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Same Window-Different Views

By William J Pyznar, P.E.

Like a chain, a building envelope is only as strong as its weakest link. Specifiers often invest significant time and effort on exterior wall detailing for materials, drainage, flashing, etc., and yet pay virtually no attention to the actual window and associated installation requirements. The variety of combinations of windows and building types is equaled only by the number of inconsistencies we have seen in material selection and installation. These inconsistencies, along with deviations from proper practice, building code and accepted standards, result in underperforming windows, and can cause everything from unnecessary air infiltration to catastrophic building damage. Accordingly, a specifier's careful adherence to window-related building codes and accepted standards, as well as, voluntary practices, can make a meaningful difference in the building envelope's ultimate performance.

To better understand window-related issues, this article discusses:

- Window Functions
- Building Codes and Standards
- Materials
- Proper Installation Considerations.

Window Functions

Windows provide:

- A light source
- Exterior views
- Protection and isolation of the interior environment from the exterior elements
- Ventilation
- (Sometimes) a means of egress.

Properly performing windows should provide resistance to:

- Water and air infiltration
- Impact in hurricane- and security-sensitive areas
- Loss of energy (e.g. heat) from one side to another (R-value).

Additionally, the window assembly must provide structural resistance to dynamic and static loads, as well as, to deformation under wind pressure. And in specific instances, a window must also be required to meet elevated structural, and, fire resistance standards.

Building Codes and Standards

There are several primary references that must be considered in window specification, including:

- AAMA 101 Voluntary Specification
- Local Building Code
- Local (city) Ordinances
- ASTM E2112
- ASTM E330.

This article focuses on the AAMA voluntary specification, as well as, local building codes and ordinances.

AAMA 101 Voluntary Specification

AAMA 101 is the Standard/Specification for windows, doors and unit skylights as produced by the AAMA (American Architectural Manufacturers Association) in cooperation with the WDMA (The Window & Door Manufacturers Association) and the CSA (The Canadian Standards Association). AAMA 101 is a voluntary Standard/Specification covering requirements for single and dual windows, single and dual side-hinged door systems, sliding doors and unit skylights for new construction and replacement applications. Each product type is categorized into a "gateway" set of primary requirements for the applicable product type as a precursor to approval within a performance classification. The gateway requirements are the ***minimum allowable performance levels*** for a product to be rated within a particular classification (R, LC, C, HC, or AW). This

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includes achieving minimum performance levels for air leakage, water penetration resistance, uniform load and where required, forced-entry resistance and operating force. There are additional minimum performance levels for auxiliary (durability) and material tests specific to the product operator type; and depending on the geography, there may be further Energy Compliance requirements. Additionally, there may be project-specific installation requirements such as special structural consideration, and/or fire-resistant consideration.

Local Building Codes

Local Building Codes ***must*** be referenced during the specification process; although these codes are often based on a national code such as the International Building Code (IBC), there may be specific requirements that result that are actually stricter than the national codes. For example, in South Florida: the Dade County Edition of the Florida Building Code provides building requirements, but the Miami-Dade Building Code Compliance Office website (http://www.miamidade.gov/buildingcode/home.asp) lists approved specific windows that meet local Design Pressure standards and classifies them with respect to the High Velocity Hurricane Zone requirements.

Another example is the New York City Building Code, which has very specific design calculations for vertical glazing (glass) installations. The code also requires that aluminum, vinyl and wood exterior windows, as well as, glass doors, conform to requirements of AAMA 101 or that they must be tested in accordance with ATM E330 – "The Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference", which evaluates the structural performance of a window.

Additionally, in New Jersey, the IBC is refined by the New Jersey Administrative Code; and, exterior windows and doors must be designed structurally to meet the specific requirements of AAMA 101.

Materials

Most specifiers begin the window selection process with the consideration of materials-which is usually based on cost, aesthetics and performance requirements. For example, because of the differences in wind load, a single-story home located 120 miles from the ocean will have a much greater selection of material choices than for a home in a high-wind area, such as a 20-story ocean-front high-rise. I am not aware of any vinyl windows that would meet the structural requirements for the ocean-front high–rise, but outside of the high wind area, material choices include vinyl, wood, aluminum, aluminum clad wood, vinyl clad wood and even fiberglass—each with their respective applications and benefits.

Among these material choices, vinyl provides excellent resistance to conducting heat and can be constructed with both high R-value and resistance to condensation. Many modern vinyl window manufacturers also weld the vinyl corners into a one-piece frame, to prevent leaks from window corners. However, vinyl windows are less resistant to structural loading, which has a direct effect on air and water infiltration. Further, their color availability is generally limited to white, since darker colors have demonstrated deformation from heat absorption. For example, an eight foot section of vinyl will change in dimension up to 11mm over a 100°F temperature change. This contrasts with the same section of wood, which would only change by up to 0.8mm under the same conditions. Accordingly, a specifier must anticipate dimension changes in detailing the window installation

Aluminum windows conduct heat much better than wood or vinyl; proper detailing of the window must include thermal breaks, to prevent "sweating". However, aluminum windows can resist significant wind loads and provide excellent air and water infiltration resistance when designed to address these specific criteria.

Wood windows are common in residential applications that require the aesthetic richness of wood at the interior and exterior; these are often clad with aluminum or vinyl to minimize maintenance.

Proper Installation Considerations

Regardless of the material selection and the design standard, the specifier must anticipate that ***all windows leak***. In part, this is because windows are only tested and designed for specific conditions, so when the conditions exceed thresholds in the design standards, there is the potential for water infiltration through the window. Therefore the design must anticipate the water's "final destination" after it has leaked through the window. Many aluminum window manufacturers build a "receptor channel" as part of their window design. The receptor channel is installed under the window to catch the water, and channel it to the exterior via a weep slot. It is imperative to ensure that the receptor channel is installed with end dams to prevent the water from flowing into the building envelope at each side of the receptor channel (while this may appear to be common sense, we regularly see this installation defect).

Proper installation can help reduce the incidence of window failure by considering:

- Orientation (E.g. Eastern vs. southern exposure)
- Loads induced (noting that the geometry of the building and the location of the window in that geometry can have a significant impact on the loads induced on to one window versus another window in the building),
- Exposure of the window elements (is the window recessed into, vs., "flush" with, the building).

Each of the major window types can be installed by using a "nailing fin" (extrusions that are attached to each side of the window and come off of the window like a fin) to fasten the window in the plane of the exterior cladding of the window structure. They allow supplemental flashing to be installed around the window to make a seamless installation between the weather resistive barrier (WRB) on the building (i.e. building paper) and the window. For new construction, nailing fins are often used, unless the window is installed into a masonry opening. For retrofit and masonry openings, the window is secured to the structure by fastening screws

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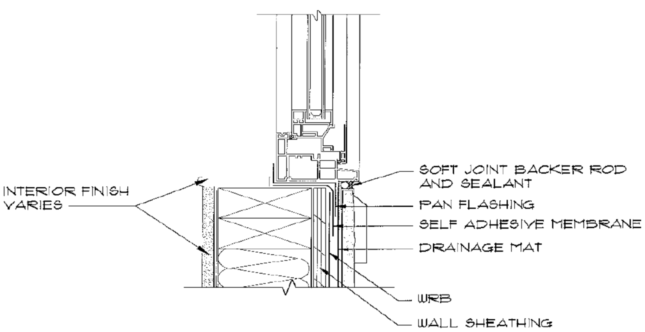
through the frame of the window. When nailing fins are not used, the seal between the building and the window frame often relies on the performance of a sealant joint.

Regardless of the installation method, the window should have flashing installed beneath the window to collect water that infiltrates the window. With an extruded welded vinyl window that has no mullions (structural elements which divide adjacent window units), this is less imperative, since there are no locations for water infiltration. For aluminum and wood windows using mitered corners that are mechanically fastened, and window sections that are mulled together to form larger windows, flashing should be installed into the window opening prior to the installation, and it should be designed to move water to the exterior.

The illustration in Figure 1 details a typical window flashing:

Figure 1-Typical Window Flashing



When moving a window from manufacturer to the window opening, the installer must be sure not to rack (let the window come out of square with) the window. Racking can loosen miters and seals, enabling future water infiltration. In addition to a pan flashing, the window should be shimmed in accordance with the manufacturer's installation requirements, or the window may deflect or distort. Also important is the integration of the window with the weather-resistive barrier (WRB) of the building wall, if one exists. The window flashing at the sill, head and jambs (bottom, top and sides respectively) must be properly integrated with the WRB.

To seal the window to the adjacent building materials, sealants must be properly designed and installed, which includes anticipating the width of the joint based upon the calculated thermal movement of the window. A sealant material should be chosen that is flexible enough to withstand this movement. Installation should include bond breakers or backer rods to control the depth of the joint and to ensure proper sealant performance. However it would be unwise to rely on the water-resistance performance of the window installation based solely on the sealant. The window sealants and gaskets will age and will fail, so installing secondary barriers, to collect and return the water to the exterior, will increase a building's resistance to water infiltration.

Conclusion

Windows provide much more than an enhanced aesthetic or the passage of light. Proper selection of window materials, coupled with effective installation can be a wise and in some cases, a code-required, investment in a problem-free building envelope.

Reducing or Avoiding Winter's Havoc

Methods and Materials to Reduce the Effects of Freeze/Thaw Cycles

By Andrew Amorosi, P.E., R.S.

Introduction

Although the amount of snowfall varies annually, the cold, and fluctuations in, winter temperatures can wreak havoc on various aspects of a community's infrastructure. This article reviews key causes of such damage, along with recommendations for repair and prevention.

Perhaps winter's most damaging circumstances are freeze/thaw cycles-particularly those after snow-or rainfall. The expansion and contraction of construction materials and soil can often lead to walkway or pavement damage. Sometimes this damage is unavoidable, but proactive maintenance, enhanced designs, proper specification and installation methods, combined with the use of the right materials, can frequently reduce, or virtually eliminate, potential infrastructure failures. The remainder of this article discusses these issues with respect to:

- Frost Heave
- Repair Methods
- Damage Prevention Strategies.

Frost Heave

Frost Heave occurs when the expansion of frozen soil causes an upward movement of a surface. The heaving itself is usually caused by the formation of ice in the soil below the walkway surface. Throughout the year, soil contains varying degrees of moisture, after rain or snowfall, the quantity of water in the soil increases. The freezing temperature causes this water to expand when it becomes ice (by volume—approximately 9%). Correspondingly, this causes the soil to expand, which in turn, places pressure on asphalt, concrete or other materials embedded in, or adjacent to, the frozen soil. This can result in an upward movement (heaving) of these materials (see the photos in Figure 1 and Figure 2).

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Figure 1 – *Example of a Heaving Walkway*

Figure 2 – *Example of a Heaving Driveway at the Curbline*

Heaving may affect sidewalks, driveways, roads, curbs, tennis courts, retaining walls, stoops and even footings for decks, buildings, fences or other structures. The movement of the materials caused by heaving may result in cracking, material failures, tripping hazards or even structural damage. The severity of heaving-related damage depends on the underlying subgrade materials or soil types, quantity of water and related drainage rates, and the duration of freezing temperatures within the soil. The amount of movement will also depend on the methods and materials used in the infrastructure's original construction.

Repairs

Frost heaving that causes movements, cracking or other damage to a building or its components, should be properly evaluated by an engineer or architect. Frequently, heaved walkways, driveways or roadways return to their original elevations after the winter. However, any resulting tripping hazards in walkways should be repaired, which may involve re-setting brick pavers or replacing sidewalk panels. When a significant failure of a patio or walkway occurs, it should be replaced. Fences can be re-set.

All linear cracks in asphalt pavement should be properly sealed prior to winter to inhibit water intrusion and additional damage. Failures or potholes should be replaced by removal and replacement of the failed sections.

Damage Prevention Strategies

Completely ***and*** cost-effectively eliminating the potential damage from frost heave is a major financial challenge. However, proper design and/or enhanced methods and materials in construction can certainly reduce damage potential. For communities considering or initiating a large scale replacement project, utilizing proper specifications would be a good practice.

The ***frost line depth***, in theory, is the point below which soil will not completely freeze and cause movement. Generally, any permanent structure, and anything attached to it, must adhere to building codes that require footings for any structure to be located below the local frost line. Structures, such as sheds with an area of less than 100 square feet, are typically exempt from such codes.

It would be unusual today for a building footing to not be below frost line depth, but the rule should ***always*** apply for any structure-including (e.g.), elevated stoops, decks, fences, pool shade structures- and even tennis court net posts.

Certain types of walkway steps, retaining walls or other structures may not require a footing below the frost line depth, but a proper footing design and soil analysis is needed for footing depth verification. Subsurface drainage should be considered to prevent excess water accumulation in, and around, the structure.

Roadways, driveways, walkways (all types), pool decks and patios should have the proper design and installation to reduce the potential for frost heave. Driveways should be replaced with proper subgrade and subsurface drainage consideration, especially along the curbline.

Summary

Taking the time and effort for proper infrastructure design and installation is the key to reducing frost heave effects. Analysis of existing or proposed subgrade materials and proper subsurface drainage, along with an evaluation of existing soil characteristics and groundwater conditions play a large role in determining the most feasible approach to prevent the damage often created by frost heave.

What's *New?*

Welcome to the associates who have joined us at our New Jersey Headquarters:

Nicola Sanders, Administrative Supervisor:
Nicola comes to us with extensive experience working for an international real estate management company

John Wehrle, Project Manager:
Certified Building Inspector, Residential, International Code Council Certified ACI Grade I Concrete Field Testing Technician, B.S., Civil Engineering, New Jersey Institute of Technology *Magna Cum Laude*

Matthew O'Hara, Project Manager:
HHS Building/HHS Plumbing /ICS Fire One and Two Family Mechanical / Multiple Dwelling & Housing; Bachelor of Applied Science, Civil Engineering, Construction Management Technology and Minor in Business Management, Temple University

Gregory Sabelnik, Project Manager:
B.S., Civil Engineering (Environmental and Water Resources Track); Virginia Polytechnic Institute and State University

Steve Weinstein, P.E., LEED AP, Senior Engineer:
B.S. Engineering, New Jersey Institute of Technology

Parviz Kamalinejad, EIT, Project Manager:
B.S., Civil Engineering, Portland State University

Scott Wilton, P.E., Senior Engineer:
M.B.A., Finance, Depaul University; B.A., Civil Engineering and Forestry, Iowa State University.

Awards & Recognitions:

Congratulations to our staff who received New Jersey's Special Inspector's state certification for EIFS & Concrete inspection: **Andrew Amorosi, William Pyznar, J.Stewart Willis, Mark McCann.**