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Rainwater Management Performance of Newly Constructed Residential Building Enclosures During August and September 2004

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Abstract:

To review the performance of residential assemblies in the central Florida (Orlando) area during the three hurricanes in August and September 2004. The specific focus of the review is on the water management details associated with stucco claddings. Two types of stucco claddings were reviewed: "traditional three coat hard coat stucco" and "cementitious decorative finishes." Both are renderings applied to substrates and the fundamental physics apply to both equally.

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Prepared for the Home Builders Association of Metro Orlando and the Florida Home Builders Association By:

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Executive Summary

Building Science Corporation was engaged by the Home Builders Association of Metro Orlando and the Florida Home Builders Association to review the performance of residential assemblies in the central Florida (Orlando) area during the three hurricanes in August and September 2004.

The specific focus of the review was on the water management details associated with stucco claddings. Two types of stucco claddings were reviewed: "traditional three coat hard coat stucco" and "cementitious decorative finishes". Both are renderings applied to substrates and the fundamental physics apply to both equally.

Stucco claddings leak (as do all claddings). When stucco claddings leak the penetrating water is traditionally managed in two fundamental ways:

- the water is directed to a water resistant barrier (WRB) and directed downwards and out of the building assembly; or

- the water is absorbed in a non water sensitive material, redistributed and released to the interior and exterior in a controlled way

The first method is used with frame wall assemblies and the traditional WRB is "building paper". The second method is used with masonry block construction. Both methods are common in the central Florida (Orlando) area. The first method is typically limited to the second floor and gable roof assemblies. The second method is the standard first floor wall construction of the majority of homes constructed in the region.

The second floor assemblies are "drained" assemblies and drain into the first floor assemblies. The first floor assemblies are "mass" assemblies where penetrating rainwater is stored in the mass of the concrete block until it is released to both the interior and exterior during "drying" periods.

The performance of a mass assembly is based on a "rate-storage" relationship. When the rate of wetting exceeds the rate of drying accumulation occurs. Accumulation of water can occur until the quantity of accumulated moisture exceeds the moisture storage capacity of the assembly. The moisture storage capacity is time, temperature and material specific. Under normal conditions the amount of penetrating rainwater through stucco into a masonry block wall is minor and easily absorbed, redistributed and released to both the interior and exterior.

August and September 2004 was not a normal time. The mass assemblies were overwhelmed due to the extraordinary weather events. The mass assemblies were not able store the quantity of penetrating water and not able to dry rapidly enough between wetting events and in many situations water entered past the interior lining.

The second floor frame assemblies provided mixed performance. In many cases the second floor assemblies were also overwhelmed – principally for two reasons:

- drainage was poor due to the failure of plastic housewraps and other WRB systems to provide drainage and water holdout

- drained rainwater was not expelled to the exterior at the base of the second floor frame assemblies

The performance of the second floor frame assemblies is also based on a "rate-storage" relationship. However, unlike the mass assemblies, very little moisture storage capacity is available. As such for the second floor frame assemblies the rate of drying must match or exceed the rate of wetting. The key drying method in the second floor frame assemblies is drainage. This drainage depends on the provision of a drainage space between the stucco rendering and WRB and the water repellency of the WRB. Additionally, the drainage depends on the draining water being expelled to the exterior at the base of the frame assembly.

In the mass assemblies water penetrated the stucco via micro cracks (as the water also did in the frame assemblies). Typical paint finishes are unable to span micro cracks. Under normal conditions this is not an issue for the reasons previously mentioned (the huge moisture storage capacity of masonry block assemblies). As stucco buildings age and are successively repainted the water entry is reduced after each layer of paint is added. In general this is why many older buildings constructed with mass walls performed somewhat better.

In the second floor frame assemblies water also penetrated the stucco via micro cracks. Again, as previously mentioned, typical paint finishes are unable to span micro cracks. In frame wall assemblies it is expected that this penetrating water will be drained back to the exterior. However, in many cases the penetrating rainwater was not drained to the exterior due to adhesion between WRB's and the stucco renderings preventing drainage between the stucco renderings and WRB's, a loss of water repellency of the WRB's and the lack of effective flashing at the base of the drained assemblies.

There appear to be significant performance issues with WRB's relating to manufacture, testing and approval. All plastic housewraps and some building papers tend to bond to stucco renderings thereby negating drainage. Additionally, many plastic housewraps loose their water repellency when in contact with sheathing and stucco renderings.

The Florida Building Code in Section 2509.2.2 sets out the requirements for WRB's and stucco renderings applied over wood sheathing. Section 2509.2.2 reads as follows: "Moisture Barrier. Wood shall be covered with 15-1b roofing felt, or other approved equally moisture-resisting layer, and metal reinforcement as set forth herein." Unfortunately, "equally moisture-resisting" is not explicitly defined in the code by reference to any ASTM standards. In fact, some of the problems identified in our review are not currently addressed in any existing ASTM standard, particularly the water hold out of WRB's under the influence of surfactants, or the loss of water repellency due to adhesion, or the drainage characteristics of stucco renderings applied over WRB's.

There are significant code enforcement issues regarding the construction of flashing at the base of the second floor frame assemblies. Code officials are enforcing a provision of ASTM C1063 (Standard Specification for Installation of Lathing and Furring to Receive Interior and Exterior Portland Cement-Based Plaster) that is not intended to apply where second floor frame assemblies intersect first floor mass assemblies. For reasons that are not explicable or defensible "reverse flashing" is mandated rather than drainage to the exterior at this location.

The water management of penetrations and openings in stucco claddings were also reviewed particularly window and door openings, and service penetrations.

With respect to window and door openings it is instructive to realize that windows and doors installed in residential buildings in Florida are rated for water holdout at 15 percent of the design wind load and no lower than 140 Pa or approximately 35 mph. These service limits were clearly exceeded many times during August and September 2004. Windows and doors are expected to leak during hurricanes; they are not expected to blow out.

However, our testing indicates that many windows leaked at conditions well below their rated value – i.e. under no wind condition.

In a similar vein wind driven rain also entered dryer vent openings, electrical service panels, and bathroom fan vent openings. But, again, our testing indicates that many service penetrations leaked in the absence of wind pressures.

The method of testing windows is specified in ANSI/AAMA 101 – specifically ASTM E 547. The ASTM standard clearly views leakage at corners to constitute failure, however, it is our contention that the mounting frames used by many window testing groups in the testing of windows for compliance to the ASTM standard obscure the view of corners and subsequently many windows are listed as passing this test when in fact they fail.

Additionally, many windows are sold as "mulled" or double windows or composite windows. However, they are tested as single units. Every mulled window unit tested leaked with no applied wind load.

Finally, with respect to windows and doors, it is our contention that the installation instructions regarding window and door installation are inadequate with respect to water management. The windows and doors themselves under the Florida Building Code are subject to an ASTM standard. The interface between the window and door and the wall assembly is currently not.

Service penetrations such as dryer vents, electrical panel boxes, electrical boxes, vent fan hoods, and roof vents are currently not rated or designed for wind driven rain.

Anecdotal evidence indicates that a significant amount of rainwater entered soffit vent assemblies. This is consistent with the physics of the applied wind loads and the geometry of the soffit assemblies. Soffit geometries are currently not designed to address extreme wind driven rain exposures. Additionally, unvented roof designs which can address this mode of rainwater entry are currently not explicitly allowed in the Florida Building Code – although they are allowed in the International Residential Code.

The use of paint as a water management technique for stucco renderings applied to mass assemblies was also examined. As the mil thickness of paint increases, the ability of some paints to span micro cracks also increases. However, this applies primarily to mostly smooth surfaces. Highly textured surfaces are almost impossible to coat in a manner to seal micro cracks.

As the mil thickness of paint coatings increases, the water vapor permeability of these coatings decreases leading to problems with blistering and re-emulsification of some stucco renderings. The appropriate mil thickness and water vapor permeability relationship is currently unknown.

Finally, as part of our review of the water management provisions of the Florida Building Code we identified a provision relating to roof membranes, Section 1518.3, that appears to make no sense: "If the underlayment is a self-adhering membrane, the membrane shall be applied over a mechanically attached anchor sheet, attached in compliance with 1518.2.1." This provision encourages roof membrane "blow off" by requiring a bond break between the self-adhering membrane and the structural roof deck. This negates the entire reason to use a self-adhering membrane. The requirement for a mechanically attached anchor sheet under a self-adhering membrane has no basis in physics or logic and prevents the construction of highly water resistant roof assemblies that can provide a high degree of secondary protection during extreme wind driven rain events.

The following recommendations are offered:

- The moisture storage capacity of mass walls be increased by providing a "seat" at the base of these assemblies.

- A bond break be provided between primary drainage planes and stucco renderings in drained assemblies. In simple terms this will require two layers of building paper or a layer of building paper over a plastic housewrap.

- The specification, rating and testing of WRB's be consistent with their installed exposure – i.e. tested and rated as part of a stucco assembly. Appropriate performance specifications need to be developed for WRB's used with stucco renderings and the Florida Building Code altered to require them.

- Code officials be instructed regarding the correct interpretation of ASTM C1063 and the Florida Building Code be explicitly altered to require drainage where drained assemblies intersect mass assemblies.

- Windows and doors be correctly rated and tested according to ANSI/AAMA 101. Mulled window units, double windows or composite windows be tested and held to the same requirements as single units.

- Water managed window and door installation requirements be developed and the Florida Building Code altered to require them.

- Pressure relieved/baffled soffit assemblies be developed for vented roof assemblies and the Florida Building Code altered to require them.

- The Florida Building Code be altered to come into compliance with the International Residential Code to explicitly allow for the construction of unvented roof assemblies.

- Water managed details for dryer vents, electrical panel boxes, electrical boxes, vent fan hoods be developed and the Florida Building Code Altered to require them.

- It is unlikely that a practical paint specification can be developed in the short term to address micro-cracking stucco issues as the relationships among water vapor permeability, mil thickness and elasticity are not known. It is recommended that these relationships be explored and that until these relationships are understood the Florida Building Code not be altered to require "elastomeric paints" on stucco renderings.

- Repeal of Section 1518.3 of the Florida Building Code requiring a mechanically attached anchor sheet between a self-adhering membrane and roof sheathing.

Background and Approach

Building Science Corporation was engaged by the Home Builders Association of Metro Orlando and the Florida Home Builders Association to review the performance of residential assemblies in the central Florida (Orlando) area during the three hurricanes in August and September 2004.

The specific focus of the review was on the water management details associated with stucco claddings. The performance of stucco claddings was called into question after the events of August and September 2004, specifically the effect of rain from hurricanes Charley, Frances and Jeanne.

The review was conducted through field investigation, field testing and experimentation, mock-up testing and experimentation, bench top testing, review of literature, review of codes and standards, and interviews with builders, contractors, materials suppliers, manufacturers, and code officials.

The specific focus of the review is on the water management details associated with stucco claddings. Two types of stucco claddings were reviewed: “traditional three coat hard coat stucco” and “cementitious decorative finishes”. Both are renderings applied to substrates and the fundamental physics apply to both equally.

Stucco claddings leak (as do all claddings). ASTM C 926 – 98a “Standard Specification for Application of Portland Cement-Based Plaster” recognizes this: “Resistance to rain penetration is improved where plaster has been adequately densified during application and properly cured. Plaster shall not, however, be considered to be “waterproof.””

When stucco claddings leak the penetrating water is traditionally managed in two fundamental ways:

- the water is directed to a water resistant barrier (WRB) and directed downwards and out of the building assembly; or

- the water is absorbed in a non water sensitive material, redistributed and released to the interior and exterior in a controlled way

The first method is used with frame wall assemblies and the traditional WRB is “building paper” (Figure 1). The second method is used with masonry block construction (Figure 2). Both methods are common in the central Florida (Orlando) area. The first method is typically limited to the second floor and gable roof assemblies (Photograph 1). The second method is the standard first floor wall construction of the majority of homes constructed in the region.

The second floor assemblies are “drained” assemblies and drain into the first floor assemblies (Figure 3). The first floor assemblies are “mass” assemblies where penetrating rainwater is stored in the mass of the concrete block until it is released to both the interior and exterior during “drying” periods.

The performance of a mass assembly is based on a “rate-storage” relationship. When the rate of wetting exceeds the rate of drying accumulation occurs. Accumulation of water can occur until the quantity of accumulated moisture exceeds the moisture storage capacity of the assembly. The moisture storage capacity is time, temperature and material specific. Under normal conditions the amount of penetrating rainwater through stucco into a masonry block wall is minor and easily absorbed, redistributed and released to both the interior and exterior.

Figure 1: Drained Assembly

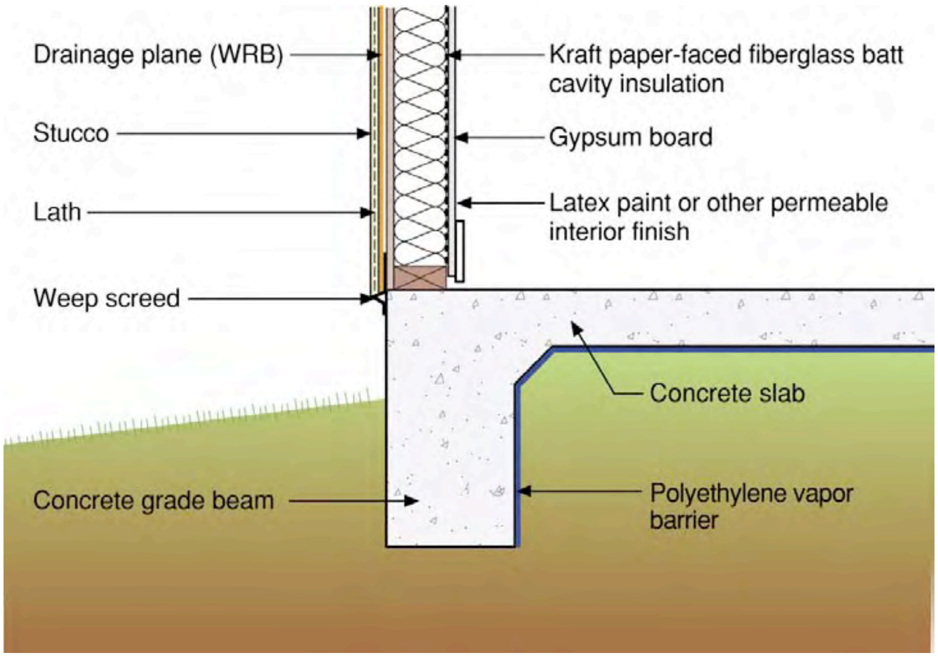


Figure 2: Mass Assembly

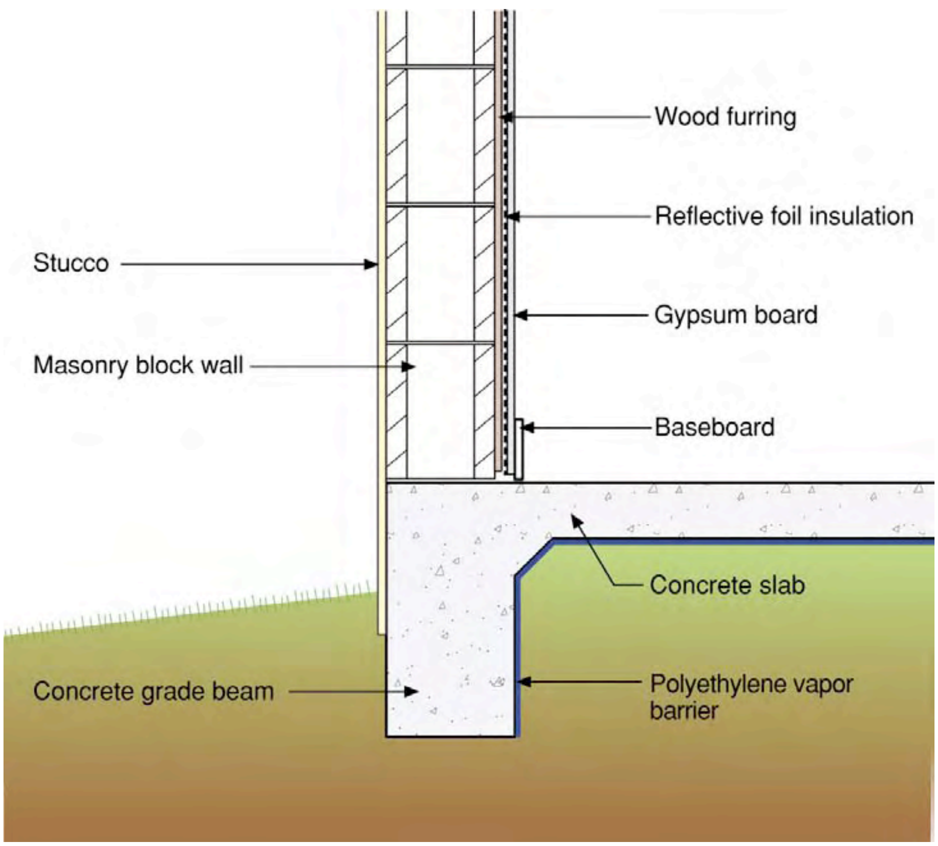
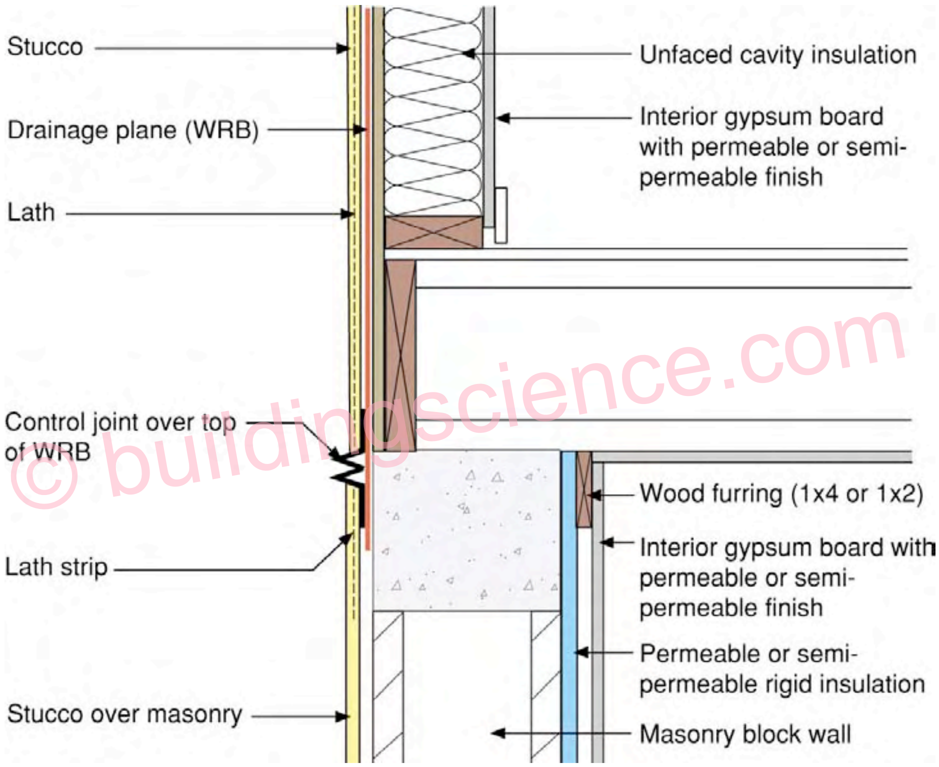


Figure 3: Second Floor Drained Assembly Drains Into First Floor Mass Assembly



Photograph 1: Typical Construction

Events of August and September 2004

August and September 2004 was not a normal time. Four hurricanes hit the State of Florida, and three of the hurricanes hit the Orlando region (Figure 4, Figure 5, Figure 6 and Figure 7). Unprecedented quantities of rain fell during high wind events.

The mass assemblies were overwhelmed due to the extraordinary weather events. The mass assemblies were not able store the quantity of penetrating water and not able to dry rapidly enough between wetting events and in many situations water entered past the interior lining (Figure 8).

The second floor frame assemblies provided mixed performance. In many cases the second floor assemblies were also overwhelmed (Photograph 2) – principally for two reasons:

- drainage was poor due to the failure of plastic housewraps and other WRB systems to provide drainage and water holdout
- drained rainwater was not expelled to the exterior at the base of the second floor frame assemblies

The performance of the second floor frame assemblies is also based on a "rate-storage" relationship. However, unlike the mass assemblies, very little moisture storage capacity is available. As such for the second floor frame assemblies the rate of drying must match or exceed the rate of wetting. The key drying method in the second floor frame assemblies is drainage. This drainage depends on the provision of a drainage space between the stucco rendering and WRB and the water repellency of the WRB. Additionally, the drainage depends on the draining water being expelled to the exterior at the base of the frame assembly.

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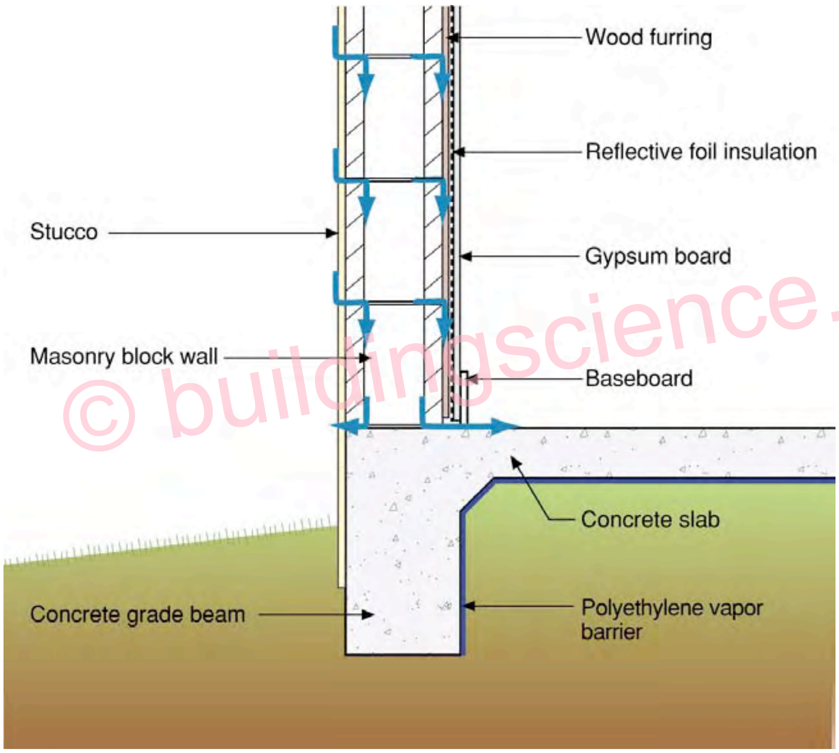
Figure 4: Hurricane Charley (Aug 9-14, 2004)

Figure 5: Hurricane Frances (Aug 25-Sept 25, 2004)

Figure 6: Hurricane Ivan (Sept 2-24, 2004)

Figure 7: Hurricane Jeanne (Sept 13-28, 2004)

Figure 8: Rainwater Entry into Mass Assembly



Photograph 2: Rainwater Entry into Second Floor Frame Assembly

Performance Issues With Water Resistant Barriers

There appear to be significant performance issues with WRB's relating to manufacture, testing and approval. All plastic housewraps and some building papers tend to bond to stucco renderings thereby negating drainage (Photograph 3). Additionally, many plastic housewraps loose their water repellency (Figure 9) when in contact with sheathing and stucco renderings (Photograph 4).

The Florida Building Code in Section 2509.2.2 sets out the requirements for WRB's and stucco renderings applied over wood sheathing. Section 2509.2.2 reads as follows: "Moisture Barrier. Wood shall be covered with 15-1b roofing felt, or other approved equally moisture-resisting layer, and metal reinforcement as set forth herein." Unfortunately, "equally moisture-resisting" is not explicitly defined in the code by reference to any ASTM standards. In fact, some of the problems identified in our review are not currently addressed in any existing ASTM standard, particularly the water hold out of WRB's under the influence of surfactants, or the loss of water repellency due to adhesion, or the drainage characteristics of stucco renderings applied over WRB's.

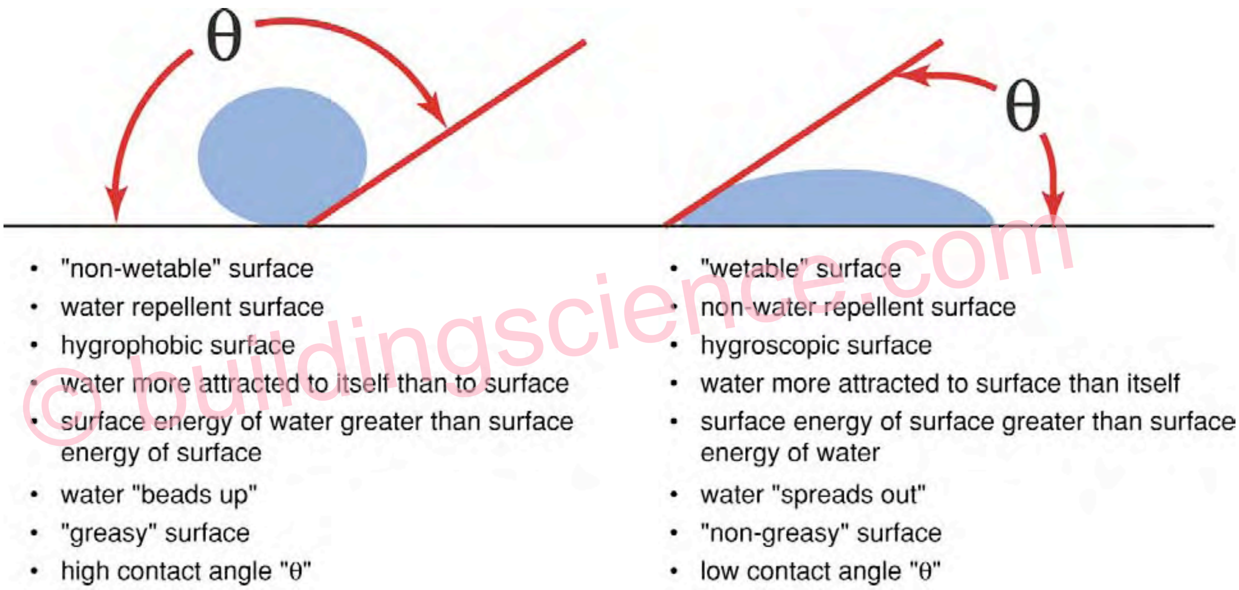
All perforated plastic housewraps fail a simple test for water repellency and water holdout (Photograph 5 and Photograph 6). Many non perforated housewraps fail a similar test when exposed to surfactants (Photograph 7, Photograph 8 and Photograph 9).

The problem of adhesion of stucco renderings to plastic housewraps and to building papers can be address by installing a "bond break" (Figure 10). Tests showed that a thin layer of asphalt saturated felt acts as an effective bond break for both building papers (Photograph 10) and plastic housewraps (Photograph 11). The felt used is similar to the backing on paper backed lath (Photograph 12).

The technique of using two layers of building paper is typical in other regions in the United States and significant trade literature exists delineating the practice (Figure 11).

Drainage between the bond break and primary drainage plane is significantly enhanced when a drainage space is provided such as through the use of a textured or profiled drainage plane (Photograph 13). A test for drainage should be developed and performance requirements established.

Figure 9: Water Repellency



Photograph 3: Stucco Rendering Bonding to Building Paper

Photograph 4: Stucco Rendering Bonding to Plastic Housewrap

Photograph 5: Water Drop Test For Water Repellency

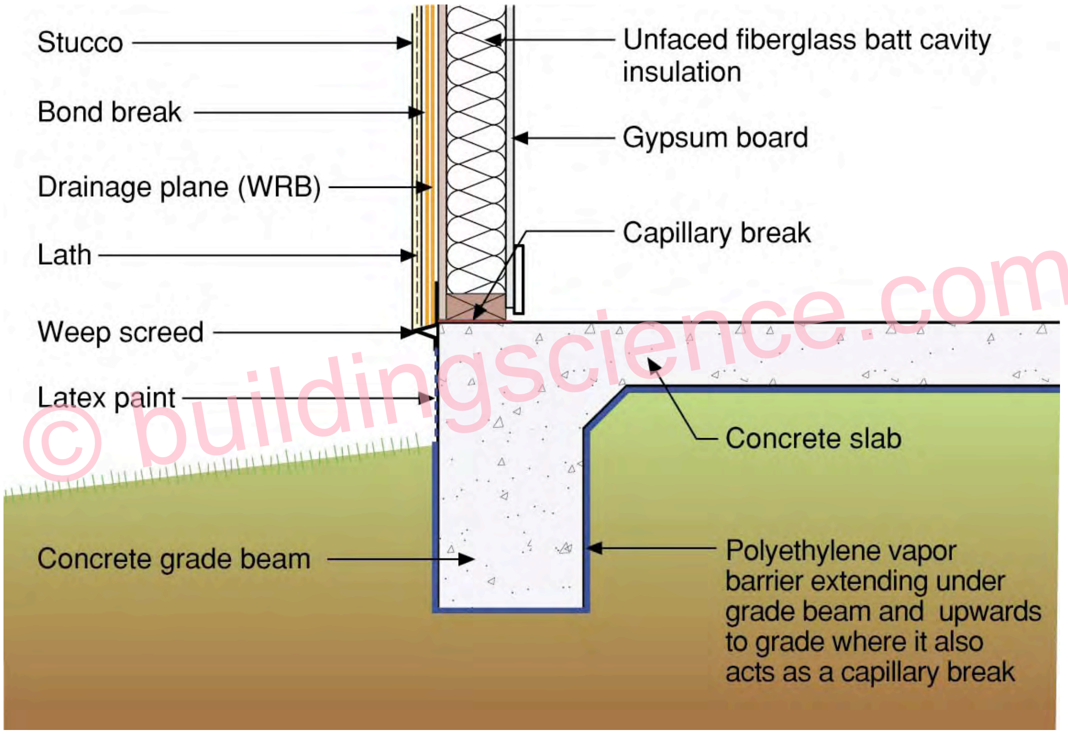
Photograph 6: Plastic Housewrap Failing Water Drop Test

Photograph 7: Absorptive Surface For Water Drop Test

Photograph 8: Plastic Housewrap Undergoing Water Drop Test

Photograph 9: Extensive Failure of Plastic Housewrap During Water Drop Test

Figure 10: Bond Break – Best Practice For Stucco Renderings Applied Over Frame Wall Assemblies



Photograph 10: Asphalt Saturated Felt As Bond Break Over Building Paper

Photograph 11: Asphalt Saturated Felt As Bond Break Over Plastic Housewrap

Photograph 12: Paper Backed Lath As A Bond Break

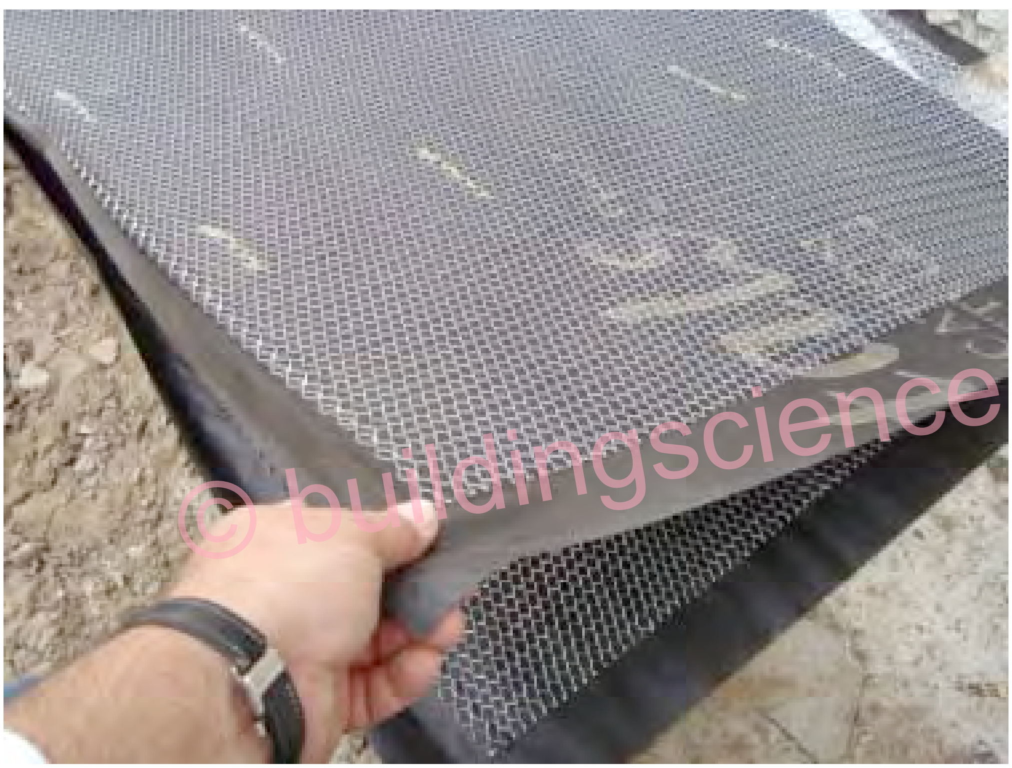
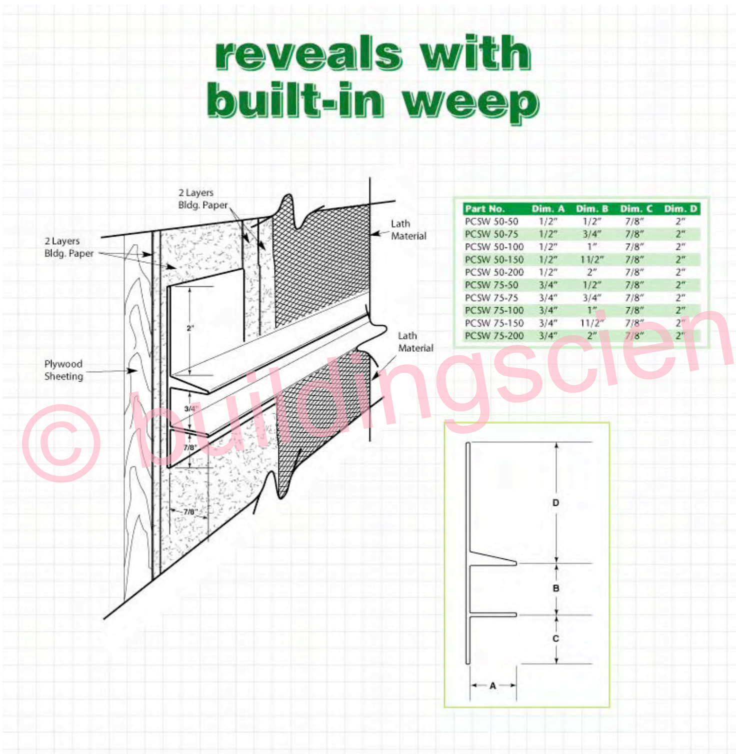


Figure 11: Trade Literature Delineating Two Layers of Building Paper



Photograph 13: Enhanced Drainage With A Profiled Plastic Housewrap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Reverse Flashing Problems

There are significant code enforcement issues regarding the construction of flashing at the base of the second floor frame assemblies. Code officials are enforcing a provision of ASTM C1063 (Standard Specification for Installation of Lathing and Furring to Receive Interior and Exterior Portland Cement-Based Plaster) that is not intended to apply where second floor frame assemblies intersect first floor mass assemblies. For reasons that are not explicable or defensible "reverse flashing" is mandated rather than drainage to the exterior at this location.

The typical method of installation is to extend the building paper downwards over the joint between the frame assembly and the mass assembly (Photograph 14). The building paper acts as a "bridge flashing" between the two assemblies.

Control joint accessories are not typically designed as water shedding devices – i.e. "flashings" (Photograph 15). They are designed in most cases to be installed over the top of building paper rather than being "tucked" behind building paper in a "shingle" or water shedding fashion. Standard application has these control joint accessories installed over the top to the building paper "bridge flashing" (Photograph 16). This creates a "dam" and water is directed inwards.

This practice results in leaks during wind driven rain events (Photograph 17) as the moisture storage capacity of the frame wall assembly is easily overwhelmed in the absence of drainage. The second floor frame assembly, which is a drained assembly is effectively unable to drain anywhere except to the interior.

The appropriate practice is to use a flashing between floors that effectively drains the water to the exterior (Figure 12). This detail is described in detail in Photograph 18, Photograph 19, Photograph 20, Photograph 21 and Photograph 22.

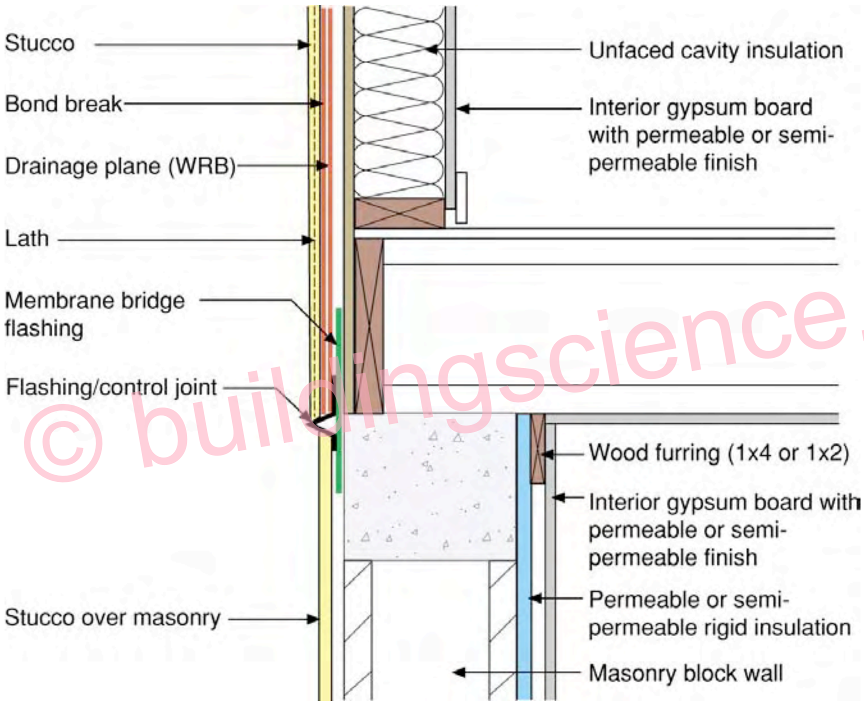
Photograph 14: Building Paper As Bridge Flashing

Photograph 15: Control Joint Accessories Installed Over Top of Drainage Plane

Photograph 16: Reverse Flashing Between Floors

Photograph 17: Water Entry Between Floors

Figure 12: Best Practice – Drained and Flashed Control Joint



Photograph 18: Flashing/Control Joint - Weep Screed Flashing

Photograph 19: Self Adhering Membrane Bridge Flashing

Photograph 20: Primary Drainage Plane Lapped Over Control Joint Flashing

Photograph 21: Paper Backed Lath Bond Break Over Primary Drainage Plane

Photograph 22: Stucco Rendering Applied At Draining Control Joint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Performance of Windows and Doors

The water management of penetrations and openings in stucco claddings were also reviewed particularly window and door openings.

With respect to window and door openings it is instructive to realize that windows and doors installed in residential buildings in Florida are rated for water holdout at 15 percent of the design wind load and no lower than 140 Pa or approximately 35 mph. These service limits were clearly exceeded many times during August and September 2004. Windows and doors are expected to leak during hurricanes; they are not expected to blow out.

However, our testing indicates that many windows leaked at conditions well below their rated value – i.e. under no wind condition (Photograph 24 and Photograph 25).

The method of testing windows is specified in ANSI/AAMA 101 – specifically ASTM E 547. The ASTM standard clearly views leakage at corners to constitute failure, however, it is our contention that the mounting frames used by many window testing groups in the testing of windows for compliance to the ASTM standard obscure the view of corners and subsequently many windows are listed as passing this test when in fact they fail.

Additionally, many windows are sold as "mulled" or double windows or composite windows. However, they are tested as single units. Every mulled window unit tested leaked with no applied wind load (Photograph 26).

Visual observations of hundreds of window units in the field and the disassembly of a dozen indicate a problem with the window sill to window jamb connection. It is our belief that quality control problems exist with the manufacturing of window units prior to delivery to the site.

The joint geometry is problematic – in general the joint design can be significantly improved. The typical design makes it a very difficult joint to seal, difficult to inspect and results in an unnecessarily high failure rate.

Finally, with respect to windows and doors, it is our contention that the installation instructions regarding window and door installation are inadequate with respect to water management. The windows and doors themselves under the Florida Building Code are subject to an ASTM standard. The interface between the window and door and the wall assembly is currently not.

Many mass wall assembly window openings are constructed with precast sill units that have a raised rib attachment that directs window water leakage inwards rather than outwards (Photograph 27, Photograph 28, and Figure 13).

Figure 14 illustrates a precast sill profile that directs window water leakage outward. A similar approach is recommended for window openings in frame wall assemblies (Photograph 29).

Door leakage can also be address in a similar fashion – a "seat" is cast into the slab edge that acts as a "pan flashing" (Photograph 30).

Photograph 23: Window Openings

Photograph 24: Window Corner Leakage

Photograph 25: Window Unit Leaking Inboard of Precast Attachment Rib

Photograph 26: Mulled Window Unit Leakage Paths

Photograph 27: Precast Sill With Illogical Attachment Rib

Photograph 28: Precast Sill That Channels Window Leakage Inward

Figure 13: Current Practice That Directs Window Leakage Inward

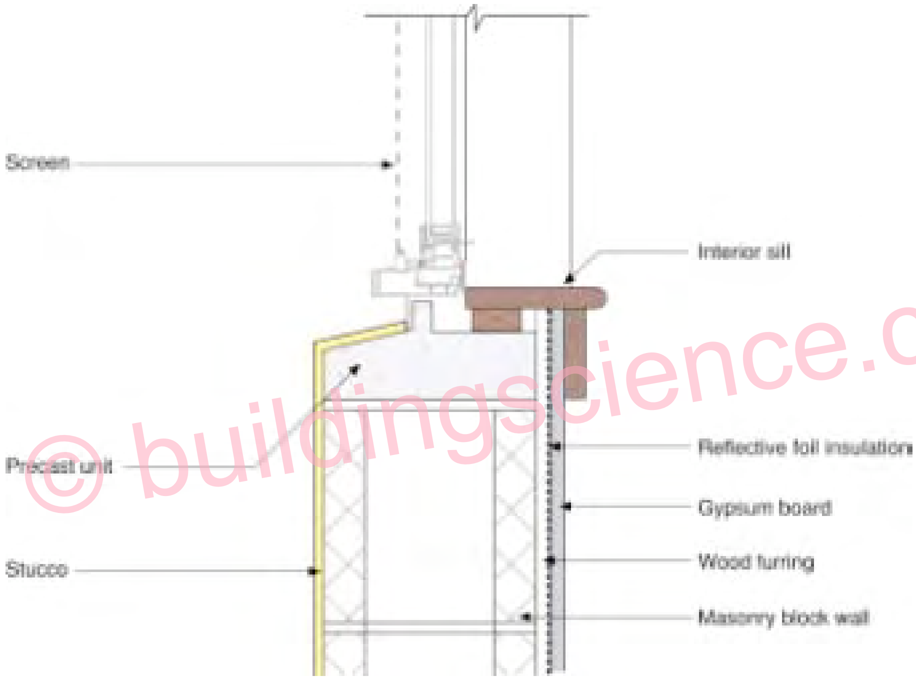
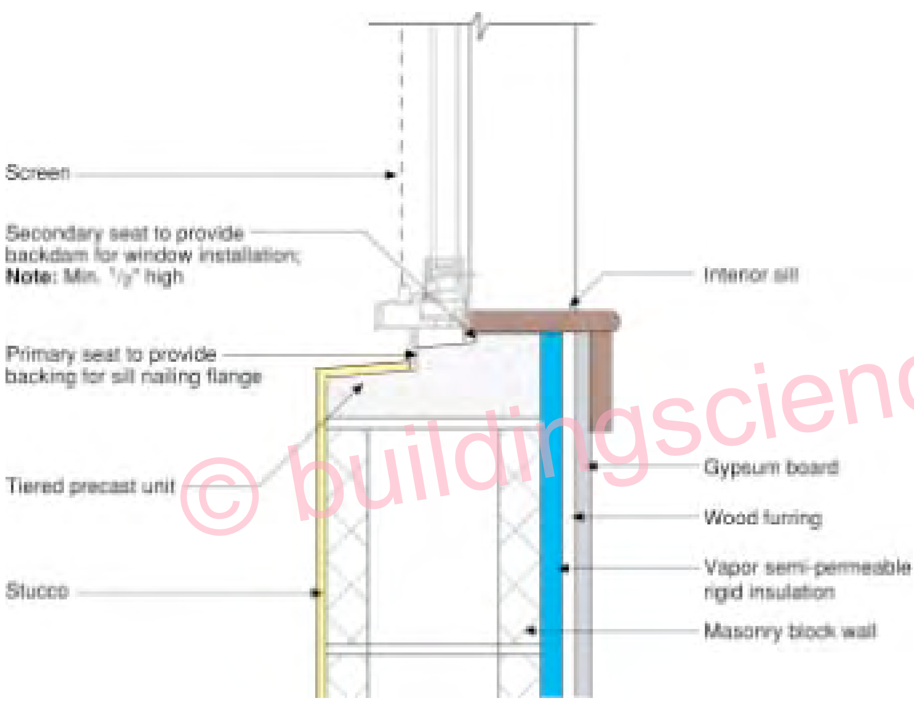


Figure 14: Recommended Practice That Directs Window Leakage Outward



Photograph 29: Frame Assembly Opening Recommended Practice

Photograph 30: Sliding Door Unit In Seat in Slab Directing Door Leakage Outward

Performance of Service Penetrations

In a similar vein wind driven rain also entered dryer vent openings, electrical service panels, and bathroom fan vent openings. But, again, our testing indicates that many service penetrations leaked in the absence of wind pressures.

Service penetrations such as dryer vents, electrical panel boxes, electrical boxes, vent fan hoods, and roof vents are currently not rated or designed for wind driven rain.

Electrical panel boxes are typically installed without water protection behind them (Photograph 31). This is typically not a major issue as these panel boxes are located on garage walls. However, it is recommended that the stucco rendering be applied prior to the installation of the electrical panel box.

Most openings rely on the application of sealant rather than a flashing approach to control rain entry (Photograph 32, Photograph 33 and Photograph 34). Sealants require maintenance.

Using a "flashing" approach to address service penetrations will provide improved performance (Photograph 35).

Photograph 36 and Photograph 37 illustrate the use of "flashing " for electrical boxes – a premanufactured unit provides water holdout during wind driven rain events.

Photograph 38, Photograph 39 and Photograph 40 illustrate effective "kick out" flashing construction.

Photograph 31: Electrical Service Panel – No Water Control Behind Panel

Photograph 32: Typical Maintenance Intensive Service Opening

Photograph 33: Maintenance Intensive Service Opening

Photograph 34: Dryer Vent Opening

Photograph 35: Recommended Practice For Dryer Vent Opening

Photograph 36: Flashed Electrical Box

Photograph 37: Electrical Box Flashing Unit

Photograph 38: Recommended KickOut Flashing Detail

Photograph 39: Kick Out Flashing

Photograph 40: Mastic Adhered Kick Out Flashing On Mass Assembly

Performance of Soffit Vent Assemblies

Anecdotal evidence indicates that a significant amount of rainwater entered soffit vent assemblies. This is consistent with the physics of the applied wind loads and the geometry of the soffit assemblies. Soffit geometries are currently not designed to address extreme wind driven rain exposures. Additionally, unvented roof designs which can address this mode of rainwater entry are currently not explicitly allowed in the Florida Building Code – although they are allowed in the International Residential Code.

Figure 15 illustrates rainwater entry during wind driven rain events. Figure 16 illustrates the use of baffles to reduce air pressure driving forces and facilitate the use of air pressure changes to deposit rain in soffit assemblies rather than in attic spaces.

Photograph 41, Figure 17, Figure 18 and Figure 19 illustrate unvented conditioned attic construction. This technology has significant advantages in the Florida climate with respect to rainwater control, energy conservation, moisture, and humidity control, wind uplift and fire performance over standard vented attic roof technology.

Figure 15: Wind Driven Rain Entry In Vented Soffit Assembly

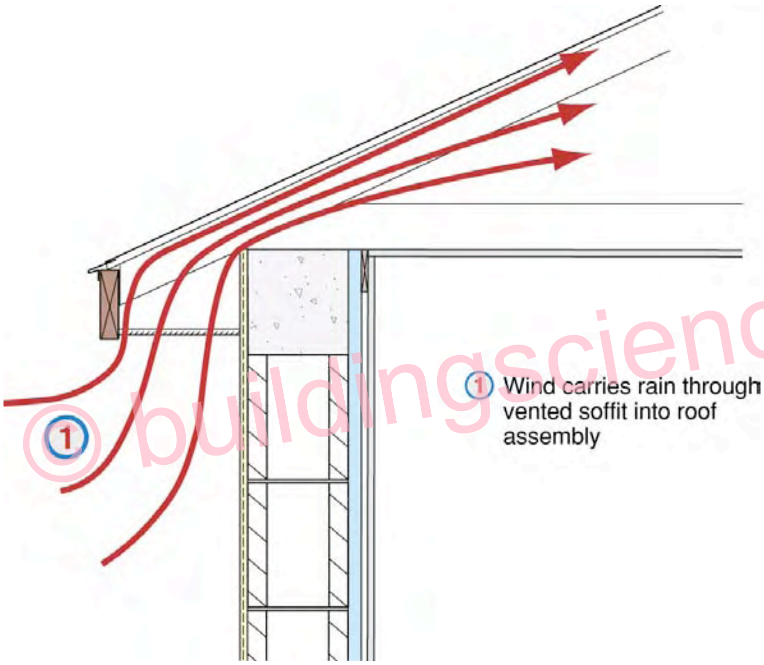
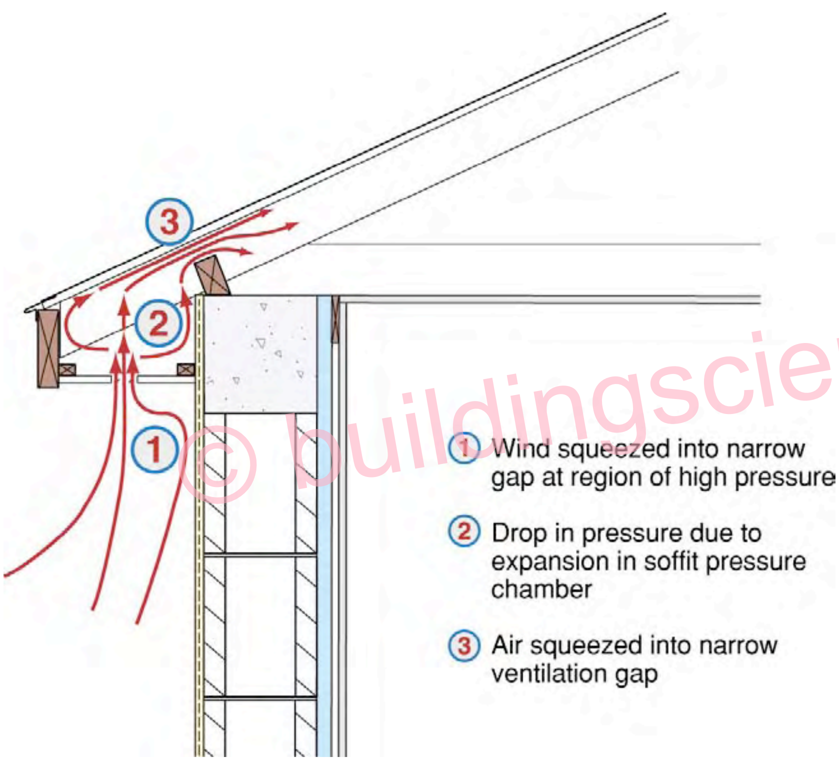


Figure 16: Pressure Relieved – Baffled Soffit Assembly



Photograph 41: Spray Foam Insulation In Unvented Conditioned Attic Assembly

Figure 17: Typical Vented Attic With Ductwork Outside of Conditioned Space

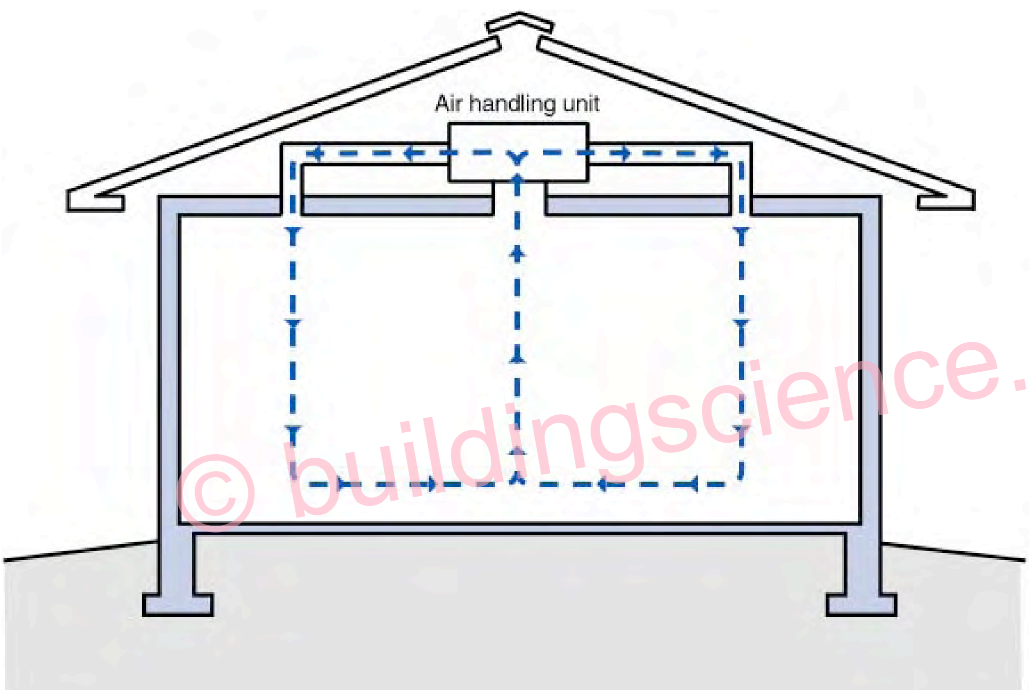
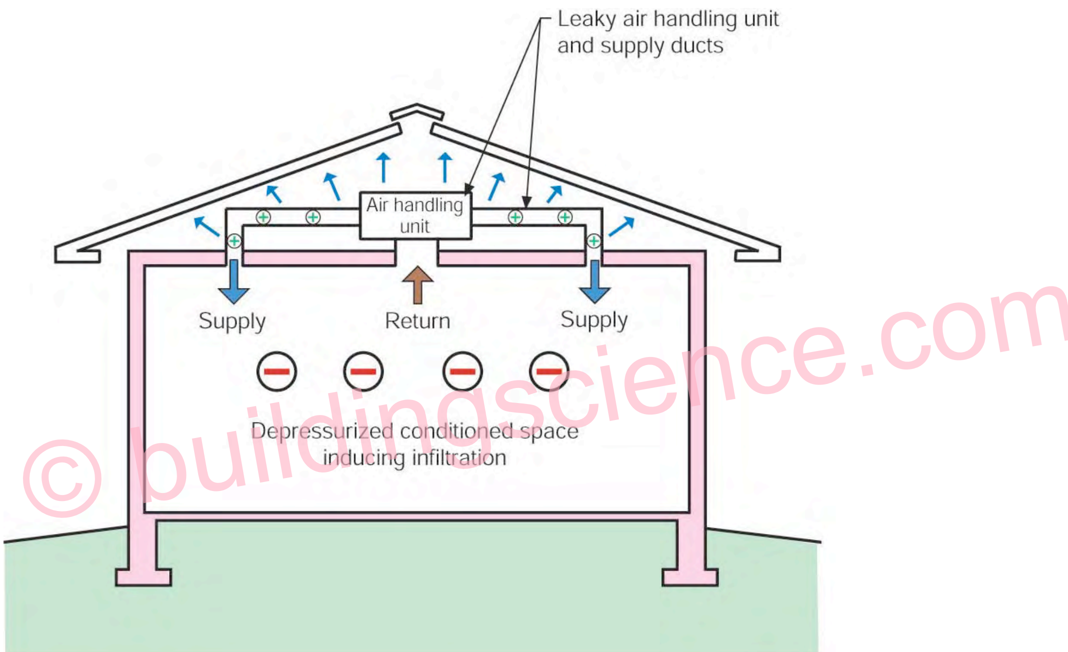
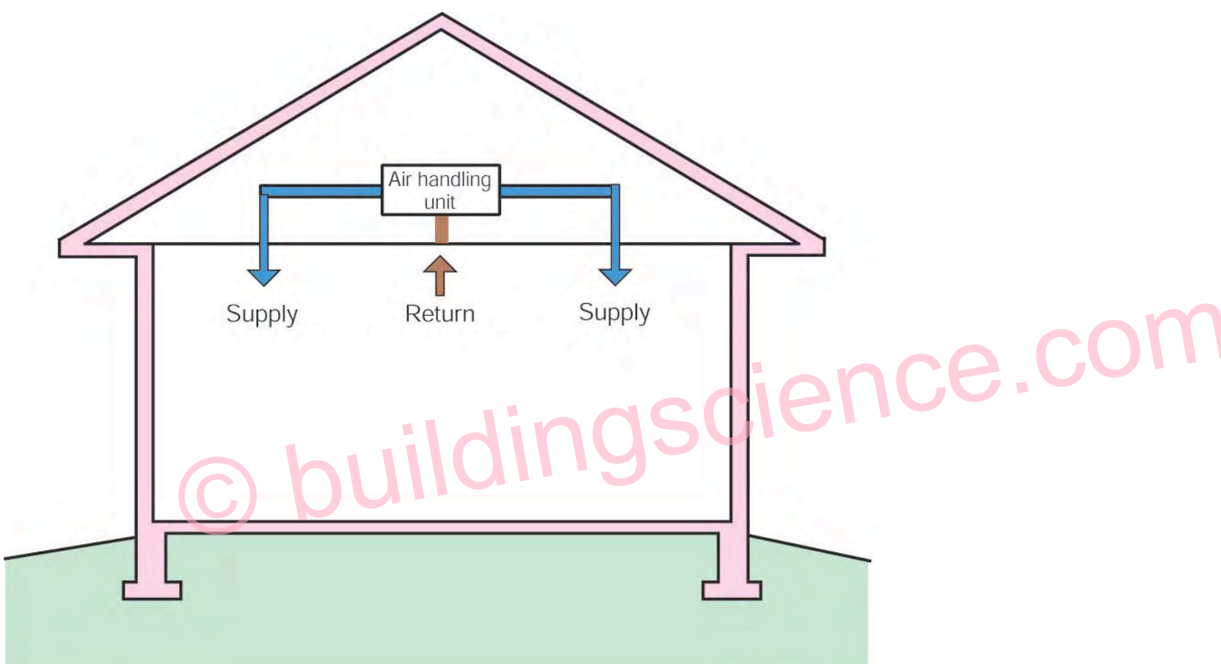


Figure 18: Negative Pressure Induced Via Duct Leakage



Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.

Figure 19: Conditioned Unvented Attic Assembly



Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.

Paint and Coating Performance

The use of paint as a water management technique for stucco renderings applied to mass assemblies was also examined. As the mil thickness of paint increases, the ability of some paints to span micro cracks also increases. However, this applies primarily to mostly smooth surfaces. Highly textured surfaces are almost impossible to coat in a manner to seal micro cracks.

As the mil thickness of paint coatings increases, the water vapor permeability of these coatings decreases leading to problems with blistering and re-emulsification of some stucco renderings. The appropriate mil thickness and water vapor permeability relationship is currently unknown.

Water leakage testing of stucco renderings was conducted using numerous methods. These methods are memorialized in Photograph 42, Photograph 43, Photograph 44, Photograph 45, Photograph 46, Photograph 47, Photograph 48 and Photograph 49.

The most useful method proved to be the use of a camera probe and a portable spray rack without the application of a pressure difference – either air or hydrostatic.

Test assemblies were constructed and baseline values were established. Stucco renderings, both painted and unpainted were tested to determine water hold out (Photograph 50, Photograph 51, Photograph 52, Photograph 53, Photograph 54, Photograph 55, Photograph 56 and Photograph 57).

Three-hour water spray tests on unpainted walls systems rendered with stucco did not leak in the absence of cracks. To state the obvious, stucco without cracks does not leak – paint or no paint (Photograph 58 and Photograph 59).

However, the presence of cracks (Photograph 60 and Photograph 61) caused all mass wall assemblies to pass water.

The type of crack shown in Photograph 60 is indicative of typical and expected stucco rendering crackage. Workmanship, quality control and cure impact the number and extent of shrinkage cracking. Soil conditions, the nature of the materials, geometry and aspect ratio of mass wall assemblies impact the number and extent of settlement cracking. However, the nature of stucco application, materials and substrates make it impossible to construct crack free monolithic stucco renderings – in other words shrinkage cracks and settlement cracks are to be expected.

These shrinkage cracks and settlement cracks traditionally are handled through ongoing maintenance. At present, technology offers no other practical approach.

Based on the field observations it is our belief that it is not possible to construct stucco assemblies without cracks. It is also our belief that paint coating systems – even the high build coatings - are unable to span the typical stucco cracks encountered, both from initial drying and from subsequent settlement.

Increasing the moisture storage capacity of mass assemblies can partially address this issue. One approach is to construct a "seat" in the perimeter slab foundation to provide a reservoir for penetrating rainwater and to direct this rainwater to the exterior (Figure 20, Figure 21 and Photograph 62).

The experience with high build paint systems – such as "elastomeric paints" can lead to blistering (Photograph 63) and re-emulsification of additives. The use of such coatings should remain a specialty technique specified and supervised by professionals.

The inward migration of moisture can also be moderated by the use of non water sensitive insulation systems (Figure 22, Photograph 64 and Photograph 65).

Low build and high build paint system on both smooth and textured surfaces were carefully examined (Photograph 66, Photograph 67 and Photograph 68) and it is our conclusion that almost no coating or painting system is able to span settlement cracks (Photograph 69). Only small hairline cracks on relatively smooth, and relatively untextured surfaces are there likely to be significant performance benefits of high build systems.

A more promising approach appears to lie with fiber reinforcement to control cracking and premium polymer modified and polymer based cementitious renderings (Photograph 70).

Most shrinkage cracking occurs over the first few weeks and most settlement cracking happens over the first year. In other words the majority of the movement resulting in stucco cracks happens within the first year. After the building and building systems have equilibrated standard paint finishes are often able to seal small cracks as subsequent movement is typically minor. However, the larger settlement cracks require flexible sealants – typically brushed into the crack.

After buildings are repainted and settlement cracks are addressed in the normal course of home maintenance stucco leakage is typically reduced significantly.

Photograph 42: Magnifying Glass Examination

Photograph 43: Rilem Tube Hydrostatic Head Test

Photograph 44: Infrared Camera Leak Detection

Photograph 45: Camera Probe Leak Detection

Photograph 46: View Screen On Camera Probe

Photograph 47: Access Openings In Mass Wall – Camera Probe Leak Detection

Photograph 48: Water Spray Rack On Masonry Mass Assembly

Photograph 49: Power Washer Simulating Wind Driven Rain

Photograph 50: Test Wall Establishing Baselines

Photograph 51: Garages Used As Test Walls – Varying Configurations

Photograph 52: Unpainted Stucco Rendering Test Wall

Photograph 53: Painted Stucco Rendering Test Wall

Photograph 54: Spray Rack Without Induced Pressure Difference

Photograph 55: Visual Indication of Water Entry At Base of Assembly

Photograph 56: Water Entry Pattern of Saturated Mass Assembly

Photograph 57: Spray Rack – Unpainted Stucco Rendering

Photograph 58: Three Hour Water Test – Unpainted Stucco Rendering

Photograph 59: Water Testing – Control Joints

Photograph 60: Typical Crack In Stucco Rendering

Photograph 61: Water Entry Associated With Typical Crack In Stucco Rendering

Figure 20: Mass Assembly With Increased Moisture Tollerance

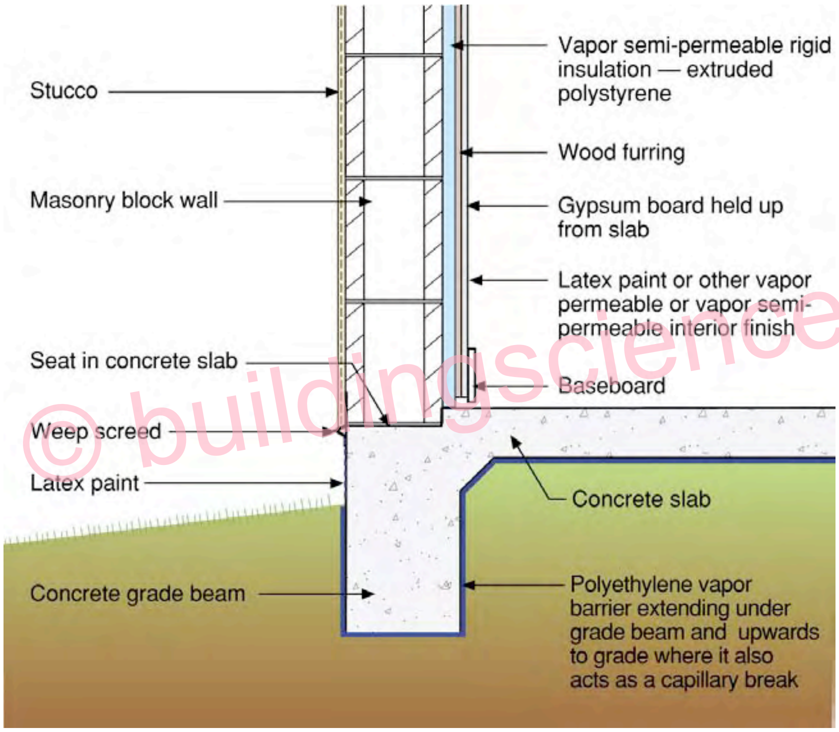


Figure 21: Seat In Foundation Increasing Moisture Storage Capacity

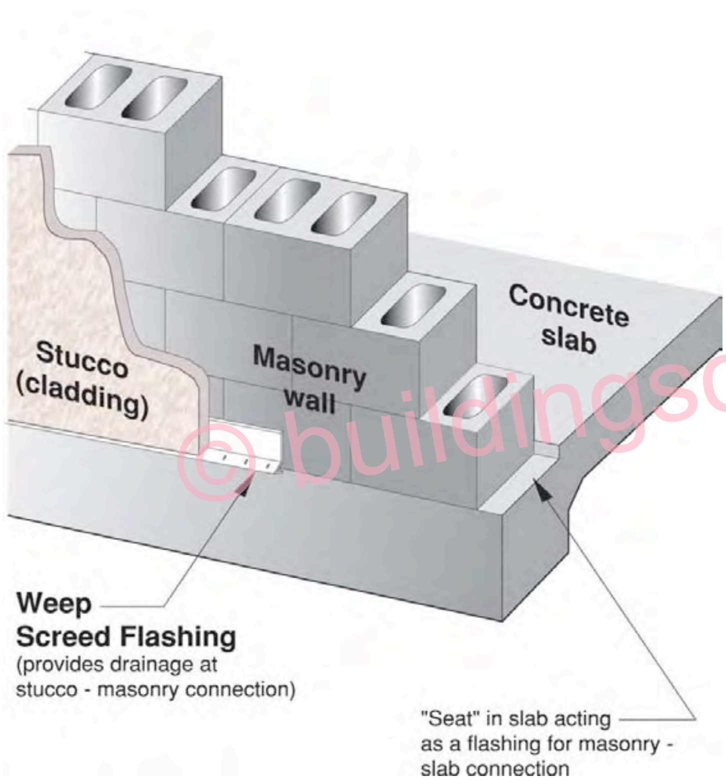
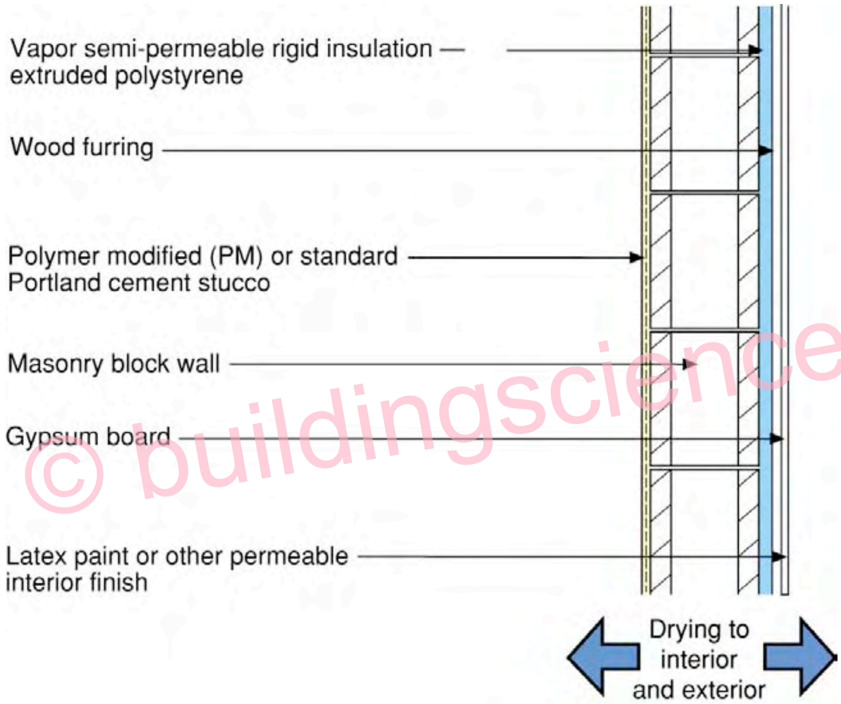


Figure 22: Vapor Semi Permeable Non Water Sensitive Rigid Insulation



Photograph 62: Seat In Concrete Slab Foundation Increasing Moisture Storage Capacity

Photograph 63: Blistering of Elastomeric Paint Coating

Photograph 64: Rigid Foam Interior Lining Protecting Interior Surfaces

Photograph 65: Rigid Insulation Extends Past Interior Framing

Photograph 66: Paint Coating Over Rough Surface

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Photograph 67: Paint Coating – 3 Mil Thickness

Photograph 68: Paint Coating – 10 Mil Thickness

Photograph 69: Settlement Cracks

Photograph 70: Fiber Reinforced Stucco Rendering to Control Cracking

Review of Florida Building Code

As part of our review of the water management provisions of the Florida Building Code we identified a provision relating to roof membranes, Section 1518.3, that appears to make no sense: “If the underlayment is a self-adhering membrane, the membrane shall be applied over a mechanically attached anchor sheet, attached in compliance with 1518.2.1.” This provision encourages roof membrane “blow off” by requiring a bond break between the self-adhering membrane and the structural roof deck. This negates the entire reason to use a self-adhering membrane. The requirement for a mechanically attached anchor sheet under a self-adhering membrane has no basis in physics or logic and prevents the construction of highly water resistant roof assemblies that can provide a high degree of secondary protection during extreme wind driven rain events.

Self-adhering membranes that are directly adhered to structural decks such as plywood and OSB sheathing are a proven technology in all climate zones in the United States (Photograph 71, Photograph 72, Photograph 73 and Photograph 74).

Photograph 71: Self Adhering Membrane

Photograph 72: Direct Applied Self Adhering Membrane

Photograph 73: Large Institutional Roof – Direct Applied Self Adhering Membrane

Photograph 74: Complex Roof Geometry – Direct Applied Self Adhering Membrane

Recommendations

Based on our investigation, testing, review and analysis, the following recommendations are offered:

- The moisture storage capacity of mass walls be increased by providing a "seat" at the base of these assemblies.

- A bond break be provided between primary drainage planes and stucco renderings in drained assemblies. In simple terms this will require two layers of building paper or a layer of building paper over a plastic housewrap.

- The specification, rating and testing of WRB's be consistent with their installed exposure – i.e. tested and rated as part of a stucco assembly. Appropriate performance specifications need to be developed for WRB's used with stucco renderings and the Florida Building Code altered to require them.

- Code officials be instructed regarding the correct interpretation of ASTM C1063 and the Florida Building Code be explicitly altered to require drainage where drained assemblies intersect mass assemblies.

- Windows and doors be correctly rated and tested according to ANSI/AAMA 101. Mulled window units, double windows or composite windows be tested and held to the same requirements as single units.

- Water managed window and door installation requirements be developed and the Florida Building Code altered to require them.

- Pressure relieved/baffled soffit assemblies be developed for vented roof assemblies and the Florida Building Code altered to require them.

- The Florida Building Code be altered to come into compliance with the International Residential Code to explicitly allow for the construction of unvented roof assemblies.

- Water managed details for dryer vents, electrical panel boxes, electrical boxes, vent fan hoods be developed and the Florida Building Code Altered to require them.

- It is unlikely that a practical paint specification can be developed in the short term to address micro-cracking stucco issues as the relationships among water vapor permeability, mil thickness and elasticity are not known. It is recommended that these relationships be explored and that until these relationships are understood the Florida Building Code not be altered to require "elastomeric paints" on stucco renderings.

- Repeal of Section 1518.3 of the Florida Building Code requiring a mechanically attached anchor sheet between a self-adhering membrane and roof sheathing.

References

AAMA 101/I.S.2/NAFS-02, "Voluntary Performance Specifications for Windows, Skylights and Glass Doors", American Architectural Manufacturers Association, 1827 Walden Office Square, Suite 550, Schaumburg, IL, 60173

ASTM E 331 – 00 "Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference", American Society for Testing and Materials, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA, 19428-2959

ASTM E 547 – 00 "Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Cyclic Static Air Pressure Difference", American Society for Testing and Materials, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA, 19428-2959

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AC38 "Acceptance Criteria for Water-Resistive Barriers", ICC Evaluation Services, Inc., Approved June 2004, 5360 Workman Mill Road, Whittier, CA, 90601

AC 132 "Acceptance Criteria for Attic Vents", ICC Evaluation Services, Inc., Approved January 2001, 5360 Workman Mill Road, Whittier, CA, 90601

Florida Building Code, State of Florida, May, 2001

About this Report

This report was prepared for the Home Builders Association of Metro Orlando and the Florida Home Builders Association.

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