

Interim Report:

Wind-Driven Rain Tests of Building Envelope Systems up to Hurricane-Strength Wind-Driven Rain Intensity

Project #: P0150337

Submitted to:

Florida Department of Business and Professional Regulation

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1 RELEVANT SECTIONS OF THE FLORIDA BUILDING CODE

- 2017 Florida Building Code- Building, Sixth Edition, Chapter 14 “Exterior wall”, this chapter establishes minimum requirements for exterior walls, exterior wall coverings; exterior wall openings, exterior windows and doors, architecture trim, balconies. This chapter refers to:
 - ASTM 226 standard test for water-resistive barrier.
 - ASTM E2273 standard test for exterior windows and doors,
 - ASTM E331 and ASTM E547 standard test for exterior windows, skylights, doors, and curtain walls.
- 2017 Florida Building Code- Building, Sixth Edition, Chapter 17 “Special installations and Test.” This chapter governs the quality workmanship and requirements for materials covered. Materials of construction and tests shall conform to the applicable standards listed in this code. This chapter refers to:
 - TAS 200 tests for exterior windows and doors,
 - ASTM E330 Standard test for garage door and rolling door.
- 2017 Florida Building Code- Building, Sixth Edition, Residential
 - Chapter 6: Fenestrations and Wall Construction,
 - Chapter 7: Wall Covering
 - Chapter 9: Roof Assemblies

1.1 Related Documents

ASTM E2112 – 19b “Standard Practice for Installation of Exterior Windows, Doors and Skylights.” ASTM International, West Conshohocken, PA, 2016, www.astm.org

ASTM E331 – 00 “Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure.” ASTM International, West Conshohocken, PA, 2016, www.astm.org

ASTM E547 - 00 “Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Cyclic Static Air Pressure Difference”. ASTM International, West Conshohocken, PA, 2016, www.astm.org

ASTM C1601 -14a “Standard Test Method for Field Determination of Water Penetration of Masonry Wall surfaces. ASTM International, West Conshohocken, PA, 2017, www.astm.org

ASTM E330 “Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference”. ASTM International, West Conshohocken, PA, 2016, www.astm.org

ASTM E2273-18 “Standard Test Method for Determining the Drainage Efficiency of Exterior Insulation and Finish Systems (EIFS) Clad Wall Assemblies”. ASTM International, West Conshohocken, PA, 2017, www.astm.org

TAS 202 – 94 “Criteria for Testing Impact and Nonimpact Resistant Building Envelope Components Using Uniform Static Air Pressure.” 2017 Florida Building Code – Test Protocols for high Velocity Hurricane Zone, Sixth Edition.

ASTM D226/D226M—17 “Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing.” ASTM International, West Conshohocken, PA, 2017, www.astm.org

AAMA/WDMA/CSA101/LS.2: NAFS-North American Fenestration Standard/ Specification for windows, doors, and skylights.

2 BACKGROUND

In the 2018-2019 fiscal year, the Florida Building Commission appointed a Working Group on Hurricane Irma Exterior Envelope Damage Reports. The motivation for forming the Working Group came because of a high number of water leakage complaints in high rise buildings in the greater Miami area, following Hurricane Irma's landfall on 10 September 2017. This hurricane event produced elevated wind speeds and heavy rain over most of the Florida peninsula. Early forecasts had Irma making landfall on the East coast, which would have created much more severe impacts in the Miami-Dade area. The number of leakage reports provided to the Working Group were concerning because the peak wind speeds from Hurricane Irma were less than 90 mph in the Miami region. The concern arose regarding what would be the water leakage outcome for a design level event with wind speeds of 175 mph and greater.

The Working Group reported that leakage often occurs at or around windows and doors and in general more frequently at interfaces in building envelope systems, although the limited forensic information was insufficient to establish cause and effect. Another part of the study used data modeling from the Florida Public Hurricane Loss Model (FPHLM) to investigate the potential impact of fenestration defects on insured losses. The study showed that defects in fenestrations could have a substantial effect on insured losses for low intensity events like Irma in Southeast Florida. The analysis did not show significant performance differences between pre- and post-2002 buildings. In addition, it suggested that hurricane catastrophe models like the FPHLM might need to be recalibrated to give a truer projection of the magnitude of this problem.

This research is a continuation of the 2019 work. Led by the University of Florida, the research team assembled a Project Advisory Group led by a building envelope consultant and including high-rise condominium owners and managers, building envelope consultants, and representatives from testing laboratories, municipal authorities, and fenestration and cladding manufacturing industries with product offerings for high-rise construction. The aim of the group is to explore key issues related to water intrusion and provide recommendations to FBC.

3 RESEARCH AIMS AND MOTIVATION

A result of the insurance crisis following the 2004 and 2005 hurricanes was that the legislature saw the impact Florida Building Codes can have on building damage and insurance losses. Subsequently, state building code law was revised further from the 2002 changes to enhance the impact of the code. The state law of Florida now prioritizes property protection from hurricane winds and water intrusion and mitigation of existing buildings. In order to do this, the Florida Building Commission continues to focus on developing the fundamental science essential to good engineering standards and buildings codes.

This project aims to characterize the major issues associated with mitigating water intrusion failures in high-rise Florida buildings. The aspirational goal is to identify a pathway towards hurricane-resistant building envelope systems that are capable of mitigating water leakage up to the design level wind speed. The work is framed as a series of moderated discussions within the Advisory Group, to better understand perspectives of the key stakeholders, review and discussion of current state-of-the-practice methods of wind fenestration design and installation and retrofit of building systems suited to hurricane-prone coastal locations.

At the conclusion, the researchers will present a final report summarizing project activities, and outcomes of Advisory Group discussions. In particular the report will include desired specifications for developing guidelines for fenestration/curtain wall systems performance at design level and post-hurricane. Some aspects may not be achievable today and the relationship of those desired specifications with current and (potential) future testing for building envelope systems will be summarized.

4 PROJECT TASK ITEMS

There are six tasks within the scope of this project. The progress on each task, and our proposed schedule to conclude it is described below.

4.1 Task A. Assemble a project team and advisory group

A Research Advisory Group was formed to provide input and support to the research team.

The Advisory Group consists of the following persons:

#	First	Last	Organization
1	Michael	Louis	Simpson Gumpertz & Heger
2	Daniel	Smith	Venrisk Consulting
3	Vince	Seijas	Miami-Dade County Permitting and Inspection Center
4	Peter	Iglesias	City of Coral Gables City Manager
5	Dave	Stammen	UL LLC Northbrook, IL
6	Bonner	Bill	Crawford Tracey Corporation
7	Brad	Fevold	Marvin Consultant
8	Greg	Galloway	YKK AP America, Inc
9	Greg	Mckenna	Kawneer
10	Lynn	Miller	PGT Consultant
11	Dean	Ruark	PGT Consultant
12	Matt	Waldren	Pella Corporation
13	Michael	Horst	WJE Consultant
14	Chris	Lipp	WJE Consultant
15	Anne	Cope	IBHS
16	Eric	Stafford	IBHS
17	Scott	Diffenderfer	Owner Representative
18	Rick	Chitwood	Owner Representative
19	John	Runkle	Intertek
20	Alan	Greenberg	Owner

The first Advisory Group meeting took place on 6 February 2020 and meeting minutes are attached in Appendix A.

4.2 Task B. Convene Advisory Group Teleconference on five occasions

The anticipated schedule of teleconferences for the project is described below.

Meeting #1 –21 February 2020

Meeting already completed. Project overview presented with broad discussion of key issues (from various perspectives) associated with water intrusion. Notes distributed to advisory group for comment with doodle poll for scheduling Meeting #2. Meeting #1 minutes are attached in Appendix A.

Meeting #2 – Week of April 20th

Discuss and confirm minutes from Meeting #1. Pose the following questions to the group (some were also addressed in Meeting #1) and record responses:

- A. Are Florida homeowners fully aware of potential liability risks from wind and water leaks?
- B. Did any homeowner units experience water leaks and what were the consequence?
- C. Is sufficient knowledge available of magnitude and duration for wind-driven rain on in high-rise buildings surfaces?
- D. Can emergency buildings or a critical facility remain leak-free during a design-level event?
- E. What are successful approaches by building envelope consultants to mitigate water leakage in FL hurricane-prone coastlines?
- F. Quantify costs to of upgraded building envelope systems to homeowners, including immediate capital costs, plus estimated damage repair costs over the life of a structure
- G. Is a 100% water-impermeable building envelope system achievable, and at what cost?

Meeting #3 – Early May (Testing focus)

Teleconference meeting with product testing lab representatives (e.g., John Runkle-Intertek) to discuss physical aspects of testing (e.g., curtain wall, etc.), limitations, etc. Based on outcomes of Meeting #1, discuss options and limitations of field (in-situ) testing.

Meeting #4 – Late May

Determine topics and aims based on progress towards deliverables following Meeting #3.

Meeting #5 – 1st Week June

Michael Louis (building envelope consultant) will lead a charrette with the project team and a handful of product manufacturers and homeowners to help develop a "desired specifications" for fenestration system/curtain wall system that will perform during and after a design-level hurricane event. The desired outcomes may be incompatible with current testing and expectations for building envelope systems, but it should be helpful to frame

enhanced testing criteria for future systems. The outcome of the charrette shall be a document that is understandable and acceptable to condominium owners and code officials as desired performance, as well as to building envelope product manufacturers.

4.3 Task C. Summary of Project Findings

Key project items to be explored over the remainder of the project are as provided below. These will be described in complete detail in the final report.

1. The Current standards for testing, product approvals that are generally accepted by building envelope consultants for installing curtain wall systems on high-rise structures in hurricane-prone regions in Florida.
2. Defining successful tests for product approvals of fenestration and the potential incompatibility between existing testing standards during hurricanes and post-hurricane performance for building envelope systems.
3. Florida Building Code provisions (and other guidelines) that are used by Building Envelope Consultants and Building owners in developing curtain wall systems.
4. Summary of homeowner/condominium owner experience during Hurricane Irma and other recent hurricanes.
5. Current homeowner desired expectation for water infiltration and wind-driven rain resistance in condominium or apartment units of high-rise buildings. The Team will report whether any or all water infiltration is unacceptable or whether the Homeowners discern a level range of water infiltration that is tolerable.

4.4 Task D. "Desired Specifications" for fenestration system/curtain wall system performance up to design-level (and post-hurricane) event.

This task item will be completed in association with Meeting #5 (charrette) as described above. Cost implications, design implications, and societal savings if design-level performance criteria is adopted for water leakage will be considered. As part of this discussion, criteria for post-hurricane event performance will be reviewed.

4.5 Task E. Proposal to develop feasibility and required steps for Hurricane-level performance design guidelines for fenestration and building wall cladding systems

The Project Team will use the desired specification wish list from Task D to develop guidelines for community leaders, the public and the industry participants to consider in developing the feasibility and required steps towards hurricane-level performance and if possible post-hurricane performance design guidelines for fenestration and building wall cladding systems. The final report to the Commission on findings to include, but not limited to:

1. Consideration of expected losses in high-rise condominiums from a direct strike of a landfalling design level event in the south-east Florida region under two situations; current level of window performance versus some (to be determined) elevated performance level.
2. Knowledge of current and future testing options and testing on new systems currently underway that manufacturers are willing to share with the goal of establishing reliable post-hurricane performance of curtain wall and fenestration systems.
3. Benefits of structural glazing and curtain walls - most hurricane regions now utilize curtain wall assemblies that are structural glazed to aid with glass retention; such full perimeter structural seals may likely provide the post hurricane performance that homeowners would desire. Window manufacturers currently do not structurally glaze their systems, but if they did, it would most definitely improve their post-hurricane performance.

APPENDIX A: MEETING #1 MINUTES

Project Background

The University of Florida, Engineering School of Sustainable Infrastructure and Environment (ESSIE) was retained by State of Florida's Florida Building Commission (Department of Business & Professional Regulation) to conduct research to study issues related to water intrusion through mid – to high-rise building envelope systems during hurricanes. The project Manager is Mr. Mo Madani (Mo.Madani@myfloridalicense.com).

This project is led by University of Florida's Dr. David O. Prevatt, Associate Professor of Civil Engineering, dprev@ce.ufl.edu. The project was initiated following a research study last year addressing the performance of tall buildings during Hurricane Irma that struck on 10 September 2019. Last year's report can be accessed from this link:

<https://www.dropbox.com/s/r6a0bse7mf4kouv/Prevatt-UF-Water%20Resistance%20WorkingGroup-%20FINAL%206-10-2019.pdf?dl=0>

Meeting #1 (21 February 2020) Participants

#	First	Last	Abbrev.	Contact	Present
1	Michael	Louis	ML	MJLouis@sgh.com	Yes
2	Daniel	Smith	DJS	daniel.smith@venriskltd.com	Yes
3	Vince	Seijas	VS	Vince.Seijas@miamidade.gov	No
4	Peter	Iglesias	PI	piglesias@coralgables.com	No
5	Dave	Stammen	DS	David.Stammen@ul.com	Yes
6	Bonner	Bill	BB	Williamhbonner@bellsouth.net	Yes
7	Brad	Fevold	BF	bradfev@marvin.com	Yes
8	Greg	Galloway	GG	GregGalloway@ykkap.com	No
9	Greg	Mckenna	GM	Greg.McKenna@arconic.com	Yes
10	Lynn	Miller	LM	lmiller@pgtindustries.com	Yes
11	Dean	Ruark	DR	druark@pgtindustries.com	Yes
12	Matt	Waldren	MW	waldrenmc@Pella.com	Yes
13	James	Hill	JH	jhill@sibfl.net	No
14	Weil	Lam	WL	WLam@rdh.com	No
15	Michael	Horst	MH	MHorst@wje.com	No
16	Chris	Lipp	CL	CLipp@wje.com	Yes
17	Anne	Cope	AC	acope@ibhs.org	Yes
18	Eric	Stafford	ES	estafford@ibhs.org	Yes
19	Scott	Diffenderfer	SD	scottd@compass.com	Yes
20	Rick	Chitwood	RC	rickc@trumpgroup.com	Yes
21	John	Runkle	JR	John.Runkle@Intertek.com	No
22	Alan	Greenberg	AG	Alangee96@yahoo.com	Yes

Meeting #1 - Key Questions

- The FLORIDA BUILDING COMMISSION has jurisdiction for developing future resilient structures by choice of code provision and enforcement today. How far can/should they go?
- What are manufacturers to design wind resistant windows? Are there product developments planned or underway today?
- What's the economic cost of extensive leakage of water in a high-rise building?
- What do condo owners expect? Can they continue living in units?
- What does city need to plan for?
- Is insurance coverage costs limited by higher performing windows?
- Where have leaks occurred during Hurricane Irma on a building? Were they extensive or minor?
- What building permitting issues occur during Irma?

Meeting #1 Minutes

Meeting #1 provided an excellent forum to introduce the varying perspectives of key stakeholders (industry, homeowners and researchers) regarding the issue of water intrusion during severe wind events. At the conclusion of meeting, these groups also provided suggestions for future research objectives of the project. Note these minutes are currently in draft form and will be confirmed by the Advisory Group (with any required edits) during Meeting #2.

1. Project lead Dr. David Prevatt kicked off this meeting by introducing the project team, the primary goals and a preliminary study of high-rise building repair and inspection permits before and after Hurricane Irma (Figure 1).

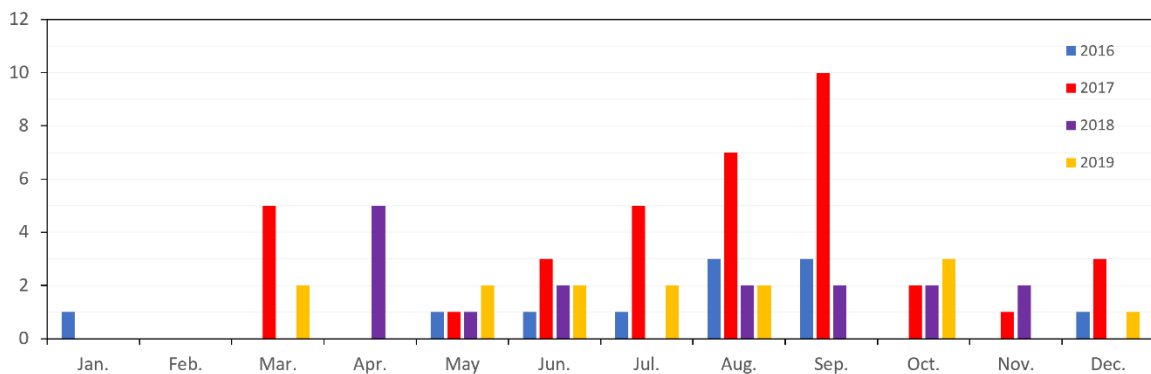


Figure 1. Number of high-rise buildings with water intrusion damage in Miami Beach, FL in the years before and after Hurricane Irma (2017)

2. Michael Louis (Senior Principal at SGH) represents the building envelope industry and led the discussion as a key team member for the project. ML notes that current codes and industry are not focused on preventing water intrusion in the aftermath of a hurricane, instead the industry is focused only on structural performance and life safety. For example, industry may simulate the effects of debris and wind during a hurricane event via standard impact (e.g., 2x4 timber missile released by pressurized debris simulator) and load cycle testing (10,000 cycles under full design wind pressure) to evaluate the performance of glass and window frames. A successful test is recorded if the test

specimen does not breach and glass stays within the window frame. In no instance of testing is the test specimen reusable after testing. Frames are severely dented and the glass is irreparably broken. The expectation is that fenestration will protect owners from debris (and keep broken glass in the frame) but is likely to require replacement post-event. ML emphasizes that per the current code provisions, industry testing aims primarily to preserve life safety. Water intrusion is not a high priority.

3. ML notes that windows are rated based on design pressure through AAMA (American Architecture Manufacturers Association). Fenestration can be designed to meet very high pressures (e.g., >200 mph) but the corresponding debris-impact rating is harder to achieve. There are examples of other applications (e.g., banks, etc.) where window products are designed to remain unbroken in extreme impact loading cases. For example, the ballistics industry has developed 6+ in glass for use in banks. This composite product is made of alternating sheets of tempered glass and a plastic interlayer to resist bullet penetration. A similar product may be able to survive in hurricanes but would require custom framing and carries substantially more weight than standard hurricane rated glass, at present.
4. Rick Chitwood (Senior VP of the Trump Group) describes his hurricane experience in Miami Beach. During hurricanes, water generally leaks from the glass sliding doors during wind-driven rain. RC notes that the sliding door products were made and installed perfectly, but the building standards have some issues. RC solves leakage issues himself, for example by replacing all the rubber seals, modifying the thresholds (water dam) seals and extending threshold heights to 6 in. This does present access issues as the step he creates is not ADA compliant, but it has been effective in addressing the water penetration issue. RC notes that sliding door sills should be required to have much deeper sills (or at least have that option) when designing for Florida weather. RC also notes that the building standards are not written to provide weather resistance for a significant weather event (neither for tropical storms or hurricanes) and that the standards that refer to hurricane-proof only relate to structural or breach performance not to water penetration resistance.
5. Alan Greenberg (Miami Beach homeowner for 10+ years) notes that in his previous home, windows and doors did not have water ingress issues because metal shutters were installed. Others without shutters did have water ingress damages. Where he lives now (farther inland, Williams Island), most residents prefer using sliding doors and installing barrier along the door to keep water out (as opposed to shutters). AG is considering shutters vs impact-rated windows and mentioned that sliding doors with shutters is a significantly cheaper option than impact-rated windows (\$14k vs \$35k respectively). The shutters are beneficial for protecting the glass from wind-driven debris and for providing a second barrier to wind-driven rainwater. AG notes that he wouldn't want extremely thick windows as this would obstruct the ocean views.
6. ML comments that shutters have been available in hurricane prone zones for many years, it can protect windows from impacted debris. However, he notes some problems for shutters: 1) storing or hiding shutters in an architecture design on a high-rise building is not easy and 2) the air and water barrier system may be breached because shutters need to come into the wall for better appearance, but that may move the location for water entry into the building to the wall as opposed to the fenestration.
7. RC builds and owns high-rises in South Florida. RC notes that shutters are better for water ingress because water doesn't hit the window, but he has observed some issues with shutters. Even with shutters the fenestration is still subject to water ingress because

1) typical terraces in South Florida do not have a slope-to-drain allowing water to run off at the side of building and 2) water sometimes isn't able to drain with constant wind and therefore it gets pushed up the wall ~6" and into the sliding door threshold (i.e. above the bottom sill). RC proposes two methods to help solve building water penetration problems: 1) put metal or plastic around the bottom of all doors to keep water from coming through the bottom and/or 2) use knee walls. RC is planning to install his own water ingress mitigation system on his properties and has a threshold strip that increases sill height (tripping hazard when not in "hurricane mode") and uses this in combination with a "water sock" on the inside. RC says there is a perception issue for owners of windows rated to 200 mph. The expectation is that they will provide full protection and functionality at those speeds, which leads to a very difficult proposition telling owners they will leak at 75 mph. RC also mentions that the problem w/ installing drains on balconies is that a p-trap is required which increases ceiling depth and reduces ocean views. ML notes that there is a drain product called corner drain that doesn't require install in middle of balcony and doesn't increase depth of balcony required.

8. Scott Diffenderfer (Homeowner, also works in real estate) lives in a 1980s high-rise and the original windows have not had any issues with water ingress. SD previously lived in a building with 1962 windows and there was no water leakage for his windows during typical Florida rainstorms, however his neighbor's hurricane windows had severe water leakage. SD points out that the hurricane windows were poorly installed (and this is a very common issue). SD also suggests that drains and gutters be installed in balconies (e.g., French drain). Water will go into the drainage system without impacting the units below. SD notes we do not need to install dams anymore.
9. Lynn Miller (PGT Consultant) provides some suggestions for addressing window leakage issues from the manufacturer's perspective. LM notes that installation and maintenance are both quite important. Homeowners need to have confirmed installations that ensure there is no path for water migration around the window during the installation and the seals need to be kept in good condition with regular maintenance. Regarding shutters, LM notes that while they offer protection, they do also require that someone is on-site to either install or activate the shutters. In comparison, windows are passive. Architectural design can also be used to alleviate some of the issues and reduce water ingress. LM also highlights the trip hazard issues with increasing sill height as a mitigation strategy for doors.
10. ML mentioned there is sliding glass doors that have better penetration resistance. The "lift and slide" product uses specialized hardware and allows door manufacturers to use better gaskets at the perimeter of doors which allow the door to fully engage against compressible gaskets instead of sliding against pile-style weather-stripping which provides a poor seal to water penetration. It is very sophisticated hardware and very expensive in the markets. There are not a lot of "lift and slide" glass doors in the market, although it would be easily adaptable to most current door designs. SD notes that "lift and slide" requires very specialized installation (tough for retrofit) and is very expensive. AG says "lift and slide" allows sliding glass door to lock down when event is coming against compressible high-quality gaskets, much better performance (sliding wall systems use similar technology), however install and maintenance are major issues.
11. Dean Ruark (PGT Consultant) notes the first priority is proper installation to ensure no water path around fenestration. Second priority should be improving the water-ingress ratings for fenestration products. DR explained that the current test standard is static. Water nozzles apply a driven rain at steady pressure and builds up a water column. If we

want to test using pressures equivalent to real hurricane pressure, we have to build a very tall water column and we need very high compression products to solve that issue.

12. Brad Fevold (Marvin Consultant) notes that some “lift and slide doors” bury part of sill so that water can be drained from below. This style of door has already been supplied in new construction projects, but it is difficult to retrofit. BF admits there are lots of things that need to be balanced between products and challenges.
13. Chris Lipp (WJE Consultant) suggests there is a lack of in-situ water intrusion testing in the South Florida construction industry. In addition, the Florida market is mainly concerned with structural problems and less concerned with water leakage issues. For the Florida Building Code, there are no requirements for field testing fenestration after installation. Field testing is voluntary and is typically only used when mandated by architects and builders on large projects such as high-rise condos.
14. Matt Waldren (Pella Corporation) notes that water will always take the path of least resistance. A good building envelope should keep water out of the building. People have to make sure water flows down off the buildings as rapidly as possible because if there is any sealant break, the water will go in.
15. ML mentions that the overwhelming problem with leakage in buildings is not that a fenestration product fails, but oftentimes, the products were not tied in well to the barrier within the wall system. The industry only defines performance of fenestration and does not define the performance of an opening system, so manufacturers of windows and curtain walls can't dictate how the fenestration goes into a wall opening such that it doesn't cause leakage after installation. ML suggested we can make changes and implement requirements to flash openings and integrate the perimeter conditions of a fenestration with a wall assembly in the codes.
16. CL suggested we should bridge the gap between the homeowner group and engineering group. For example, engineers always talk in pressure and homeowners only understand mph.
17. Bonner Bill (Worked for building envelope industry for 38) summarized several reasons for water leakage issues: 1) the current industry test standard ASTM 1105 is too low, 2) installation is always problematic because of the labor pool, 3) there is a lack of installation standards to follow through on, 4) building envelope design does not address coupling with fenestration, 5) the shutters must be waterproof as well, fatigue of metal and movement of shutters may cause water leakage, 6) the biggest problem is that design levels in the current building code are not high enough to meet the needs and requirements of end users.
18. The group was interested in hearing about real data on rainfall intensity and volumes of water that may flow down a wall during a hurricane event and how that information may help to inform the direction we need to move in Florida. Dr. Prevatt notes that in his studies with the University of Florida, he has assembled much of this data from notable hurricanes and he will present some of these findings to the group at the next meeting.
19. The group was interested in discussing what best practices would look like as part of this study.

APPENDIX B: BUILDING PERMITS AND WATER DAMAGE HYPOTHESIS

Direct evidence of hurricane-induced leakage in high-rise building is limited to anecdotal evidence, few engineering reports and individual statements from condominium managers, owners and residents in South Florida. The researchers utilized an indirect approach by exploring the hypothesis that water leaks in a building may be associated with condominium owners' need to repair damage caused by water leaks. We understand that wind-driven rain induced leaks will produce damage to cladding and interior damage to condominium units, resulting in need for repairs. Thus, we hypothesized one measure to establish the effects of Hurricane Irma on high-rise units may be to assess the number of building permit applications related to water intrusion, and/or fenestration-related construction work following Hurricane Irma. A logic flow chart explaining the approach is provided below. Findings related to this analysis (if conclusive) will be discussed in the final report.

