ICF Field Testing Report

Prepared for

BC Housing

BC Ready-Mixed Concrete Association

Prepared by

RDH Building Science

Table of Contents

Acknowledgements

This study has been made possible by the cooperation and participation of the following: AMVIC Building System, Airlite Plastics Company & Fox Blocks, Logix Insulated Concrete Forms Ltd., Superform Products Ltd., NUDURA Corporation Plasti-Fab/Advantage ICF System, Quad-Lock Building Systems, Ltd., Gorilla Buck, and Dryvit Systems Inc.

Disclaimer

1. Introduction

Insulating Concrete Forms (ICFs) are formwork systems for reinforced concrete walls that stay in place providing an insulated assembly during the building's operation and forming a permanent substrate for the addition of finishes on both the interior and exterior. ICF systems consist of expanded polystyrene (EPS). The popularity of ICF systems continues to grow as a result of their potential for cost effectively achieving high R-value walls that are resistant to air leakage and water penetration.

ICF systems present some unique challenges with respect to water-sealing at construction interfaces, particularly around window rough openings. In 2014, RDH Building Science Inc. (RDH) undertook a laboratory study evaluating the water penetration resistance of several ICF window installation techniques, each with varying levels of air and water penetration resistance.

The current study, Phase 3, addresses the need to validate the findings of the laboratory testing with full-scale field testing, in order to develop standard construction details and procedures that will reliably provide water and air penetration resistance levels that are comparable or better than other conventional building systems. RDH was retained by the BC Ready-Mixed Concrete Association (BCRMCA) with funding support from the Homeowner Protection Office (HPO, Branch of BC Housing) to undertake the work outlined in our September 6, 2012 proposal, in cooperation with the ICF Stakeholder Group, which consists of AMVIC Building Systems, Fox Blocks, Logix Insulated Concrete Forms, Superform Products, Ltd., NUDURA Corporation, Plasti-Fab/Advantage ICF System, and Quad-Lock Building Systems, Ltd. This report details the results of this work.

The following is a summary of the proposed scope of work in Phase 3 from our proposal.

Wall Testing In-Situ

Once the Laboratory testing program has verified the details in a controlled situation, the standardized details will be included in a local construction project and tested full scale on-site. The site testing will help to confirm that the assemblies are effective at controlling air and water infiltration on a full scale basis and that the details are simple and economical enough to be performed consistently on a full scale basis with variable trades and weather conditions. The In-situ testing will be performed in accordance with ASTM 1105 for water penetration resistance and ASTM E1186-03 for air leakage.

2. Background

In September 2011 and May 2014 RDH completed Phase 1 and 2 of the ICF research testing program, respectively.

In Phase 1, the ICF wall itself was found to be reasonably water and airtight; however, conventional detailing of the window to wall interface was identified as a weak point in the system with respect to air and water-tightness. Six different window buck and installation methods were tested with varying results. The more successful window interface methods included a watertight tie-in detail to the concrete core of the ICF system.

Based on the results of the Phase 1 testing, window installation details were developed to reliably and economically allow an air and watertight tie-in of the window system to the concrete core of the ICF.

In Phase 2, six ICF window installation details were tested for water ingress resistance in a laboratory setting according to ASTM E1105 laboratory test procedures. The results of the Phase 2 testing is summarized in Table 2.1.

Table 2.1.1 Phase 2 Water Penetration Test Results (2014 Testing)

Test Pressure	Internal Buck with Flashing	External Buck with Flashing	Direct to Concrete	EIFS Basecoat	Benchmark – Sheathing Paper	Gorilla Buck
150 Pa	Pass	Pass	Pass	Pass	Fail	Pass
300 Pa	Pass	Pass	Pass	Pass		Fail
700 Pa	Pass	Fail	Pass	Pass		
1400 Pa			Pass	Pass		
5000 Pa			Pass			

As part of the current project (Phase 3) the Internal Buck, External Buck, Direct to concrete and exterior insulation and finish system (EIFS) Basecoat window installation details, all highlighted in red above, were selected for field testing. This report summarizes the results of the water penetration field testing performed by RDH in November 2015 and provides considerations for the development of acceptable and best practice ICF window installation details for different building types across Canada.

3. Methodology

Field water penetration testing was performed on four different ICF window installation details. In addition, the center of the ICF wall without details was also tested for water penetration resistance. All testing was performed without exterior cladding in place so that the water tightness of the ICF and its interface with the window could be assessed and compared to the code compliant water resistive barrier (WRB) details tested in Phase 2. The following summarize the objectives for the test program:

- Determine the water penetration resistance of various ICF window details, installed full scale in the field without cladding, and compare with the laboratory results.
- Field test other ICF wall details and center of wall areas around windows to check water tightness of the foam layer and core on full sized wall areas.
- Based on the test results, identify considerations for air and water tightness strategies for ICF wall assemblies, as well as interface and penetration details.

3.1. Selection of Test Modules

Four unique window installation details, or “test modules,” were selected by the ICF Stakeholder Group for field testing. The four field test modules are shown below:

⇢ **Module 1 – Internal Buck with SAM flashing and Reglet (Rebate)**: Rebate window with internal buck-out and self-adhesive membrane (SAM) flashing. Reglet, membrane, and sealant are installed at window head and extend past the window 6” to seal waterproof flashing to concrete core.

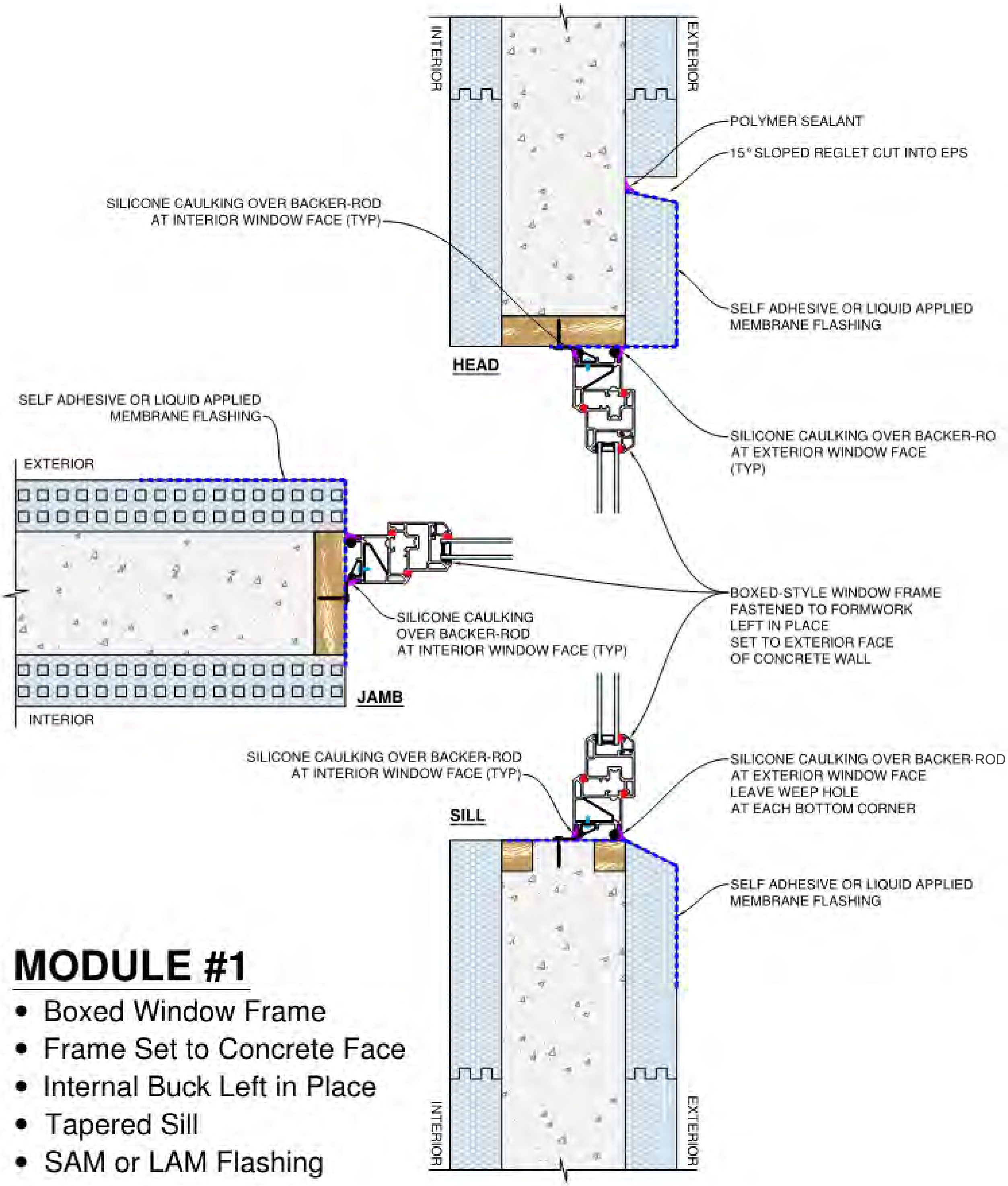

Fig. 3.1.1 Head, jamb and sill details of test module 1.

- **Module 2 – EIFS Weather Resistive Barrier:** Rebate window with internal buck and continuous reinforced EIFS Basecoat WRB.

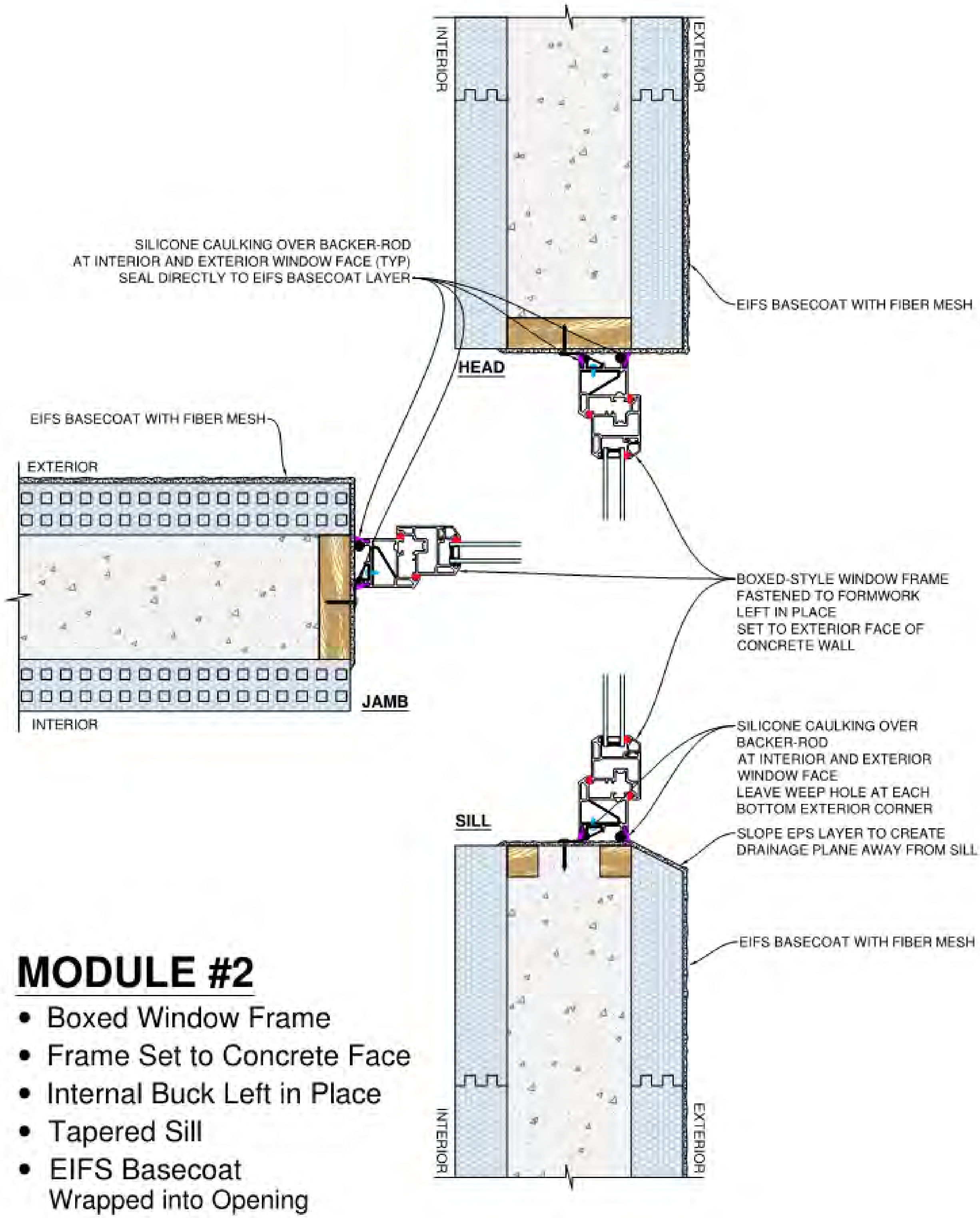

Fig. 3.1.2 Head, jamb and sill details of test module 2.

⇢ **Module 3 – External Buck with SAM flashing and Reglet (Flanged):** Flanged window with internal buck and self-adhesive membrane (SAM) flashing. Reglet flashing and sealant are installed at window head and extend past the window 6" to seal waterproof flashing to concrete core.

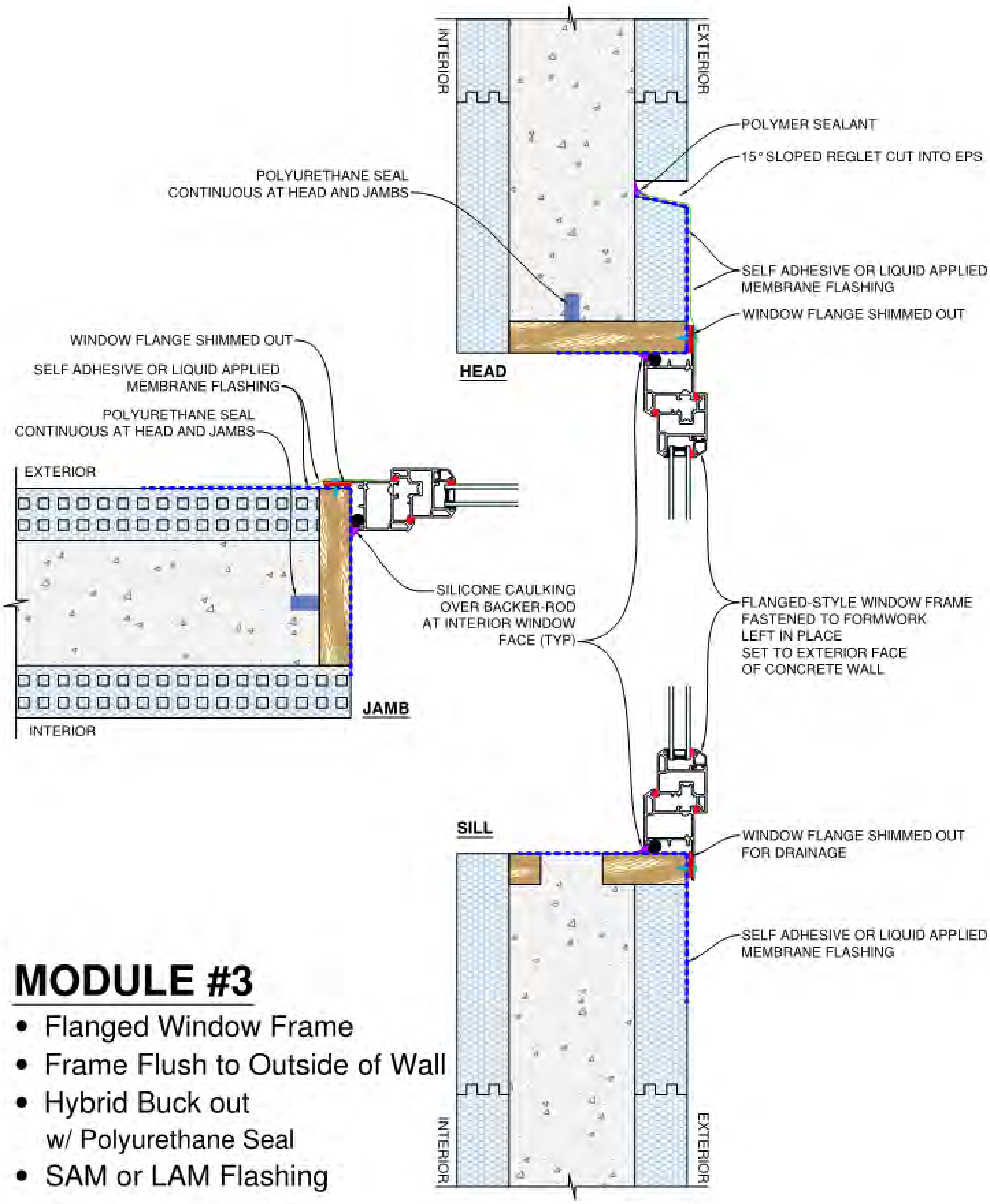

Fig. 3.1.3 Head, jamb and sill details of test module 3.

⇢ **Module 4 – Direct to Concrete:** Rebate window mounted and sealed directly to the ICF concrete core.

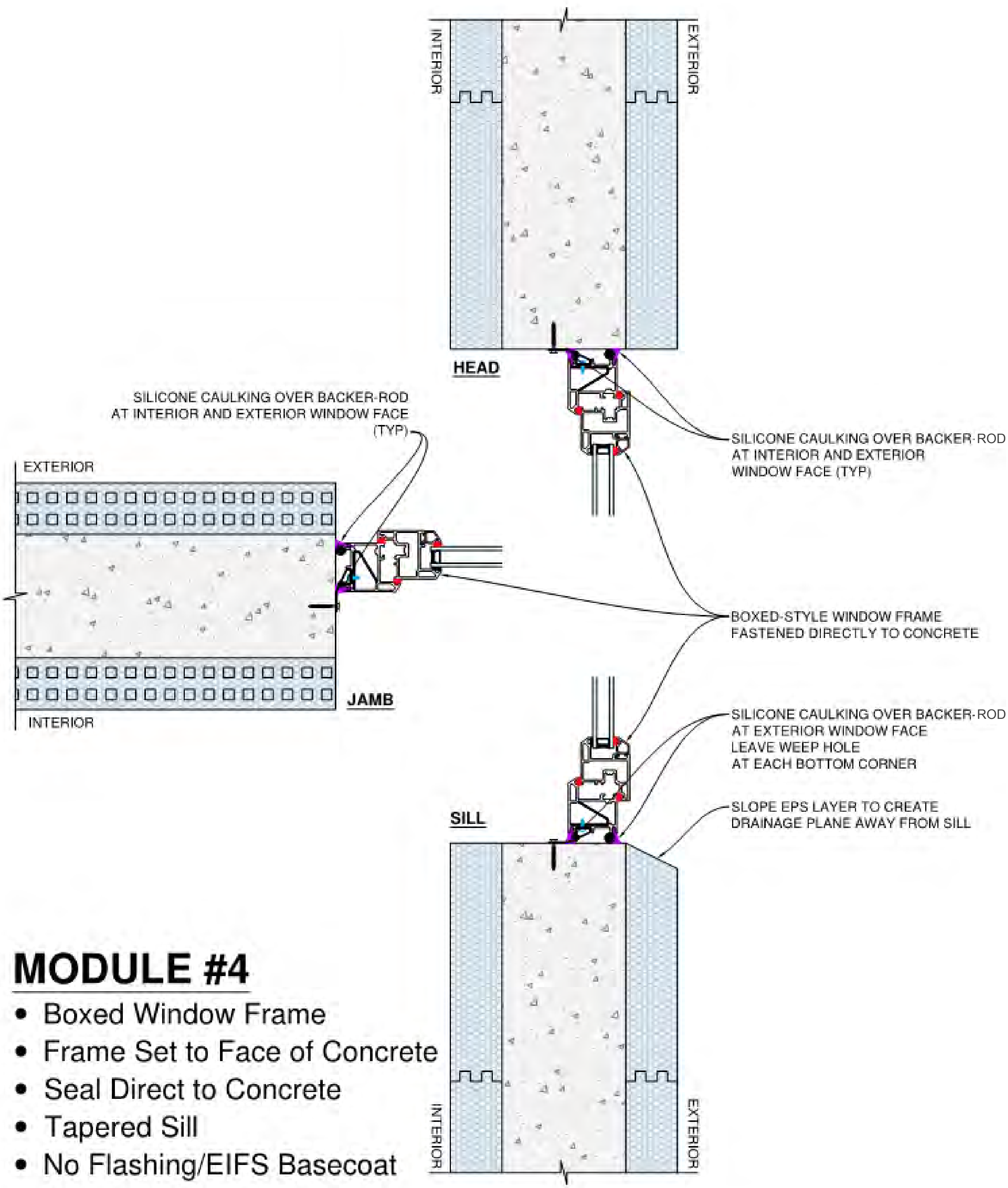

Fig. 3.1.4 Head, jamb and sill details of test module 4.

The windows consisted of Starline 7100 series vinyl windows. Module 3 utilized a flanged window, while Modules 1, 2, and 4 were rebate windows.

Modules 1 and 3 differ from the comparative details tested in Phase 2 Laboratory Testing as follows:

1. SAM flashing was used instead of galvanized metal flashing.
2. SAM flashing was only sealed back to the core at the window head. At the jambs and sill, SAM flashing was lapped onto the exterior of the ICF foam.
3. At the window head a reglet was cut into the outer layer of EPS and the SAM flashing was caulked to the concrete ICF core (Figure 3.1.5).

Fig. 3.1.5 Reglet cut into EPS, sealed to concrete, and sloped at 15 degrees to facilitate water shedding and drainage.

3.2. Field Water Penetration Testing

An ICF building under construction in Surrey, BC was selected as the test site for Phase 3 Field Water Penetration Testing. Each of the four window installation details, Modules 1-4, were installed into a window rough opening on the building, using the Quad-Lock Building Systems ICF product. Elevation images of the test building, along with the four window modules, are provided in Figure 3.2.1 and Figure 3.2.2 below.

Fig. 3.2.1 Module 2 EIFS Basecoat (outlined in red) and Module 1 Internal Buck with SAM Flashing (outlined in green) on Northwest façade of test building.

Fig. 3.2.2 Module 4 Direct to Concrete (outlined in blue) and Module 3 External Buck with SAM Flashing (outlined in purple) installed on Southeast face of test building.

The window installation details and adjacent ICF construction were tested in general conformance with ASTM E1105-00 (2008) test procedure for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform of Cyclic Static Air Pressure Difference.

Water penetration testing was performed at increasing test pressures of 150, 300, and 700 Pa to allow a performance comparison between the different samples. In practice, the required in situ performance of windows is determined using Driving Rain Wind Pressure (DRWP) for known locations and buildings, and calculating the test pressure that has a 1 in 10 year chance of reoccurrence (a 10% chance of occurring in a one-year period). For most low-rise buildings, this is in the order of 200 to 300 Pa. Images of the field testing setup are provided in Figure 3.2.3 and Figure 3.2.4.

Fig. 3.2.3 Calibrated rain rack installed to spray sample with water. Rain rack was oversized to spray window and surrounding ICF wall area.

Fig. 3.2.4 Transparent pressure chamber installed on interior face of sample .

Test water supply and pressure was provided by reservoir and water pump (Figure 3.2.5).

Fig. 3.2.5 Water bladder and pump used to deliver water at consistent pressure to the calibrated rain rack.

4. Results and Observations

4.1. Water Penetration Testing

Testing of all four modules was completed throughout the course of one clear day (10°C) on November 11, 2015, between 7:00 AM and 8:00 PM. ASTM E1105 water penetration testing was performed on each of the four modules using Procedure A. The results of this testing are shown in Table 4.1.

Table 4.1.1 Water Penetration Test Results

Test Pressure	Module 1- Internal Buck with SAM Flashing	Module 2- EIFS Basecoat	Module 3- External Buck with SAM Flashing	Module 4- Direct to Concrete
150 Pa	Pass	Pass	Pass	Pass
300 Pa	Pass	Pass	Pass	Pass
700 Pa	Fail	Pass	Fail	Pass

Out of the four window installation details tested, two modules successfully prevented water ingress at 150, 300 and 700 Pa (Modules 2 and 4). Modules 1 and 3 successfully prevented water ingress at 150 and 300 Pa.

A complete description of the results of each of the four test modules is provided in the Appendix I - Water Penetration Test Reports. The implications of these results are discussed in the Discussion and Recommendations section to follow.

4.2. Additional Field Observations

In addition to testing the four window installation methods, the below grade waterproofing membrane and interior of the ICF was also inspected for water penetration from the testing above. The below grade waterproofing membrane consisted of a self-adhesive bituminous membrane fully adhered to the exterior surface of the ICF (Figure 4.2.1).

Fig. 4.2.1 Waterproofing membrane terminating on exterior face of ICF foam, with leading edge fully adhered to ICF foam.

During the course of water penetration testing, water was sprayed on the exterior face of the ICF and was found to be infiltrating between the joints of the ICF units. Once in the ICF joints, the water was able to run down inside the ICF foam layer between the waterproofing membrane and the concrete core. This water was able to accumulate behind the waterproofing membrane and create water filled blisters. A small cut was made though the waterproofing membrane at a blister, and water immediately leaked out (Figure 4.2.2). The observed water leakage path is a result of utilizing a water-resistant core approach for the weather resistive barrier for the above grade portion of the ICF wall and a face sealed waterproofing membrane for the below grade portion of the wall without an effective tie in between the two systems. On the test building, a traditional breathable building wrap was specified for the weather resistive barrier. When this is installed and shingled over the waterproofing membrane at grade it will resolve this issue. If this building was designed to utilize a watertight core approach, the below grade waterproofing membrane could be sealed to the core similar to the head of Modules 1 and 3 and this would also resolve the same issue by eliminating the leakage path.

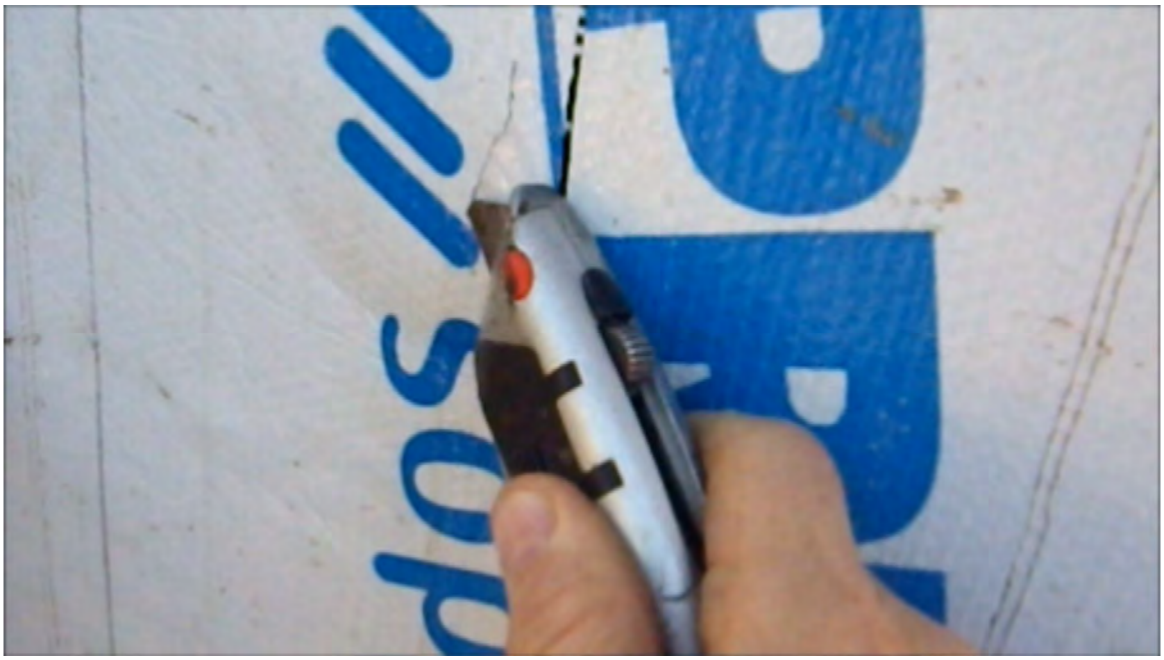

Fig. 4.2.2 Water leaking out from behind waterproofing membrane.

5. Discussion and Recommendations

All four field test modules evaluated in Phase 3 passed water infiltration tests at 300 Pa without exterior cladding installed. This level of water tightness exceeded the benchmark sheathing paper module that was manufactured in accordance with Part 9 of the Code and tested during Phase 2.

5.1. Validation of Phase 2 Laboratory Testing

The results of the field testing are generally supportive of the results of the laboratory testing conducted in Phase 2 of this project. A table comparing the results of Phase 2 and Phase 3 testing is provided in Table 5.1, indicating discrepancies in red and green. Note that Modules 1 and 3 that were tested as part of Phase 3 differ from the comparative modules tested in Phase 2 in that they use a SAM flashing, as opposed to a galvanized metal flashing and were sealed back to the concrete core at the window head only.

Table 5.1.1 Comparison Of Phase 3 and Phase 2 Test Results

Test Pressure	Module 1- Internal with Buck Flashing		Module 2- EIFS Basecoat		Module 3- External with Buck Flashing		Module 4- Direct to Concrete		Benchmark Sheathing Paper
	Phase 3	**Phase 2**	**Phase 3**	**Phase 2**	**Phase 3**	**Phase 2**	**Phase 3**	**Phase 2**	**Phase 2**
150 Pa	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail
300 Pa	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Fail
700 Pa	Fail	Pass	Pass	Pass	Fail	Fail	Pass	Pass	Fail

5.2. Water Tightness of the ICF Assembly

Based on the laboratory and field testing of the ICF samples to date, the most air and watertight layer in the ICF wall assemblies tested was the reinforced concrete core and the EIFS Basecoat applied to the exterior of the ICF wall. Uncoated ICF walls allow some water to enter joints between the foam modules and run behind surface applied membranes and flashings if they are not sealed back to the core at terminations. This was observed at the base of the wall where it interfaced with the below grade waterproofing membrane and was the ultimate failure mechanism on modules 1 and 3 at the higher test pressures. On more exposed buildings this risk can be mitigated by making the exterior surface of the ICF watertight by using a water resistant membrane or coating (module 2) or by sealing to the core at all interfaces with adjacent enclosure systems (module 3). We did not observe water leakage though the concrete core in any of the samples tested on site or in the laboratory. However, the water tightness of the core will be highly dependent on the ICF manufacturer, installation, reinforcing, soil conditions, concrete quality and application. If the core is used as the primary water penetration resistance layer in the enclosure system it is critical that individual ICF manufacturers test and develop installation procedures to ensure that the system will perform as intended on site.

5.3. ICF Suitability as a Water Resistive Barrier (WRB)

Based on the testing performed to date, all of the test samples resisted water penetration better than the Benchmark sheathing paper module from Phase 2. In addition, modules that either waterproofed the exterior surface of the ICF or sealed all penetrations to the concrete core out-performed the options that used the exterior foam layer as part of the moisture barrier. These high performing WRB strategies may be appropriate for moderate and high exposure buildings.

Where an ICF exterior surface waterproofing strategy such as Module 2 is not used, a suitable through wall flashing is recommended between the concrete core and the exterior surface of the ICF at all penetrations and horizontal transitions above adjacent enclosure assemblies such as windows and waterproofing.

5.4. Recommendations for Detail Development

The ICF testing results can provide guidance for the development of the ICF best practice guide details when combined with the collective experience of the industry and ongoing research by individual manufacturers to confirm performance of individual systems.

We recommend that ICF Best Practice Guide details clearly articulate the water management strategy and that the intended exposure rating is defined for each strategy.

Sincerely,

RDH Building Science Inc.

Brian Hubbs | P.Eng.

Managing Principal, Senior Building Science Specialist, RDH Building Science Inc.

Appendix I

Water Penetration Test Reports

Making Buildings Better

224 W 8th Avenue
Vancouver, BC V5Y 1N5

604 873 1181
rdh.com

ASTM E1105 Window Test Report: HPO Test Module 1

ICF Testing Phase 3

TEST STANDARD ASTM E1105-00 (2008)
Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Air Pressure Difference.

CLIENT BC Ready-Mixed Concrete Association
26162 - 30A Avenue
Aldergrove, BC
V4W 2W5 CAN

SUBMITTED BY RDH Building Engineering Ltd.
224 W 8th Avenue
Vancouver, BC V5Y 1N5

WINDOW HPO Test Module 1 – Internal Buck

REPORT NO	DATE	DESCRIPTION
4975.011 – 01	March 22, 2016	Final Report

224 W 8th Avenue
Vancouver, BC V5Y 1N5

604 873 1181
rdh.com

Contents

1 Summary

1.1 Test Results

TABLE 1.1 TEST RESULTS SUMMARY	
HPO TEST MODULE 1 - INTERNAL BUCK WITH SILL FLASHING	
Required Test Pressure	150 / 300 / 700 Pa
Test Method	ASTM E1105-00 (2008) Procedure A: Uniform Static
Number of Tests Performed	3
Details Included	Fixed Lite, Perimeter Interface
Final Result	Conformance at 150 / 300 Pa, Fail at 700 Pa

1.2 Remedial Work

No remedial work was performed on this test sample.

2 General Information

RDH Building Engineering Ltd. (RDH) was retained by Homeowner Protection Office as the testing agency to perform testing in general conformance with the ASTM E 1105-00 (2008) standard test method at the in-situ Mock-up site in Surrey, BC. This report has been prepared for Homeowner Protection Office and is not to be relied on by others.

This test was conducted as part of the ICF research testing program's Phase 3 in-situ testing. A window specimen was installed into an opening using the HPO Module 1 method of the Internal Buck. This in-situ test is being conducted to assess the installation methods performance level. The testing is being performed at pressure differentials of 150, 300 and 700 Pa as was used in the original lab testing.

2.1 Attendees

The following people observed the testing in part or whole.

- Rob Orlowski – RDH Building Science Inc.
- Jesse Moore – RDH Building Science Inc.
- Andrew Stiffman – RDH Building Science Inc.
- Douglas Bennion – Quadlock Building Systems Ltd.

2.2 Test Specimen

TABLE 2.2.1 SPECIMEN CONSTRUCTION	
HPO TEST MODULE 1 - INTERNAL BUCK WITH SILL FLASHING	
Manufacturer	Starline
Series Name/Number	6100
Age	New
Overall Dimensions (WxH)	1320 × 1740 mm (52" × 68 ½"inches)
Frame Material	Vinyl
Thermally Broken	N/A
Details Included	Fixed lite, Perimeter interface
Shop Drawing Reference Number	N/A
Shop Drawing Set	N/A

TABLE 2.2.1 SPECIMEN CONSTRUCTION	
Photo	

TABLE 2.2.1 SPECIMEN CONSTRUCTION

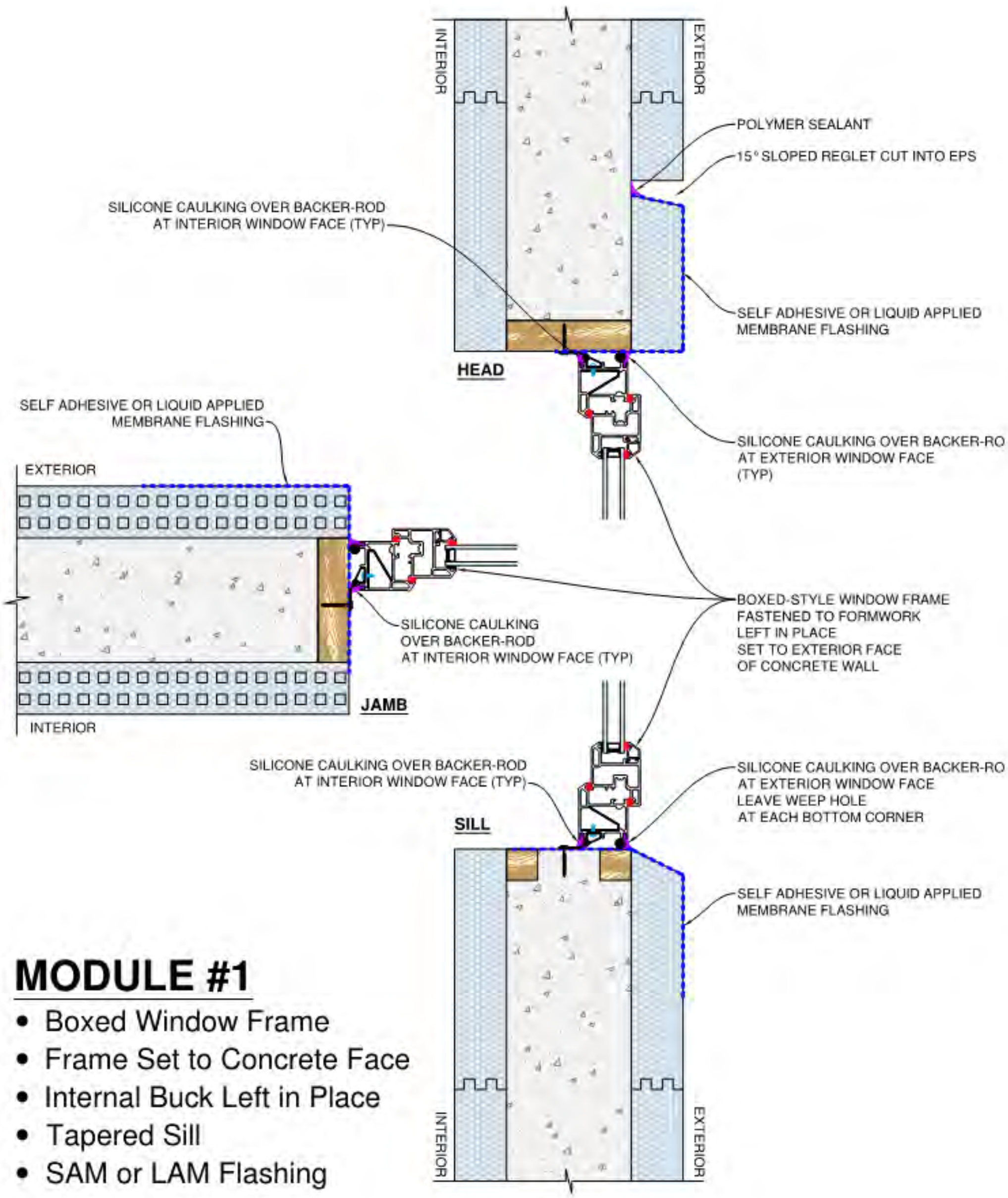

TABLE 2.2.2 SPECIMEN LOCATION	
Elevation	East
Floor	2
Facing Direction	East
Suite	N/A

TABLE 2.2.3 VISUAL EXAMINATION	
Damage	We observed no damage that would impact performance.
Missing Components	We observed no missing items.
Misaligned Vents	N/A
Misaligned Gaskets	N/A
Cleanliness	We observed no debris on the specimen that would impact the performance.
Level*	The specimen is level.
Plumb*	The specimen is plumb.
Square*	The specimen is square.

*Acceptable readings fall within the specified construction tolerances provided by the window manufacturer or the project specifications.

2.3 Test Chamber

Test chambers are used to achieve a pressure differential across the specimen. For a complete description of the chamber used, refer to Appendix A.5.

TABLE 2.3.1 CHAMBER TYPE	
Type	Clear Plastic Enclosure
Photo	

3 Test Results

3.1 Test #1

Test Conditions

Test Date: November 11, 2015

Test Time: 4:00 PM

Weather: Clear, Calm, 8 ˚C

Test Parameters

Pressure Difference: 150 Pa

Duration: 15 minutes (Complete)

Procedure: Procedure A: Uniform Static

TABLE 3.1.1	TEST RESULTS
Result	Conformance with 150 Pa

3.2 Test #2

Test Conditions

Test Date: November 11, 2015

Test Time: 4:20 PM

Weather: Clear, Calm, 8 ˚C

Test Parameters

Pressure Difference: 300 Pa

Duration: 15 minutes (Complete)

Procedure: Procedure A: Uniform Static

TABLE 3.2.1	TEST RESULTS
Result	Conformance with 300 Pa

3.3 Test #3

Test Conditions

Test Date: November 11, 2015

Test Time: 4:40 PM

Weather: Clear, Calm, 8 ˚C

Test Parameters

Pressure Difference: 700 Pa

Duration: 15 minutes (Complete)

Procedure: Procedure A: Uniform Static

TABLE 3.3.1	WATER OBSERVATION POINT
Water Penetration Point	P1
Location	Bottom right corner through a fastener that penetrates the window sill membrane. The water ingress was from between the membrane and the wood buck.
Time	1 minute
Volume of Water	Large pool
Photo	

TABLE 3.3.2	WATER PENETRATION POINT
Water Penetration Point	P2
Location	Top left corner between the wood buck and the SAM. The water ingress was from between the membrane and the wood buck.
Time	3 minutes
Volume of Water	Small pool
Photo	

TABLE 3.3.3	WATER PENETRATION POINT
Water Penetration Point	P3
Location	Bottom left corner between the wood buck and the ICF wall.
Time	Observed after test when the chamber was removed
Volume of Water	Large pool
Photo	 

TABLE 3.3.4	TEST RESULTS
Result	Fail 700 Pa

Additional Comments:

- After the test was completed the sill anchor at P1 location was removed and SAM window wrap was pulled up to confirm that the leakage that occurred at P1 was a result of water entering under the SAM and through the sill angle fastener onto the sill.
- The SAM wrap at the jamb was also removed and the water was found to be leaking from the top left corner of the window from between the wood buck and the SAM window wrap membrane

4 Summary

When tested to the standard of ASTM E1105, the specimen, as prepared, prevented water ingress as defined by the standard at pressure of 150 and 300 Pa but failed to prevent water ingress at 700 Pa.

RDH is available to discuss this report and any potential next steps. Please contact the undersigned at your convenience.

Yours truly,

Rob Orlowski |AScT
Associate, Specialist
rob@rdh.com
RDH Building Science Inc.

Appendix A

Supplementary Information

Appendix A

A.1 Test Pressure Difference

The testing was performed at pressure differentials outlined in the ICF research testing program lab testing phase.

A.2 Test Procedures

Testing was performed in general conformance with ASTM E1105-00 (2008) - *Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Air Pressure Difference*.

A Uniform Static water test (Procedure A) consists of maintaining the specified static air pressure difference across the test specimen with the specified rate of water spray for 15 minutes.

A Cyclical Static water test (Procedure B) consists of applying the specified static air pressure difference across the test specimen, along with the specified rate of water spray, for 5 minutes. While maintaining water spray, the air pressure difference is reduced to 0 for 1 minute. The preceding 2 steps are repeated 4 times for a total test time of 24 minutes.

Refer to the individual test parameters for the procedure used.

A.3. Sampling Procedures

Test samples are selected to include representative details typical on the project. Window test samples are selected based on the following criteria:

- → Budget
- → Access
- → Construction schedule
- → Percentage of the glazing system currently installed on the project
- → Configuration of typical details to be tested
- → Exposure of in-situ specimens

Additional samples may be selected based on the results of the original sample, and would focus on complex or problematic details.

A.4. Failure Criteria

Criteria as defined by the standard:

- → Failure occurs when water that penetrates through the frame or other portions of the test specimen reaches a vertical plane inboard of the innermost projection of the specimen or when water reaches interior finishes or hardware.

- → Failure occurs whenever water penetrates through the perimeter frame of the test specimen.
- → Water contained within drained flashing, gutters, and sills is not considered failure.

Criteria as defined by NAFS AAMA/WDMA/CSA 101/I.S.2/A440-08 "North American Fenestration Standard/Specification for Windows, Doors, and Skylights" including the Canadian Supplement AAMA/WDMA/CSA 101/I.S.2/A440S1-07

- → Failure occurs when water remains trapped in the window, door, or skylight assembly after the test pressure has been released.
- → Water retained as droplets or surface film due to surface tension within the drained cavities is not considered as failure of the test.

A.5. Test Equipment

Spray Rack

The spray rack consisted of a 19 mm copper tube grid with Spraying Systems Co. - 1/8GG4.3W Fulljet Brass nozzles spaced at 610 mm on-centre.

Water was pumped through the rack and into the nozzles with a Honda WH15 water pump to the calibrated test pressure. The pressure was controlled by throttling the flow of water with valves and was measured by model P500 2½-inch water pressure gauge. The spray rack was calibrated in accordance with ASTM Standard E 1105-00 to a pressure of 97 kPa (14 psi). The spray rack was positioned 380 ±51 mm (15 ±2 in) from the test specimen during the tests.

Test Chamber

The specimen was encapsulated by sealing a clear plastic sheet or acrylic glass to the perimeter of the assembly adjacent to the test specimen. The cavity between the enclosure and the specimen was depressurized and then the test specimen was viewed through the enclosure throughout the duration of the test.

Depressurization

Depressurization of the test chamber was achieved by the use of a high-pressure fan (Dayton Blower model # 4C108 with 6-inch intake). The fan evacuates the air from the chamber at a controlled rate to create the desired pressure differential across the window system. The pressure differential is measured across the chamber wall with an Extech Instruments HD755 digital manometer.

The chamber is located in an active construction zone where sections of the exterior walls have not been completed, thus ensuring there was no pressure difference between the exterior and the location of the manometer.

During windy conditions, the pressure difference across the window is also measured to ensure any fluctuations are within 10% of the specified test pressure.

A.6. Documentation

Terminology

In the report, water ingress paths and various forms of remedial work are denoted in the following manner:

Water Observation Points – Any point of water ingress visible from the interior. These items are designated with a “W” sequence in the test results.

Water Penetration Points – Water Observation Points that result in a failure of the test as defined in the test standard. These items are designated with a “P” sequence in the test results. Multiple Water Observations Points can contribute to an eventual Water Penetration Point.

Adjustments – Adjustments are items on the test specimen where an installed component required realignment to properly interface with another component. These items are designated with an “A” sequence in remedial work.

Deficiencies – Deficiencies are items found on the test specimen that are not manufactured or installed per the manufacturer or project requirements. These items are designated with a “D” sequence in remedial work.

Modifications – Modifications are items that are performed on the test specimen that differ from the manufacturer or project requirements. These items are designated with an “M” sequence in remedial work.

Orientation References

All references denoting orientation are taken as viewed from the interior of the test specimen

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ASTM E1105 Window Test Report: HPO Test Module 2

ICF Testing Phase 3

TEST STANDARD: ASTM E1105-00 (2008)
Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Air Pressure Difference.

CLIENT: BC Ready-Mixed Concrete Association
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Aldergrove, BC
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SUBMITTED BY: RDH Building Engineering Ltd.
224 W 8th Avenue
Vancouver, BC V5Y 1N5

WINDOW: HPO Test Module 2 – EIFS Basecoat

REPORT NO	DATE	DESCRIPTION
4975.011 – 02	March 22, 2016	Final Report

Contents

1 Summary

1.1 Test Results

TABLE 1.1 TEST RESULTS SUMMARY	
HPO TEST MODULE 2 – EIFS BASECOAT	
Required Test Pressure	150 / 300 / 700 Pa
Test Method	ASTM E1105-00 (2008) Procedure A: Uniform Static
Number of Tests Performed	3
Details Included	Fixed Lite, Perimeter Interface
Final Result	Conformance at 150, 300, and 700 Pa

1.2 Remedial Work

No remedial work was performed on this test sample.

2 General Information

RDH Building Engineering Ltd. (RDH) was retained by Homeowner Protection Office as the testing agency to perform testing in general conformance with the ASTM E 1105-00 (2008) standard test method at the in-situ Mock-up site in Surrey, BC. This report has been prepared for Homeowner Protection Office and is not to be relied on by others.

This test was conducted as part of the ICF research testing program's Phase 3 in-situ testing. A window specimen was installed into an opening using the HPO Module 2 method of the EIFS Basecoat. This in-situ test is being conducted to assess the installation methods performance level. The testing is being performed at pressure differentials of 150, 300 and 700 Pa as was used in the original lab testing.

2.1 Attendees

The following people observed the testing in part or whole.

→ Rob Orlowski – RDH Building Science Inc.

→ Jesse Moore – RDH Building Science Inc.

→ Andrew Stiffman – RDH Building Science Inc.

→ Douglas Bennion – Quadlock Building Systems Ltd.

2.2 Test Specimen

TABLE 2.2.1 SPECIMEN CONSTRUCTION	
HPO TEST MODULE 1 - INTERNAL BUCK WITH SILL FLASHING	
Manufacturer	Starline
Series Name/Number	6100
Age	New
Overall Dimensions (WxH)	1320 × 1740 mm (52" × 68 ½"inches)
Frame Material	Vinyl
Thermally Broken	N/A
Details Included	Fixed lite, Perimeter interface
Shop Drawing Reference Number	N/A
Shop Drawing Set	N/A

TABLE 2.2.1 SPECIMEN CONSTRUCTION	
Photo	

TABLE 2.2.1 SPECIMEN CONSTRUCTION

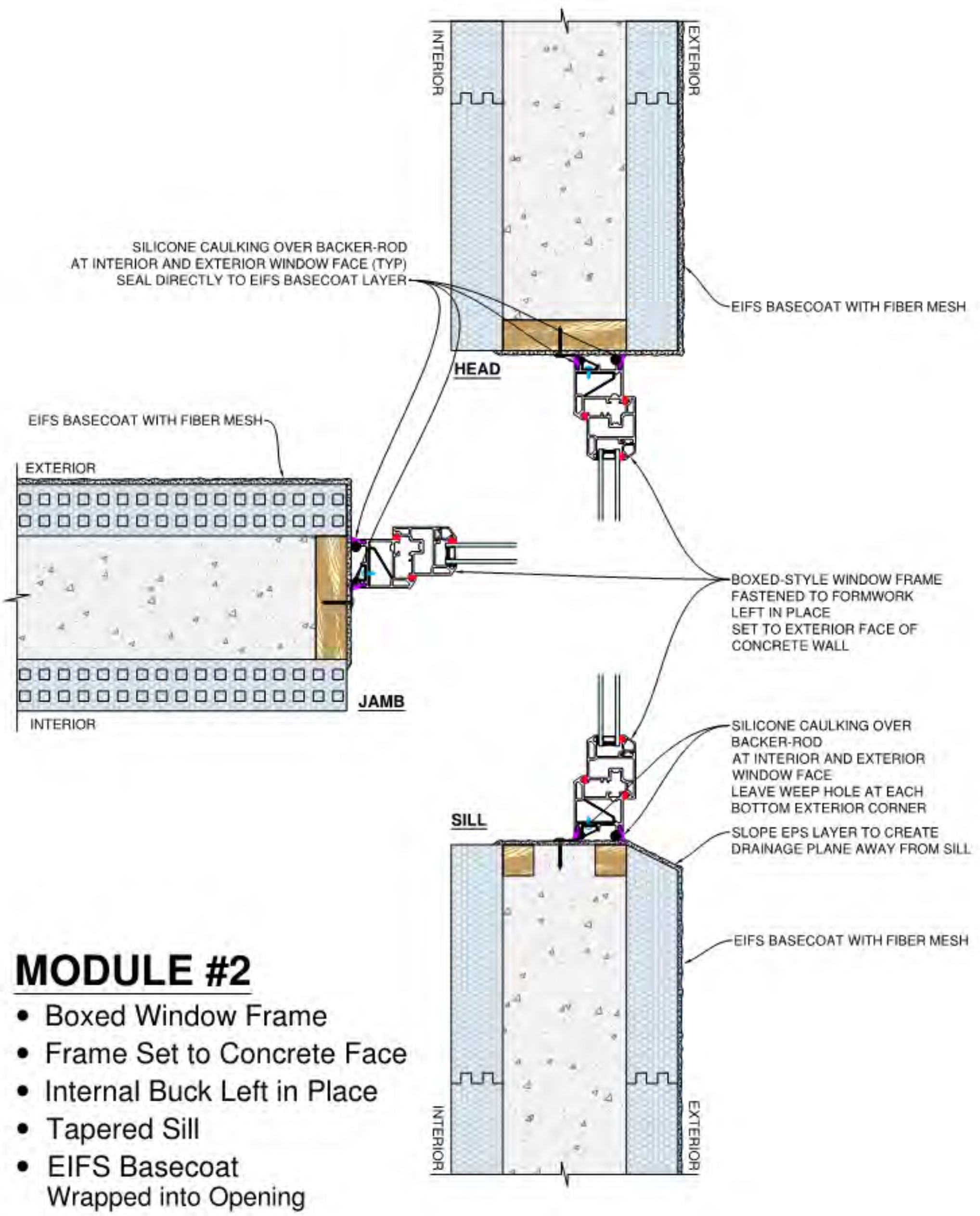

TABLE 2.2.2 SPECIMEN LOCATION	
Elevation	East
Floor	2
Facing Direction	East
Suite	N/A

TABLE 2.2.3 VISUAL EXAMINATION	
Damage	We observed no damage that would impact performance.
Missing Components	We observed no missing items.
Misaligned Vents	N/A
Misaligned Gaskets	N/A
Cleanliness	We observed no debris on the specimen that would impact the performance.
Level*	The specimen is level.
Plumb*	The specimen is plumb.
Square*	The specimen is square.

*Acceptable readings fall within the specified construction tolerances provided by the window manufacturer or the project specifications.

2.3 Test Chamber

Test chambers are used to achieve a pressure differential across the specimen. For a complete description of the chamber used, refer to Appendix A.5.

TABLE 2.3.1 CHAMBER TYPE	
Type	Clear Plastic Enclosure
Photo	

3 Test Results

3.1 Test #1

Test Conditions

Test Date: November 11, 2015

Test Time: 5:30 PM

Weather: Clear, Calm, 8 ˚C

Test Parameters

Pressure Difference: 150 Pa

Duration: 15 minutes (Complete)

Procedure: Procedure A: Uniform Static

TABLE 3.1.1	TEST RESULTS
Result	Conformance with 150 Pa

3.2 Test #2

Test Conditions

Test Date: November 11, 2015

Test Time: 5:50 PM

Weather: Clear, Calm, 8 ˚C

Test Parameters

Pressure Difference: 300 Pa

Duration: 15 minutes (Complete)

Procedure: Procedure A: Uniform Static

TABLE 3.2.1	TEST RESULTS
Result	Conformance with 300 Pa

3.3 Test #3

Test Conditions

Test Date: November 11, 2015

Test Time: 7:00 PM

Weather: Clear, Calm, 8 ˚C

Test Parameters

Pressure Difference: 700 Pa

Duration: 15 minutes (Complete)

Procedure: Procedure A: Uniform Static

TABLE 3.3.1 TEST RESULTS	
Result	Conformance with 700 Pa

4 Summary

When tested to the standard of ASTM E1105, the specimen, as prepared, prevented water ingress as defined by the standard at pressure of 150, 300 and 700 Pa.

RDH is available to discuss this report and any potential next steps. Please contact the undersigned at your convenience.

Yours truly,

Rob Orlowski |AScT
Associate, Specialist
rob@rdh.com
RDH Building Science Inc.

Appendix A

Supplementary Information

Appendix A

A.1 Test Pressure Difference

The testing was performed at pressure differentials outlined in the ICF research testing program lab testing phase.

A.2 Test Procedures

Testing was performed in general conformance with ASTM E1105-00 (2008) - *Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Air Pressure Difference*.

A Uniform Static water test (Procedure A) consists of maintaining the specified static air pressure difference across the test specimen with the specified rate of water spray for 15 minutes.

A Cyclical Static water test (Procedure B) consists of applying the specified static air pressure difference across the test specimen, along with the specified rate of water spray, for 5 minutes. While maintaining water spray, the air pressure difference is reduced to 0 for 1 minute. The preceding 2 steps are repeated 4 times for a total test time of 24 minutes.

Refer to the individual test parameters for the procedure used.

A.3. Sampling Procedures

Test samples are selected to include representative details typical on the project. Window test samples are selected based on the following criteria:

- → Budget
- → Access
- → Construction schedule
- → Percentage of the glazing system currently installed on the project
- → Configuration of typical details to be tested
- → Exposure of in-situ specimens

Additional samples may be selected based on the results of the original sample, and would focus on complex or problematic details.

A.4. Failure Criteria

Criteria as defined by the standard:

- → Failure occurs when water that penetrates through the frame or other portions of the test specimen reaches a vertical plane inboard of the innermost projection of the specimen or when water reaches interior finishes or hardware.

- → Failure occurs whenever water penetrates through the perimeter frame of the test specimen.
- → Water contained within drained flashing, gutters, and sills is not considered failure.

Criteria as defined by NAFS AAMA/WDMA/CSA 101/I.S.2/A440-08 "North American Fenestration Standard/Specification for Windows, Doors, and Skylights" including the Canadian Supplement AAMA/WDMA/CSA 101/I.S.2/A440S1-07

- → Failure occurs when water remains trapped in the window, door, or skylight assembly after the test pressure has been released.
- → Water retained as droplets or surface film due to surface tension within the drained cavities is not considered as failure of the test.

A.5. Test Equipment

Spray Rack

The spray rack consisted of a 19 mm copper tube grid with Spraying Systems Co. - 1/8GG4.3W Fulljet Brass nozzles spaced at 610 mm on-centre.

Water was pumped through the rack and into the nozzles with a Honda WH15 water pump to the calibrated test pressure. The pressure was controlled by throttling the flow of water with valves and was measured by model P500 2½-inch water pressure gauge. The spray rack was calibrated in accordance with ASTM Standard E 1105-00 to a pressure of 97 kPa (14 psi). The spray rack was positioned 380 ±51 mm (15 ±2 in) from the test specimen during the tests.

Test Chamber

The specimen was encapsulated by sealing a clear plastic sheet or acrylic glass to the perimeter of the assembly adjacent to the test specimen. The cavity between the enclosure and the specimen was depressurized and then the test specimen was viewed through the enclosure throughout the duration of the test.

Depressurization

Depressurization of the test chamber was achieved by the use of a high-pressure fan (Dayton Blower model # 4C108 with 6-inch intake). The fan evacuates the air from the chamber at a controlled rate to create the desired pressure differential across the window system. The pressure differential is measured across the chamber wall with an Extech Instruments HD755 digital manometer.

The chamber is located in an active construction zone where sections of the exterior walls have not been completed, thus ensuring there was no pressure difference between the exterior and the location of the manometer.

During windy conditions, the pressure difference across the window is also measured to ensure any fluctuations are within 10% of the specified test pressure.

A.6. Documentation

Terminology

In the report, water ingress paths and various forms of remedial work are denoted in the following manner:

Water Observation Points – Any point of water ingress visible from the interior. These items are designated with a “W” sequence in the test results.

Water Penetration Points – Water Observation Points that result in a failure of the test as defined in the test standard. These items are designated with a “P” sequence in the test results. Multiple Water Observations Points can contribute to an eventual Water Penetration Point.

Adjustments – Adjustments are items on the test specimen where an installed component required realignment to properly interface with another component. These items are designated with an “A” sequence in remedial work.

Deficiencies – Deficiencies are items found on the test specimen that are not manufactured or installed per the manufacturer or project requirements. These items are designated with a “D” sequence in remedial work.

Modifications – Modifications are items that are performed on the test specimen that differ from the manufacturer or project requirements. These items are designated with an “M” sequence in remedial work.

Orientation References

All references denoting orientation are taken as viewed from the interior of the test specimen.

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ASTM E1105 Window Test Report: HPO Test Module 3

ICF Testing Phase 3

TEST STANDARD
ASTM E1105-00 (2008)
Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Air Pressure Difference.

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SUBMITTED BY
RDH Building Engineering Ltd.
224 W 8th Avenue
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WINDOW
HPO Test Module 3 – External Buck

REPORT NO	DATE	DESCRIPTION
4975.011 – 03	March 14, 2016	Final Report

224 W 8th Avenue
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Contents

1 Summary

1.1 Test Results

TABLE 1.1 TEST RESULTS SUMMARY	
HPO TEST MODULE 3 – EXTERNAL BUCK WITH SILL FLASHING	
Required Test Pressure	150 / 300 / 700 Pa
Test Method	ASTM E1105-00 (2008) Procedure A: Uniform Static
Number of Tests Performed	3
Details Included	Fixed Lite, Perimeter Interface
Final Result	Conformance at 150 / 300 Pa, Fail at 700 Pa

1.2 Remedial Work

No remedial work was performed on this test sample.

2 General Information

RDH Building Engineering Ltd. (RDH) was retained by Homeowner Protection Office as the testing agency to perform testing in general conformance with the ASTM E 1105-00 (2008) standard test method at the in-situ Mock-up site in Surrey, BC. This report has been prepared for Homeowner Protection Office and is not to be relied on by others.

This test was conducted as part of the ICF research testing program's Phase 3 in-situ testing. A window specimen was installed into an opening using the HPO Module 3 method of the External Buck. This in-situ test is being conducted to assess the installation methods performance level. The testing is being performed at pressure differentials of 150, 300 and 700 Pa as was used in the original lab testing.

2.1 Attendees

The following people observed the testing in part or whole.

- → Rob Orlowski – RDH Building Science Inc.
- → Jesse Moore – RDH Building Science Inc.
- → Andrew Stiffman – RDH Building Science Inc.
- → Douglas Bennion – Quadlock Building Systems Ltd.

2.2 Test Specimen

TABLE 2.2.1 SPECIMEN CONSTRUCTION	
HPO TEST MODULE 3 - INTERNAL BUCK WITH SILL FLASHING	
Manufacturer	Starline
Series Name/Number	6100
Age	New
Overall Dimensions (WxH)	1320 × 1740 mm (52" × 68 ½"inches)
Frame Material	Vinyl
Thermally Broken	N/A
Details Included	Fixed lite, Perimeter interface
Shop Drawing Reference Number	N/A
Shop Drawing Set	N/A

TABLE 2.2.1 SPECIMEN CONSTRUCTION	
Photo	

TABLE 2.2.1 SPECIMEN CONSTRUCTION

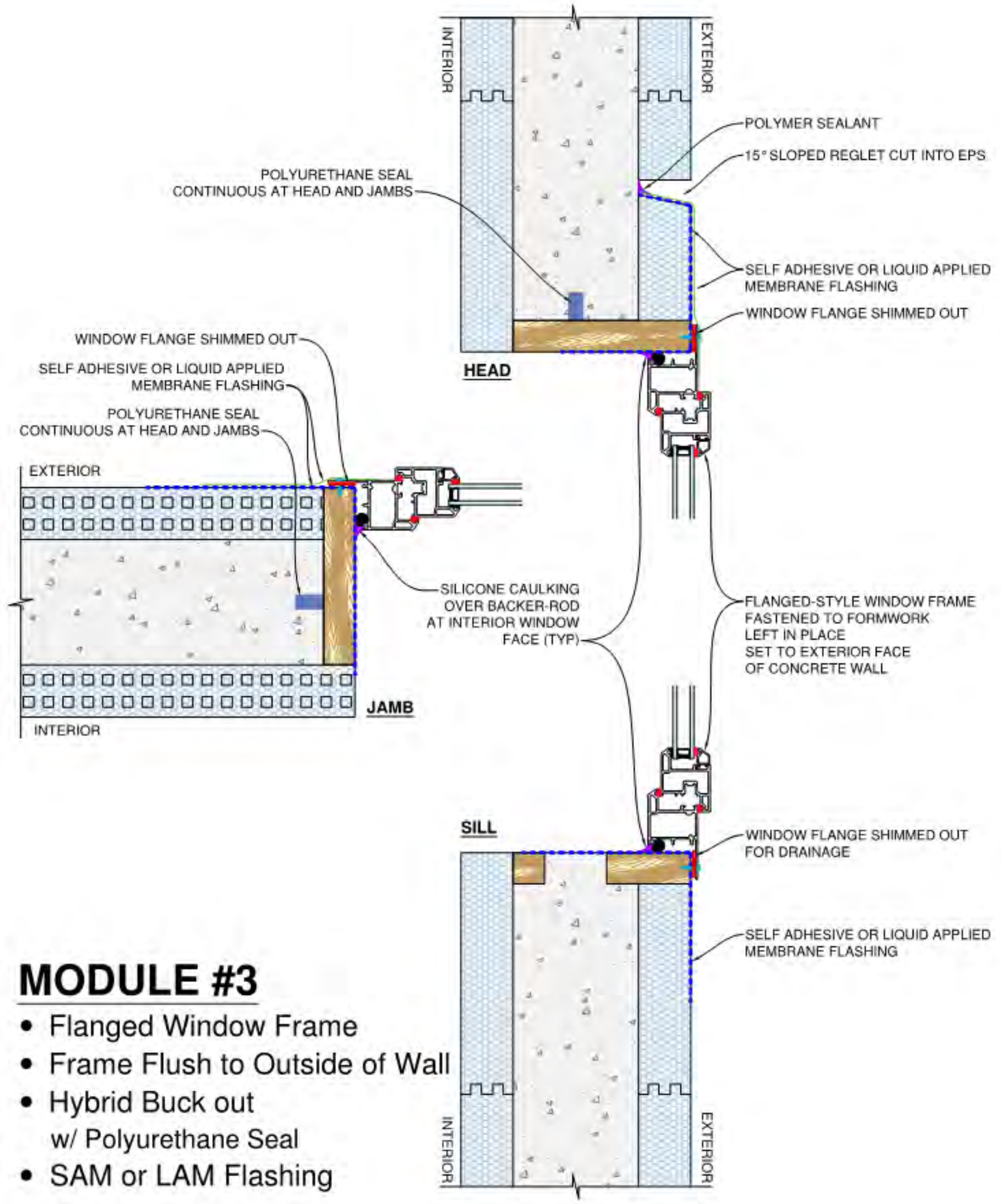

TABLE 2.2.2 SPECIMEN LOCATION	
Elevation	East
Floor	2
Facing Direction	East
Suite	N/A

TABLE 2.2.3 VISUAL EXAMINATION	
Damage	We observed no damage that would impact performance.
Missing Components	We observed no missing items.
Misaligned Vents	N/A
Misaligned Gaskets	N/A
Cleanliness	We observed no debris on the specimen that would impact the performance.
Level*	The specimen is level.
Plumb*	The specimen is plumb.
Square*	The specimen is square.

*Acceptable readings fall within the specified construction tolerances provided by the window manufacturer or the project specifications.

2.3 Test Chamber

Test chambers are used to achieve a pressure differential across the specimen. For a complete description of the chamber used, refer to Appendix A.5.

TABLE 2.3.1 CHAMBER TYPE	
Type	Clear Plastic Enclosure
Photo	

3 Test Results

3.1 Test #1

Test Conditions

Test Date: November 11, 2015

Test Time: 1:55 PM

Weather: Clear, Calm, 8 °C

Test Parameters

Pressure Difference: 150 Pa

Duration: 15 minutes (Complete)

Procedure: Procedure A: Uniform Static

TABLE 3.1.1 TEST RESULTS	
Result	Conformance with 150 Pa

3.2 Test #2

Test Conditions

Test Date: November 11, 2015

Test Time: 2:25 PM

Weather: Clear, Calm, 8 °C

Test Parameters

Pressure Difference: 300 Pa

Duration: 15 minutes (Complete)

Procedure: Procedure A: Uniform Static

TABLE 3.2.1 TEST RESULTS	
Result	Conformance with 300 Pa

3.3 Test #3

Test Conditions

Test Date: November 11, 2015

Test Time: 2:50 PM

Weather: Clear, Calm, 8 °C

Test Parameters

Pressure Difference: 700 Pa

Duration: 15 minutes (Complete)

Procedure: Procedure A: Uniform Static

TABLE 3.3.1 WATER OBSERVATION POINT	
Water Penetration Point	P1
Location	Bottom right corner between the wood buck and the concrete core
Time	After test completion
Volume of Water	Large pool
Photo	  

TABLE 3.3.4 TEST RESULTS	
Result	Fail 700 Pa

Additional Comments:

- There was a crack in the concrete at the window opening corner directly below the leak between the buck and the concrete core. It was unclear if water ingress through the crack was a direct result of the water ingress from above or if water entered directly through the crack itself.

4 Summary

When tested to the standard of ASTM E1105, the specimen, as prepared, prevented water ingress as defined by the standard at pressure of 150 and 300 Pa but failed to prevent water ingress at 700 Pa.

RDH is available to discuss this report and any potential next steps. Please contact the undersigned at your convenience.

Yours truly,

Rob Orlowski |AScT
Associate, Specialist
rob@rdh.com
RDH Building Science Inc.

Appendix A

Supplementary Information

Appendix A

A.1 Test Pressure Difference

The testing was performed at pressure differentials outlined in the ICF research testing program lab testing phase.

A.2 Test Procedures

Testing was performed in general conformance with ASTM E1105-00 (2008) - *Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Air Pressure Difference*.

A Uniform Static water test (Procedure A) consists of maintaining the specified static air pressure difference across the test specimen with the specified rate of water spray for 15 minutes.

A Cyclical Static water test (Procedure B) consists of applying the specified static air pressure difference across the test specimen, along with the specified rate of water spray, for 5 minutes. While maintaining water spray, the air pressure difference is reduced to 0 for 1 minute. The preceding 2 steps are repeated 4 times for a total test time of 24 minutes.

Refer to the individual test parameters for the procedure used.

A.3. Sampling Procedures

Test samples are selected to include representative details typical on the project. Window test samples are selected based on the following criteria:

- → Budget
- → Access
- → Construction schedule
- → Percentage of the glazing system currently installed on the project
- → Configuration of typical details to be tested
- → Exposure of in-situ specimens

Additional samples may be selected based on the results of the original sample, and would focus on complex or problematic details.

A.4. Failure Criteria

Criteria as defined by the standard:

- → Failure occurs when water that penetrates through the frame or other portions of the test specimen reaches a vertical plane inboard of the innermost projection of the specimen or when water reaches interior finishes or hardware.

→ Failure occurs whenever water penetrates through the perimeter frame of the test specimen.

→ Water contained within drained flashing, gutters, and sills is not considered failure.

Criteria as defined by NAFS AAMA/WDMA/CSA 101/I.S.2/A440-08 "North American Fenestration Standard/Specification for Windows, Doors, and Skylights" including the Canadian Supplement AAMA/WDMA/CSA 101/I.S.2/A440S1-07

→ Failure occurs when water remains trapped in the window, door, or skylight assembly after the test pressure has been released.

→ Water retained as droplets or surface film due to surface tension within the drained cavities is not considered as failure of the test.

A.5. Test Equipment

Spray Rack

The spray rack consisted of a 19 mm copper tube grid with Spraying Systems Co. - 1/8GG4.3W Fulljet Brass nozzles spaced at 610 mm on-centre.

Water was pumped through the rack and into the nozzles with a Honda WH15 water pump to the calibrated test pressure. The pressure was controlled by throttling the flow of water with valves and was measured by model P500 2½-inch water pressure gauge. The spray rack was calibrated in accordance with ASTM Standard E 1105-00 to a pressure of 97 kPa (14 psi). The spray rack was positioned 380 ±51 mm (15 ±2 in) from the test specimen during the tests.

Test Chamber

The specimen was encapsulated by sealing a clear plastic sheet or acrylic glass to the perimeter of the assembly adjacent to the test specimen. The cavity between the enclosure and the specimen was depressurized and then the test specimen was viewed through the enclosure throughout the duration of the test.

Depressurization

Depressurization of the test chamber was achieved by the use of a high-pressure fan (Dayton Blower model # 4C108 with 6-inch intake). The fan evacuates the air from the chamber at a controlled rate to create the desired pressure differential across the window system. The pressure differential is measured across the chamber wall with an Extech Instruments HD755 digital manometer.

The chamber is located in an active construction zone where sections of the exterior walls have not been completed, thus ensuring there was no pressure difference between the exterior and the location of the manometer.

During windy conditions, the pressure difference across the window is also measured to ensure any fluctuations are within 10% of the specified test pressure.

A.6. Documentation

Terminology

In the report, water ingress paths and various forms of remedial work are denoted in the following manner:

Water Observation Points – Any point of water ingress visible from the interior. These items are designated with a “W” sequence in the test results.

Water Penetration Points – Water Observation Points that result in a failure of the test as defined in the test standard. These items are designated with a “P” sequence in the test results. Multiple Water Observations Points can contribute to an eventual Water Penetration Point.

Adjustments – Adjustments are items on the test specimen where an installed component required realignment to properly interface with another component. These items are designated with an “A” sequence in remedial work.

Deficiencies – Deficiencies are items found on the test specimen that are not manufactured or installed per the manufacturer or project requirements. These items are designated with a “D” sequence in remedial work.

Modifications – Modifications are items that are performed on the test specimen that differ from the manufacturer or project requirements. These items are designated with an “M” sequence in remedial work.

Orientation References

All references denoting orientation are taken as viewed from the interior of the test specimen.

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ASTM E1105 Window Test Report: HPO Test Module 4

ICF Testing Phase 3

TEST STANDARD
ASTM E1105-00 (2008)
Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Air Pressure Difference.

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SUBMITTED BY
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WINDOW
HPO Test Module 4 – Direct to Concrete

REPORT NO	DATE	DESCRIPTION
4975.011 – 04	March 22, 2016	Final Report

Making Buildings Better

224 W 8th Avenue
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Contents

1 Summary

1.1 Test Results

TABLE 1.1 TEST RESULTS SUMMARY	
HPO TEST MODULE 4 – DIRECT TO CONCRETE	
Required Test Pressure	150 / 300 / 700 Pa
Test Method	ASTM E1105-00 (2008) Procedure A: Uniform Static
Number of Tests Performed	3
Details Included	Fixed Lite, Perimeter Interface
Final Result	Conformance at 150, 300 Pa and 700 Pa

1.2 Remedial Work

No remedial work was performed on this test sample.

2 General Information

RDH Building Engineering Ltd. (RDH) was retained by Homeowner Protection Office as the testing agency to perform testing in general conformance with the ASTM E 1105-00 (2008) standard test method at the in-situ Mock-up site in Surrey, BC. This report has been prepared for Homeowner Protection Office and is not to be relied on by others.

This test was conducted as part of the ICF research testing program's Phase 3 in-situ testing. A window specimen was installed into an opening using the HPO Module 2 method of Direct to Concrete. This in-situ test is being conducted to assess the installation methods performance level. The testing is being performed at pressure differentials of 150, 300 and 700 Pa as was used in the original lab testing.

2.1 Attendees

The following people observed the testing in part or whole.

- Rob Orlowski – RDH Building Science Inc.
- Jesse Moore – RDH Building Science Inc.
- Andrew Stiffman – RDH Building Science Inc.
- Douglas Bennion – Quadlock Building Systems Ltd.

2.2 Test Specimen

TABLE 2.2.1 SPECIMEN CONSTRUCTION	
HPO TEST MODULE 4 – DIRECT TO CONCRETE	
Manufacturer	Starline
Series Name/Number	6100
Age	New
Overall Dimensions (WxH)	1320 × 1740 mm (52" × 68 ½"inches)
Frame Material	Vinyl
Thermally Broken	N/A
Details Included	Fixed lite, Perimeter interface
Shop Drawing Reference Number	N/A
Shop Drawing Set	N/A

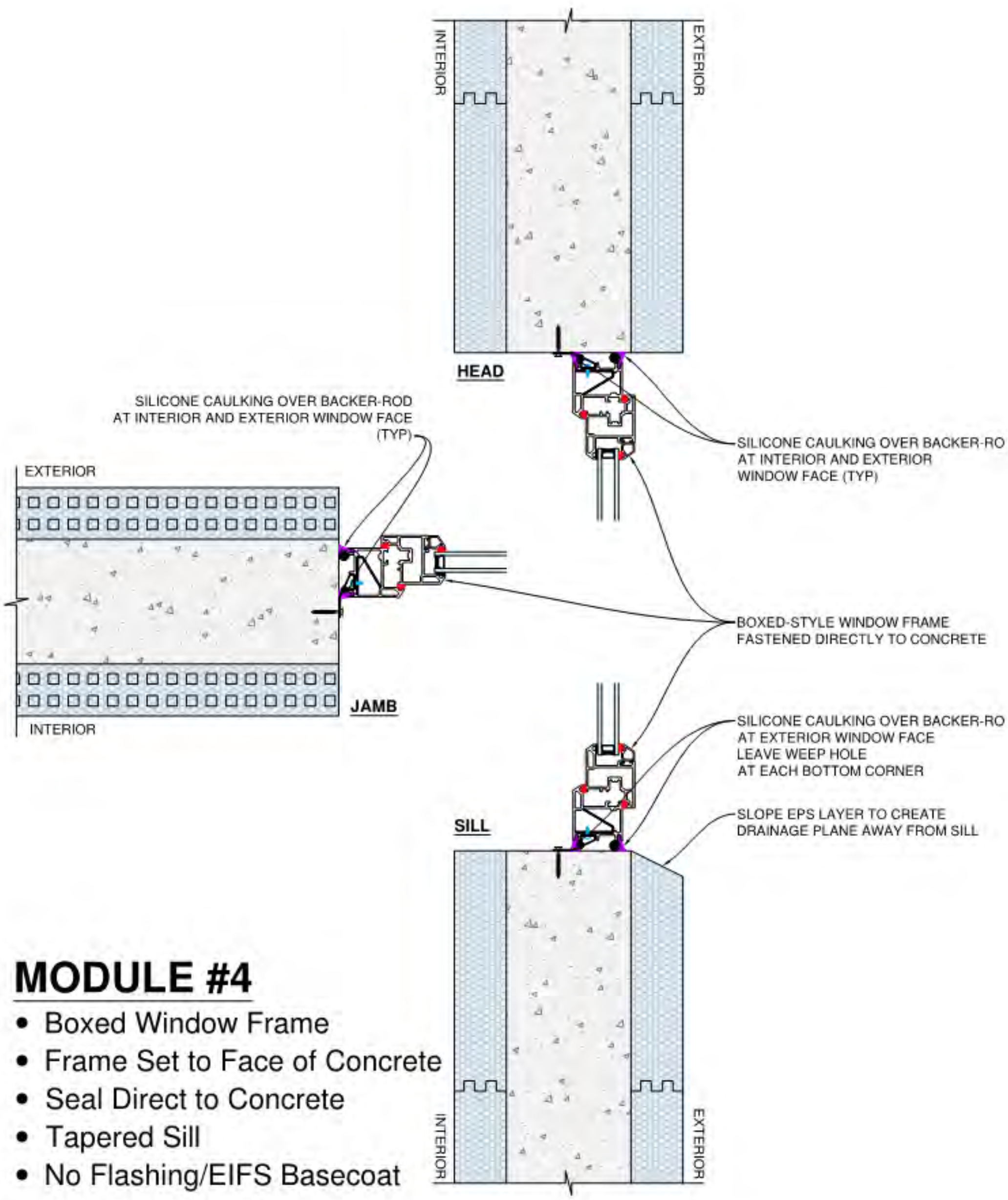
TABLE 2.2.1 SPECIMEN CONSTRUCTION	
Photo	
	

TABLE 2.2.2 SPECIMEN LOCATION	
Elevation	East
Floor	2
Facing Direction	East
Suite	N/A

TABLE 2.2.3 VISUAL EXAMINATION	
Damage	We observed no damage that would impact performance.
Missing Components	We observed no missing items.
Misaligned Vents	N/A
Misaligned Gaskets	N/A
Cleanliness	We observed no debris on the specimen that would impact the performance.
Level*	The specimen is level.
Plumb*	The specimen is plumb.
Square*	The specimen is square.

*Acceptable readings fall within the specified construction tolerances provided by the window manufacturer or the project specifications.

2.3 Test Chamber

Test chambers are used to achieve a pressure differential across the specimen. For a complete description of the chamber used, refer to Appendix A.5.

TABLE 2.3.1 CHAMBER TYPE	
Type	Clear Plastic Enclosure
Photo	

3 Test Results

3.1 Test #1

Test Conditions

Test Date: November 11, 2015

Test Time: 11:25 AM

Weather: Clear, Calm, 8 ˚C

Test Parameters

Pressure Difference: 150 Pa

Duration: 15 minutes (Complete)

Procedure: Procedure A: Uniform Static

TABLE 3.1.1	TEST RESULTS
Result	Conformance with 150 Pa

3.2 Test #2

Test Conditions

Test Date: November 11, 2015

Test Time: 11:45 AM

Weather: Clear, Calm, 8 ˚C

Test Parameters

Pressure Difference: 300 Pa

Duration: 15 minutes (Complete)

Procedure: Procedure A: Uniform Static

TABLE 3.2.1	TEST RESULTS
Result	Conformance with 300 Pa

3.3 Test #3

Test Conditions

Test Date: November 11, 2015

Test Time: 12:10 PM

Weather: Clear, Calm, 8 ˚C

Test Parameters

Pressure Difference: 700 Pa

Duration: 15 minutes (Complete)

Procedure: Procedure A: Uniform Static

TABLE 3.3.1 TEST RESULTS	
Result	Conformance with 700 Pa

4 Summary

When tested to the standard of ASTM E1105, the specimen, as prepared, prevented water ingress as defined by the standard at pressure of 150, 300 and 700 Pa.

RDH is available to discuss this report and any potential next steps. Please contact the undersigned at your convenience.

Yours truly,

Rob Orlowski |AScT
Associate, Specialist
rob@rdh.com
RDH Building Science Inc.

Appendix A

Supplementary Information

Appendix A

A.1 Test Pressure Difference

The testing was performed at pressure differentials outlined in the ICF research testing program lab testing phase.

A.2 Test Procedures

Testing was performed in general conformance with ASTM E1105-00 (2008) - *Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Air Pressure Difference*.

A Uniform Static water test (Procedure A) consists of maintaining the specified static air pressure difference across the test specimen with the specified rate of water spray for 15 minutes.

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Refer to the individual test parameters for the procedure used.

A.3. Sampling Procedures

Test samples are selected to include representative details typical on the project. Window test samples are selected based on the following criteria:

- → Budget
- → Access
- → Construction schedule
- → Percentage of the glazing system currently installed on the project
- → Configuration of typical details to be tested
- → Exposure of in-situ specimens

Additional samples may be selected based on the results of the original sample, and would focus on complex or problematic details.

A.4. Failure Criteria

Criteria as defined by the standard:

- → Failure occurs when water that penetrates through the frame or other portions of the test specimen reaches a vertical plane inboard of the innermost projection of the specimen or when water reaches interior finishes or hardware.
- → Failure occurs whenever water penetrates through the perimeter frame of the test specimen.
- → Water contained within drained flashing, gutters, and sills is not considered failure.

Criteria as defined by NAFS AAMA/WDMA/CSA 101/I.S.2/A440-08 "North American Fenestration Standard/Specification for Windows, Doors, and Skylights" including the Canadian Supplement AAMA/WDMA/CSA 101/I.S.2/A440S1-07

- → Failure occurs when water remains trapped in the window, door, or skylight assembly after the test pressure has been released.
- → Water retained as droplets or surface film due to surface tension within the drained cavities is not considered as failure of the test.

A.5. Test Equipment

Spray Rack

The spray rack consisted of a 19 mm copper tube grid with Spraying Systems Co. - 1/8GG4.3W Fulljet Brass nozzles spaced at 610 mm on-centre.

Water was pumped through the rack and into the nozzles with a Honda WH15 water pump to the calibrated test pressure. The pressure was controlled by throttling the flow of water with valves and was measured by model P500 2½-inch water pressure gauge. The spray rack was calibrated in accordance with ASTM Standard E 1105-00 to a pressure of 97 kPa (14 psi). The spray rack was positioned 380 ±51 mm (15 ±2 in) from the test specimen during the tests.

Test Chamber

The specimen was encapsulated by sealing a clear plastic sheet or acrylic glass to the perimeter of the assembly adjacent to the test specimen. The cavity between the enclosure and the specimen was depressurized and then the test specimen was viewed through the enclosure throughout the duration of the test.

Depressurization

Depressurization of the test chamber was achieved by the use of a high-pressure fan (Dayton Blower model # 4C108 with 6-inch intake). The fan evacuates the air from the chamber at a controlled rate to create the desired pressure differential across the window system. The pressure differential is measured across the chamber wall with an Extech Instruments HD755 digital manometer.

The chamber is located in an active construction zone where sections of the exterior walls have not been completed, thus ensuring there was no pressure difference between the exterior and the location of the manometer.

During windy conditions, the pressure difference across the window is also measured to ensure any fluctuations are within 10% of the specified test pressure.

A.6. Documentation

Terminology

In the report, water ingress paths and various forms of remedial work are denoted in the following manner:

Water Observation Points – Any point of water ingress visible from the interior. These items are designated with a “W” sequence in the test results.

Water Penetration Points – Water Observation Points that result in a failure of the test as defined in the test standard. These items are designated with a “P” sequence in the test results. Multiple Water Observations Points can contribute to an eventual Water Penetration Point.

Adjustments – Adjustments are items on the test specimen where an installed component required realignment to properly interface with another component. These items are designated with an “A” sequence in remedial work.

Deficiencies – Deficiencies are items found on the test specimen that are not manufactured or installed per the manufacturer or project requirements. These items are designated with a “D” sequence in remedial work.

Modifications – Modifications are items that are performed on the test specimen that differ from the manufacturer or project requirements. These items are designated with an “M” sequence in remedial work.

Orientation References

All references denoting orientation are taken as viewed from the interior of the test specimen.

Appendix II

Photos of Window Installations

Module 1 – Internal Buck with Sill Flashing

Figure II.1 Exterior of module 1 with window installed. Note reglet above window, sealing window head membrane flashing to concrete core.

Figure II.2 Module 1 sill flashing after disassembly. Note that hole in membrane corresponds with leakage location.

Module 2 – EIFS Basecoat

Figure II.3 Module 2 window sill prior to application of EIFS basecoat.

Figure II.4 Window installed in Module 2 rough opening, sealed to EIFS basecoat.

Module 3 – External Buck with Sill Flashing

Figure II.5 Module 3 rough opening prior to installation of self-adhered membrane

Figure II.6 Module 3 with window installed, prior to sealing exterior of head and jamb flanges with SAM.

Figure II.7 Module 3 reglet above window head. Note that SAM is sealed to concrete core of ICF.

Figure II.8 Module 3 leakage location, below sill at corner.

Module 4 – Direct to Concrete

Figure II.9 Module 4 installation. Note that no membrane was provided around window rough opening, seals were all directly between window frame and ICF concrete core.

Figure II.10 Corner of window sill, prior to application of backer rod and sealant. Note that window frame was sealed to concrete ICF core and window clips were bedded in caulking prior to fastening to concrete.

Figure II.11 Module 4 after disassembly, photo taken from exterior scaffolding looking into the building.