essential facilities such as hospitals, emergency facilities, government facilities such as fire and police stations, water treatment facilities and power generating stations have importance factors of IV. Higher factors are used for places where more than three hundred people congregate, where there are daycare facilities with a capacity of over 150, elementary schools and schools with populations of over 250, health care facilities and jails. Standard construction and most buildings in the United States have an importance factor of II. These structures include residential dwellings, apartments, condominiums and offices as well as shopping centers. Temporary structures, storage units, and agricultural facilities are the least important.

For most buildings the importance factor will be either 1.00 or 1.15. The design professional selects the importance factor from tables in the ASCE. The importance factor is designed to keep wind forces from destroying cladding components during wind storms. Importance factors account for the degree of hazard to human life and damage to property during a typical storm for the design location.

WIND SPEED, EFFECTIVE WIND AREAS, AND BUILDING ZONES

P_{net30}= *Net design wind pressure for exposure B, at h = 30 ft, and for I = 1.0*

Wind pressure changes from positive to negative as it moves around and over a building. Wind speeds up at corners and along roof planes. As one side of a building experiences positive pressure, the other sides and roof experience negative pressures. This has implications for fastening, flashing and installation requirements which should be addressed by the designer when specifying windows. The architect is responsible for determining, by themselves or with the advice of a qualified professional engineer, not only the basic wind speed applicable to the project but also the specific positive and negative design pressures at corners and other areas of the building.

Chapter 6 of the ASCE standard provides numerous tables and figures which assist the designer in the calculations for the net design wind pressure (P_{net30}). This variable depends on the design wind speed at the project site, the effective wind area of a component, and the building zone in which the component is located. P_{net30} is determined from Figure 6-3 Components and Cladding — Method 1.

Basic wind speed is selected from the wind speed maps included in ASCE Figure 6-1 and is based on a 3 second wind gust, recorded in miles per hour, at 33 feet above the ground in Exposure C. Average wind speeds vary throughout the United States. They are greater along the gulf and east coasts than in the Midwest and west coast. Special wind areas include regions with mountains and gorges where it is too difficult to predict the average wind speed so local designers rely on area climatic studies and input from local building officials. As the wind speed increases, the design wind pressure increases.

For windows in punched openings, the effective wind area is the area of the window opening in square feet. Larger windows tend to benefit from pressure averages and can be designed using lower pressure values. Consequently, as the effective wind area increases, the design wind pressure decreases.

The building zone of a component is based on its location on the building. Zone 4 is for windows located in the center of the façades and zone 5 is for windows located on the corners of a building. The corner zone dimension “a” is 10 percent of the least horizontal building width or 40 percent of the mean roof height, whichever is smaller, but not less than either 4 percent of the least horizontal width or three feet. Both zones experience positive and negative pressures as the wind flows over and around the building. Values for corner zones are higher since wind swirls at the corners of a building causing high negative pressures to occur at these locations. Windows located on the building corners (zone 5) will experience the highest design wind pressures and may require a different specification from windows located at the center of the building (zone 4).

LOCATION, LOCATION, LOCATION

The Greensboro Public Library can be used to demonstrate the effect of building location on design wind pressure.

J. Hyatt Hammond and Associates designed the Greensboro Library within a very tight, public budget. The library required the architect to design a building that would be a welcoming home for the whole community. Project Architect with J. Hyatt Hammond, of Greensboro, North

Carolina, Patrick Deaton, AIA, reports that “one of the primary goals in the design of the new Central Library facility was to have an abundance of natural light and views both into and out of the building. The previous facility was a 1960s design with very few windows and two underground levels. Patrons told the design team that the new facility should be warm and welcoming, and that the building should have plenty of windows.

Greensboro Public Library, Greensboro, NC
Architect: J. Hyatt Hammond & Associates

The design team selected individual two foot square wood windows to create a wood grid on the interior that contributes to the warm and natural atmosphere.

After considering various storefront systems, the design team selected individual 2-foot square wood windows with a dark green aluminum cladding on the exterior, with low-E glazing. The individual window units, when joined together into larger assemblies, create a wood grid on the interior that could not be achieved through other means and contributes to the warm and natural atmosphere. The wood mullions also create more shade at certain times of the day than a typical storefront system. In total, there are approximately 7800 square feet of exterior window openings in the Central Library."

This traditional design included large arched windows and horizontal ribbons of glass. Since its completion, which was part of community revitalization, this building has drawn the community together. Windows provide natural daylight and views into the quiet, engaging library environment.

To provide an example of how building location can affect wind pressure, the design pressure calculations shown in the Calculating for Design Wind Pressure Table have been solved for the Greensboro Library as if it were built in two different states. All elements are equal except for the wind speed and exposure to wind in the performance calculation. In general, the wind speed for most of the United States is approximately 90 mph. The coastal areas from Texas to Maine have higher wind speeds, some of which are as high as 150 mph.

Calculating for Design Wind Pressure							
$P_{net} = \lambda \times K_{zt} \times I \times P_{net30}$							
			P_{net}	λ	K_{zt}	I	P_{net30}
Location	Wind speed	Exposure	Design Wind Pressure	Adjustment Factor for building height & exposure	Topographic Factor	Importance Factor	Net Design Wind Pressure
Iowa	90 mph	B	18.3 / - 24.4	1.09	1.0	1.15	14.6 / - 19.5
Iowa	90 mph	C	25.0 / - 33.4	1.49	1.0	1.15	14.6 / - 19.5
Coast	130 mph	B	38.1 / - 51.0	1.09	1.0	1.15	30.4 / - 40.7
Coast	130 mph	C	52.1 / - 69.7	1.49	1.0	1.15	30.4 / - 40.7
Greensboro Library as if built in two locations with different wind speeds and exposures							

In most of the United States where the wind speed is 90 mph and the exposure is B, as shown for the Iowa location, a building the size of the Greensboro library or smaller will require a design wind pressure of less than 25 psf. As the wind exposure increases to C, the design wind pressure increases to -33.4 psf. Changing the location and corresponding wind speed to 130 mph while maintaining a wind exposure of C (as shown for the coastal location) increases the design wind pressure to as much as -69.7 psf at the building corners. Specifying performance based on building code requirements for design wind pressure will allow for the broadest range of window options and price points.

At the time of its development, the Greensboro Library was designed to the local codes as influenced by the International Building Code and the ASCE. The designers were careful to determine the structural forces which would impact the design which included large glass window walls. The project was built on schedule in part, because of the coordination with the window manufacturer, who was able to coordinate manufacturing with the construction schedule.

DESIGN METHODS

In solving for design wind pressure (P_{net}) for the Greensboro Library, Method 1 — Simplified Procedure from ASCE 7 Chapter 6 was used. Method 1 can be used to calculate the design wind pressure for components and cladding when the following conditions are met:

- The mean roof height is less than or equal to 60 feet
- The building is enclosed and conforms to wind borne debris section
- Regular-shaped building
- Is not subject to across wind loading
- Has either a flat roof, a gable roof with a slope less than or equal to 45 degrees or a hip roof with a slope less than or equal to 27 degrees.

According to the United States Department of Energy publication *Commercial Building Characteristics*, approximately 96 percent of the buildings in the United States are three stories or less in height so Method 1 can be applied to many buildings.

Method 2 — Analytical Procedure must be used when the conditions of Method 1 are not met and/or the building height exceeds 60 feet. Taller buildings have more demanding performance requirements than shorter buildings and require more analytical calculations. In addition to the variables included in Method 1, the design procedure in Method 2 includes extra variables like gust effect factor, internal and external pressure coefficients, and velocity pressure. Although the height of the building is important the height of components such as windows are not a factor when calculating design pressures.

In some cases, the designer may use Method 3 — Wind Tunnel Procedure to determine design wind pressures. A wind tunnel test or a test using other fluids is conducted with assigned test conditions. Wind tunnel testing can be used in place of Methods 1 and 2 for any building. The variation of wind speed to actual height, the scale of the building, and topographic modeling are only a few of the parameters involved in these tests. As architects design more complex forms, additional tests and calculations will be required by the designer to assure the integration and performance of the window system.

KEEPING DRY — WATER PERFORMANCE

Exterior walls protect us from invasions by water as rain. Well detailed, exterior building systems function biologically to prevent water from eroding the building structure. The window's complex organism comprised of glass, thermal filters, mullions, and flashing is placed in openings to create views and allow for daylight. This organism must work together to protect the building from the elements.

There is a direct relationship between the design for positive wind pressure and the design for water performance. The fenestration industry standard, AAMA/WDMA/CSA 101/I.S.2/A440-05, *Standard/Specification for windows, doors, and unit skylights* addresses this relationship.

"Three things are required to move water through a surface, a source of water, a path for the water to follow, and a force to drive the water through the opening. If any one of these items is absent, leakage cannot occur… The forces, which can drive leakage, are generally considered to be kinetic forces, gravity, capillary action, surface tension, and pressure differentials. In some circumstances only one or two of these forces may be present, but in a windy rainstorm all of them will likely be acting to move the water through any available leakage path."

Water pressure differences can drive water through any gaps in the windows or the window to wall interfaces. The direction of the flow is from the side with higher pressure to the side with lower pressure. The industry standard specification ties the water penetration resistance test pressure to the positive design wind pressure requirements. This condition renders the biggest pressure difference between internal pressure of the building and external wind pressure creating the conditions to drive water to the interior of the building.

Specifically, the industry standard recommends that the design-er multiply the maximum positive design wind pressure determined from the building code by 15 percent in order to determine the corresponding water test pressure. However, the industry standard also suggests that the water test pressure never be less than 2.9 psf. In the Greensboro library example, the maximum positive design pressure for 90 mph and Exposure B is 18.3 psf. Fifteen percent of 18.3 psf is 2.8 psf so the recommended water test pressure for the windows in the library is 2.9 psf.

Window components including glass quality, integrated flashing and installation methods are innovations which have been tested in many ways to verify performance values. Since rain penetrates a wall during a wind/rain storm, the tests include both a maximum wind load as well as a uniform water spray. Water test pressure is indicated in pounds per square foot (psf) and the most commonly used laboratory test method is ASTM E547*Standard Test Method for Water Penetration of Exterior Window, Skylights, Doors, and Curtain Walls by Cyclic Static Air Pressure Difference.* In this 23-minute sequential test, five minutes of water and wind are applied to the window surface, followed by one minute with just water applied to the surface. This sequence is repeated four times. This one minute break allows the window to recover and redirect the water to the exterior as it would in a typical rain storm. This is the most common test for the window frame, sash, weather stripping and other window components. The water resistance of the window to wall interface is most effectively determined through field testing during window installation.

PERFORMANCE SPECIFICATIONS

An accurate specification for a window will include the Performance Class and Performance Grade of the window. The Performance Grade is equivalent to the design wind pressure for components and cladding based on the following factors: wind speed, wind exposure, and an importance factor based on building occupancy. The design professional must verify with the local municipality regarding specific wind factors and code variations. Professionals should design for the code-mandated performance values and then select values from the window manufacturers' catalogs that meet or exceed the requirements of the code.

Design professionals specify structural loads on buildings, including wind loads, based on the International Building Code, ASCE 7, and the fenestration industry standard developed jointly by the American Architectural Manufacturers Association (AAMA), the Window & Door Manufacturers Association (WDMA) and the Canadian Standards Association (CSA). AAMA and WDMA are trade associations which "develop industry standards and test methods, certify products to industry standards, represent the industry before building code and regulatory bodies, conduct research on the fenestration industry, collect industry data, conduct educational programs for members and serve as an information clearinghouse for specifiers, architects, builders, contractors and consumers. CSA is a not-for-profit membership-based association serving business, industry, government and consumers in Canada and the global marketplace."1 CSA works to develop standards which enhance public safety and health as well as environmental preservation in Canada and around the world.

Complying with the AAMA/WDMA/CSA recommendations for specifications does not mean that the designer is achieving required code regulations for window performance. However, many of the codes and master specification systems reference the standards and recommendations developed by these organizations.

PERFORMANCE GRADE AND CLASS— GETTING IT RIGHT!

The Performance Grade is based on the design wind pressure calculated from the building code as noted previously. If the maximum design wind pressure is 25 psf, then the Performance Grade needs to be 25 or greater. Performance Grade is designated by a number following the product type and class designation. If the rating is desired in SI (metric) units, the design pressure in Pascals is preceded by an "M". For example, a casement R-class window designated C-R25 or C-RM1200 has the same design pressure rating of 25 psf or 1200 Pascal's, as well as the same Performance Grade.

- C is the product type, in this case casement
- R is the performance class
- 25 (or 1200) is the performance grade based on the design wind pressure

Five performance classes are listed in the AAMA/WDMA/CSA 101/I.S.2/A440-05 industry standard in order of increasing performance: R, LC, C, HC, and AW. According to the standard, each product type has a defined 'gateway' set of primary requirements before entry into the Performance Class is permitted. Gateway performance requirements are the minimum allowable performance levels that a gateway test specimen shall achieve in order for a product to be rated with a particular classification (R, LC, C, HC or AW). These designations are recommendations provided to assist the designer in selecting the right type of window for the designed purpose.

John E. Fetzer Institute

Wood windows were selected to frame nature and provide additional texture to the design of the building.

Selecting the Performance Class for windows and doors is more complex than specifying Performance Grade due to a large number of factors that must be considered.

- Gateway minimum frame test sizes, which increase from R class to AW class and differ widely among product types
- Minimum design wind pressure/performance grade
- Minimum structural test pressure, which is set at 150 percent of the design wind pressure

- Minimum water pressure, which is set at 15 percent of the maximum positive design pressure for all classes except AW. For AW class windows, the water-resistance test pressure is 20 percent of the positive design pressure. Note that for R class windows, the water-resistance test pressure is 15 percent of the positive design pressure, but is never less than 2.9 psf.
- Air-infiltration test pressure, which is set at 1.6 psf for R, LC, and C class windows, and 6.2 psf for HC and AW class windows. Allowable air leakage, either 0.1 or 0.3 cfm/sq. ft. varies depending on the product type.
- Maximum operating force, with more difficult operation allowed for C, HC, and AW
- Maximum locking force, with no minimum restrictions for HC and AW
- Maximum deflection at design pressure, which applies only to HC and AW
- Maximum permanent set after structural test pressure, lower for C, HC, and AW
- Forced entry resistance, same requirement for all classes
- Durability tests that vary greatly by product type

Each Performance Class is assigned a minimum design pressure by the standard. The minimum design pressure and, consequently, the gateway performance for R, LC, C, HC, and AW class windows is 15, 25, 30, 40, and 40, respectively. Besides the minimum design pressure, the industry standard recognizes optional performance grades above the minimum, based on higher design pressures stated in increments of 5 psf. So architects may assign higher design pressures if required by the building code.

The Performance Class Comparison chart shows the corresponding performance requirements for each class of the most common window types. In general, R and LC class windows have smaller test sizes and are allowed less force to operate and lock. But in many cases they offer sizes, design wind pressures, water resistance, air leakage resistance, forced entry resistance, and hardware performance associated with the C, HC, and AW classes.

In general, HC and AW class windows have larger test sizes, are allowed to have higher operating and locking forces, and are subject to additional unglazed sash tests. The unglazed sash tests are primarily designed for aluminum casement and awning windows that may be glazed in the field. Wood, fiberglass, and vinyl windows are typically glazed at the factory and are not designed to pass the unglazed sash tests. As a result, casement and awning windows manufactured from those materials will typically not meet HC or AW requirements.

The AW class is the only one that requires life-cycle tests in accordance with AAMA 910, *Voluntary "Life Cycle" Specifications and Test Methods for Architectural Grade Windows and Sliding Glass Doors.* The life cycle tests in AAMA 910 are designed to simulate the loading conditions expected during washing, maintenance, and predictable misuse situations like carelessness, ignorance of proper operating procedures, and operation without proper keys or devices. The tests are not designed to predict damage from vandalism, improper handling, or intentional abuse. Venting windows are subject to 2500 vent cycles (open and close) and 2500 hardware locking cycles (lock and unlock).

Since windows with Rand LC Performance Classes can meet many of the other performance criteria associated with C, HC, and AW classes as noted above, the big question is how to select one performance class vs. another. One approach is to use the code-mandated design wind pressure, the industry standard driven water test pressure, and the largest window sizes on the project as the starting point. Other key differentiators between classes are operating and locking forces for operable windows. As shown in the Performance Class Comparison Chart for Common Window Types, the differences in air leakage, forced entry resistance, and durability tests are relatively small between classes. Once the key performance criteria are identified, the designer can select the Performance Class and specify suitable windows based on review of the manufacturer's performance data.

Since 96 percent of the buildings in the United States are three stories or less, the most common exposure to wind is B, and the most common wind speed is 90 mph, the maximum positive design pressure will often be less than 20 psf and the corresponding water test pressure will be 3.0 psf. If the windows in the building are of average size and the owner is looking for ease of operation, then a Performance Class of R or LC may be suitable for many buildings across the country. Factors that may drive the specification to HC or AW might include extreme design wind pressures, extra large window sizes, or projects with aluminum windows that will be glazed in the field.

The John E. Fetzer Institute's Seasons Retreat Center near Kalamazoo, MI was designed by Harley Ellis Devereaux as a building for research and healing. Numerous conversations by researchers were inspired by the sunlight which streams through well detailed windows. The window system was detailed to frame nature. Choosing the right Performance Class and Performance Grade was important for the design of these windows so they would meet the owner's needs. For this building, wood windows were selected to frame nature and provide additional texture to the design of the building.

Using the industry standard as a guide, as well as the type of window the designer intends to use, the performance class can be selected from the combination of the design wind and water pressure as well as the other factors noted above. The designer should specify Performance Grade based on the requirements of the building code and ASCE 7 and Performance Class based on the guidelines in the industry standard and manufacturer's product data.

WINDOWS FOR THE FUTURE

Designers, who control window selection through a complete understanding of wind and water design pressures, performance class and performance grades, will have a larger choice of window products with a variety of frame choices including aluminum, wood, fiberglass, and vinyl. Windows which work well are structurally sound, energy efficient, durable, watertight, and should be specified to meet the needs of the building owner. Design professionals are designing similar buildings in many different locations and need to verify local weather and wind conditions in order to design safe, healthy and environmentally effective buildings. Window manufacturers can assist design professionals to make good window choices among the numerous models, shapes, combinations and materials as long as the designer can provide the design parameters as well as the design vision.

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