Interim Report for Project Entitled:

Investigation of Fastening of Wood Structural Panels for Opening Protection (Phase 2)
PO Number AB3DBA

Performance Period: 10/10/2014 – 6/30/2015

Submitted on

February 15, 2015

DRAFT

Presented to the

Florida Building Commission
State of Florida Department of Business and Professional Regulation

by

Forrest J. Masters, Ph.D., P.E., masters@ce.ufl.edu, (352) 392-9537 x 1505, Principal Investigator
Kurtis R. Gurley, Ph.D., kgurl@ce.ufl.edu, (352) 392-9537 x 1508
Zach Harper, Graduate Research Assistant

Designated Project Leader: Forrest Masters

Engineering School of Sustainable Infrastructure & Environment

UF | UNIVERSITY of FLORIDA

Table of Contents

1. Disclaimers

- This report presents the findings of research performed by the University of Florida. Any opinions, findings, and conclusions or recommendations expressed in this paper are those of the authors and do not necessarily reflect the views of the sponsors, partners and contributors. The Structural Technical Advisory Committee of the Florida Building Commission will provide a final disposition on the implications for the Florida Building Code.
- This document applies to Section 1609 of the Florida Building Code, Building (5th Ed.). Although not explicitly addressed herein, the findings also apply to Section R301.2.1.2 of Florida Building Code 2010: Residential

2. Applicable Sections of the Code

- 1609.1.2, Exception 1, Florida Building Code 2010: Building
- Table 1609.1.2, Florida Building Code 2010: Building
- R301.2.1.2, Exception, Florida Building Code 2010: Residential
- Table R301.2.1.2, Florida Building Code 2010: Residential

3. Major Findings and Recommendations for the Code from Phase 1 (FY 2013-14)

The letter from Joe Belcher in **Appendix A** on behalf of the International Hurricane Protection Association (IHPA) describes the issues that led to the initiation of the original (Phase 1) project conducted during FY 2013-14. This final report may be obtained from FBC staff or the lead investigator.

Phase 1 research findings were used to suggest modifications to the 5th Ed. of the Florida Building Code-Building (see **Appendix B**), which are summarized below:

1. Determination of wind loads for labeling and product approval of impact resistant coverings should be streamlined and made consistent with ASCE 7-10 Components and Cladding (C&C) load calculations. The current approach yields an ultimate load that is 90% of the ASCE 7-10 C&C counterpart. Further, the Code should explicitly define the relationship between ASD and LRFD (ultimate) pressures and the terminology incorporated in the testing application standards, which vary. Appendix B contains the authors' suggestion modifications to the 5th Ed. of the Florida Building Code-Building. We suggest that the Code allows a single prescriptive design (proposed herein) and simplified guidance for designers seeking alternative fastening solutions
2. The wind-borne debris protection fastening schedule (Table 1609.1.2) for wood structural panels is not conservative, e.g. an 8 ft unsupported span of 7/16 OSB with 1 inch of spacing between the fastener and the panel edge will fail in strong winds
3. Structural wood panels are a good choice for a low-cost storm shutters outside of the HVHZ if the fastening schedule is adequate. A one-approach-fits-all, low-cost design was developed and tested for Group R-3 or R-4 occupancy buildings with a mean roof height of 45 feet or less in locations where Vult is 180 mph or less. The system did not exhibit failure during static and cyclic pressure tests derived from ASTM E330 and ASTM E1996. We believe this design reasonably complements the options for metal shutter products, which are generally rated for higher pressures with the tradeoff of increased cost

The following items were found to merit additional study and are the focal points of the Phase 2 study:

4. Predicting the catenary forces is not straightforward given the current knowledge base. The flexibility of 7/16 OSB causes large deflections (~L/15) that cause in-plane forces that combine with the withdrawal force induced by the out-of-plane wind loading. The lateral (shear) forces are

dependent on a combination of factors, including flexural bending of the fasteners or other yield modes (crushing, rotating, hinging) and the free translation of the panel caused by oversizing of the holes that receive the fasteners

5. Designers need conservative yet realistic closed-form solutions to calculate catenary loads in a rational engineering analysis, however the standard equations most likely to be used by a designer are expected to significantly overpredict the lateral forces. Additional experimental research is required to validate closed-form solutions and to establish baseline parameters (e.g. load/slip) for typical panel materials, thicknesses and physical properties (e.g., moisture content). These data can be readily incorporated into existing standards published by APA and AWC that are referenced by the Code
6. Other combinations of hardware and wall types should be studied to determine if the one-approach-fits-all approach proposed in the study is acceptable or requires modifications to achieve suitability. Time and budget precluded the investigators from evaluating other combinations that are prevalent in Florida, however the experimental configuration required to perform this testing is now in place
7. Developing recommendations for larger openings is warranted, especially given the widespread use of sliding glass doors in one- and two-story residential buildings. Additional research is required to develop a prescriptive design solution for large openings that require more than one panel. The APA T460 *Hurricane Shutter Design Considerations for Florida* provides a logical starting point for designing multi-panel configurations

4. Scope of Work

- Develop a rational engineering analysis method to calculate catenary (lateral) forces for flexible panel systems
- Determine prescriptive fastening requirements for structural wood panels attached to masonry wall systems and validate the design through experimental testing
- Design structural wood panel systems for large openings and validate the design through experimental testing. Evaluate APA T460 as a starting point for this design
- Interpret results, determine whether the problem requires action, and produce a report that explains the results and implications for the Code

5. Deliverables

- Interim report by February 15, 2015 – Interim progress report detailing the current status and progress toward completing the work described above. In addition, the Interim report will be presented to the Commission's Structural Technical Advisory Committee at a time agreed to by the Contractor and Department's Project Manager
- Final report by June 1, 2015 providing technical information on the problem background, results and implications to the Code. In addition, the final report will be presented to the Commission's Structural Technical Advisory Committee at a time agreed to by the Contractor. The department's Project Manager recommendation(s) may require revision to a future edition of the FBC will be analyzed using the criteria outlined in the currently adopted code modification form
- A breakdown of the number of hours or partial hours, in increments of fifteen (15) minutes, of work performed and a brief description of the work performed. The Contractor agrees to provide any additional documentation requested by the Department to satisfy audit requirements

6. Status of Project

Current focus areas include attachment methods for masonry wall systems (e.g., concrete-block-stucco

and brick veneer over wood frame) and large openings that require more than one panel. Development of a rational analysis technique to predict catenary loads is integral to this work. Activities to date are summarized below:

- The investigator reconvened an oversight committee formed by members of APA, the American Wood Council (AWC) and the International Hurricane Protection Association (IHPA) to discuss issues related to use of structural wood panels for opening protection. One teleconference was held on January 12, 2015. The group agreed to proceed with the proposed plan without any major modifications. The maximize size of the 'large' opening was determined to be nominally 8 ft X 8 ft, or equivalently a two panel system. This size corresponds to a sliding glass door on a low-rise residential building. The group also agreed that additional tests should be performed on conventional metal shutter systems to provide a baseline comparison
- Two undergraduate students were hired at the start of the spring semester. Major activities (conducted under the supervision of laboratory staff) have included:
    - Initial staging of testing area, including the Instron universal testing machine and moisture analyzer to conduct the strip width tests to characterize the catenary loads
    - Design of light wood frame and masonry (CMU and CMU-brick veneer) test frames for one- and two-panel systems. A subset of these drawings may be found in **Appendix C**
    - Reviewing basis documents from FY 2013-14 experimental series
- The investigator presented the research program to the IHPA General Meeting in Pensacola on February 12, 2015 and elicited additional feedback on the project.

7. Remaining Tasks

The following six test series are planned. **Full assembly testing will commence Friday, March 6, 2015 and continue through Friday, April 24, 2015.** Live testing will be performed on Monday and Friday each week from 1 PM to 6 PM. Additional testing will be performed throughout the remainder of the week as time allows. Individuals interested in witnessing testing should contact the lead investigator to confirm attendance.

Series 1. Quantification of catenary loads developed in strip width panels subjected to out-of-plane pressure loading. Variables may include strip length (36, 48, 72 and 96 in end-to-end), panel thickness (7/16, 19/32, etc.), material type (OSB, plywood). Measurements will include applied pressure, withdrawal and lateral load on the fastener and midspan deflection. These data will be used validate a closed form solution to predict catenary force for an applied uniformly distributed load, accounting for elastic behavior and large deflections (2^{nd} order analysis). Additional testing will be performed using the Instron Universal Testing Machine to quantify the axial restraint (stiffness) for the hanger bolt configurations and measure the modulus of elasticity of the wood. We are take delivery of a six-axis load cell that ships Feb. 27. Tests should start immediately thereafter

Series 2. Experimental validation of prescriptive guidance for single-panel shutters for CMU wall systems. These tests are identical to the FY2013-14 approach except that

a. the shutter will mount to a CMU wall system (lintel above the rough opening and either block or a sill below)

b. a perimeter shim piece may be required to project the panel beyond the sill

c. the distance from the rough opening to the fastener may be increased from 1 in to a suitable distance to minimize the possibility of cracking

Series 3. Same as Test Series 2 except for brick veneer over wood frame wall systems (See Figure 1 in **Appendix C**). At the time of submission, we are designing a perimeter channel frame that accommodates a brick wythe. This frame will mount offset from the wall to create a cavity, if

required

Series 4. Experimental validation of prescriptive guidance for double-panel shutters for light frame wood wall systems (See Figure 2 in **Appendix C**). The initial thought process is to try multiple design variations that incorporate one or more of the following design components:

a. Longitudinal stiffeners perpendicular to the fastener rows to enhance the flexural resistance (see Figure 1A in APA T460)

b. An intermediate framing column that attaches to the top and bottom of the opening to accommodate installation of two individual panels (in the same manner as the prescriptive design developed in the 2013-14 research cycle). Benefits to this approach include consistency between single and double panel installations and ease of storage (the system will break down into two panels and the intermediate support)

Series 5. Same as Test Series 4 except for brick veneer over wood frame wall systems (See **Appendix C**)

Series 6. Same as Test Series 4 except for CMU wall systems

Series 7. Comparative testing of conventional metal panel systems

Series 8. [If time allows] Supplementary impact testing

The draft final report should be available by early May for stakeholders collaborating on the project to review.

8. References and Project Material

- Provided by IHPA
  - Letter to Florida Building Commission dated September 16, 2013
  - ATI Test Report dated December 1, 2011. Videos:
    - http://youtu.be/iDLzf0wF0Zc
    - http://youtu.be/2fcv5GD_qUM
    - http://youtu.be/BdSNDsSclcE
  - Letter from Engineering Express dated January 10, 2014
- Provided by APA
  - APA T460 Hurricane Shutter Design Considerations in Florida
  - Applied Research Associates. 2001. Impact and Pressure Testing of Hawaii Hurricane Relief Fund Window Protection Design.
  - Applied Research Associates. 2003. Impact and Pressure Testing of Florida Building Code Minimum Plywood and OSB Shutter Systems.
  - Institute for Business & Home Safety. 2012. Industry Perspective: Impact Resistance Standards. In: Natural Hazard Mitigation Insights No. 12
- Other resources
  - Kopp GA, Morrison MJ, Gavanski E, Henderson DJ, Hong HP. The Three Little Pigs' Project: hurricane rick mitigation by integrated wind tunnel and full-scale laboratory tests. Natural Hazards Review 2010; November, 151-161.
  - Young, W. C. and Budynas, R. G. (2002). Roark's Formulas for Stress and Strain: 7th Edition, McGraw–Hill, New York, NY.

- Zahn, J. (1991). “Design Equation for Multiple-Fastener Wood Connection”, Journal of Structural Engineering, ASCE, Vol. 117, No. 11, pp. 3477–3486.

Appendix A. Letter from the International Hurricane Protection Association

JDB CODE SERVICES, INC.

September 16, 2013

Florida Building Commission
C/O Mo Madani, DBPR
1940 North Monroe Street
Tallahassee, FL 32399

SUBJECT: IHPA Request for Funding For Research Project Related to Fastening of Wood Structural Panels for Opening Protection

Florida Building Commission:

Please consider this a request for funding for an important research project related to the fastening of wood structural panels as specified by the Florida Building Code. During the August meetings at Fort Lauderdale the Florida Building Commission (Commission) adopted a definition for the term "research" as follows:

> "An important and necessary endeavor that aimed at studying specific code related issue(s)/topics for the purpose of providing solutions to a specific problem or future code change(s) directed at improving the implementation and enforcement of the FBC. The issue to be researched must be fully understood (i.e. with clear purpose and goals); clearly defined with specific scope of work/approach; and within budget."

The International Hurricane Protection Association (IHPA) requests up to $10,000.00 be expended for testing of the fastening specified at Tables 1609.1.2 and R301.2.1.2 of the Florida Building Code. This is an important and necessary endeavor because testing conducted and previously submitted to the Commission indicates the current code is inadequate for the intended task.

Testing conducted by Architectural Testing, Inc. for IHPA indicates there is a problem with the ability of the code specified fastening schedule to resist the structural loads specified by the code for opening protection products. The failures noted were under structural loading and would undoubtedly lead to failure of the panel if subjected to the cyclical loading specified by the code for opening protection products. Additionally, it was discovered during the testing that the fasteners specified by the code are not readily available in the marketplace.

The research proposal is to review the findings of the 2003 Loss Relativities for FBC Wood Panel Shutters[1] (LRWPS or the Study). The Study was used to develop the fastening tables for wood structural panels used in the FBC. The Study conducted testing on both the wet and dry condition. The technical approach of this project will involve:

1. Engineering Analysis. The performance of engineering analysis based on a review of the LRWPS and including catenary loading based on the findings of the testing previously sponsored by IHPA[2] to develop values for a table that incorporates edge distance on the buck, edge distance on the panel, tensile strength, deflection, end failure, and yielding or over-pulling of the anchors used for attachment of wood structural panels. A test strategy will be developed based on the final calculations considering

1 Loss Relativities for FBC Wood Panel Shutters, Department of Community Affairs DCA Contract 03-RC-11-14-00-22-034, ARA IntraRisk June 30, 2003, Final Report,
2 Architectural Testing, Inc. Test Report dated December 1, 2011.

41 Oak Village Boulevard ◆ Homosassa ◆ Florida ◆ 34446 ◆ 352-450-2631 ◆ Fax 813-925-4152 ◆ joe@jdbcodeservices.com

appropriate safety factors for wood structural panels installed using common anchors that are widely available in the marketplace.

2. The engineering analysis will be contributed to the project by an IHPA member. The estimated value of the analysis is $5,000.00.
3. Testing will be to ASTM E 330-02 for structural testing and ASTM E 1886-05 and ASTM E 1996-09 for impact and cyclic testing for large missile.
4. Testing Program. The testing will involve a maximum of three tests to validate the data generated in the engineering analysis.
    a. A dry test using an OSB wood structural panel in accordance with the methodology of the LRWPS.
    b. A wet test using an OSB wood structural panel in accordance with the methodology of the LRWPS.
    c. A dry test using a plywood structural panel in accordance with the methodology of the LRWPS.
5. Testing to be performed by a Florida Building Commission approved testing laboratory.
6. Responsibilities of the testing lab include:
    a. All testing will be on a wood test buck as constructed by the testing laboratory.
    b. Mounting test specimens.
    c. Conducting tests.
    d. Writing of sealed test report.
7. IHPA will provide test specimens of commonly available materials and fasteners purchased from a retail outlet.
8. IHPA will attend and witness testing.
9. IHPA will provide installation drawings which will indicate fastener type and spacing, required shim space, and any other details pertinent to installation of wood structural panels.
10. Installation drawings shall become a referenced document in the final test report.
11. IHPA estimates the cost of Items 7, 8, and 9 at $1,000.00
12. Testing is estimated to cost $8,775.00 and shall not exceed $10,000.00. The total funding requested is to cover the testing costs only.
13. The results of the engineering analysis and testing will be used to validate the existing values or, as indicate, to develop final recommendations for new table values to replace those of Tables 1609.1.2 and R301.2.1.2 of the Florida Building Code, Building and Residential, respectively.
14. If indicated, new values will be submitted to the Florid Building Code as proposed code changes.

Respectfully submitted,

Joseph D. Belcher

Joseph D. Belcher, Code Consultant

Cc. Frank Browning, IHPA President
Tom Johnston, Immediate Past President

Appendix B. Recommendation for changes to the 5th Edition (2014) Florida Building Code

Note: These recommendations are based on FY 2013-14 research. These recommendations will be updated with findings resulting from the FY2014-15 research.

Red text = edits made by project investigators

Note 1: The 5th Edition (2014) Florida Building Code - Post Commission Post Glitch revisions call out Section 1609.1.2.3. That section (now edited) appears as 1609.1.2.4

Note 2: Corresponding changes will need to be made to FBCR R301.2.1.2.

Note 3: The version corresponds to the Post Commission Post Glitch document

CHAPTER 16
STRUCTURAL DESIGN

SECTION 1609
WIND LOADS

1609.1.2 Protection of openings. In *wind-borne debris regions*, ~~glazing~~ glazed openings in buildings shall be impact resistant or protected with an impact-resistant covering meeting the requirements of ~~, an *approved* impact-resistant standard or ASTM E 1996 and ASTM E 1886 referenced herein as follows: ,~~ SSTD 12, ANSI/DASMA 115 (for garage doors and rolling doors) or TAS 201, 202 and 203, AAMA 506. ASTM E 1996 and ASTM E 1886 referenced herein, or an *approved* impact-resistant standard as follows:

1. Glazed openings located within 30 feet (9.1 m) of grade shall meet the requirements of the Large Missile Test of ASTM E 1996.

2. Glazed openings located more than 30 feet (9.1 m) above grade shall meet the provisions of the Small Missile Test of ASTM E 1996.

3. Storage sheds that are not designed for human habitation and that have a floor area of 720 square feet (67 m2) or less are not required to comply with the mandatory windborne debris impact standards of this code.

4. Openings in sunrooms, balconies or enclosed porches constructed under existing roofs or decks are not required to be protected provided the spaces are separated from the building interior by a wall and all openings in the separating wall are protected in accordance with Section 1609.1.2 above. Such spaces shall be permitted to be designed as either partially enclosed or enclosed structures.

Exceptions:

1. Wood structural panels with a minimum thickness of 7/16 inch (11.1 mm) ~~and maximum panel span of 8 feet (2438 mm)~~ shall be permitted for opening protection in Group R-3 or R-4 occupancy buildings with a mean roof height of 45 feet (13 716 mm) or less in locations where Vult is 180 mph (80 m/s) or less ~~as Group R-3 or R-4 occupancy~~. The opening shall not exceed 42 inches (1 067 mm) X 90 inches (2 286 mm). Panels shall be precut to overlap the wall by 3 inches (76.2 mm) on all sides and ~~so that they shall be~~ attached to the framing surrounding the opening containing the product with the glazed opening. Panels shall be predrilled as required for the ~~anchorage~~ attachment method and ~~shall be~~ secured with ~~the~~ corrosion-resistant attachment hardware permanently installed on the building ~~provided~~. ~~Attachments shall be designed to resist the components and cladding loads determined in accordance with the provisions of ASCE 7, with corrosion-resistant attachment hardware provided and anchors permanently installed on the building.~~ At a minimum, panels shall be fastened at 16 inches (406.4 mm) o.c. along the edges of

the opposing long sides of the panel. Fasteners shall be located 1 inch (25.4 mm) from the opening and 2 inches (50.8 mm) inward from the panel edge. The hardware shall consist of ¼-inch hanger bolts and either (a) 1/4 inch (6.3 mm) washer with a 1 inch (25.4 mm) flange and a ¼-20 hexnut or (b) a ¼-20 washered wingnut with a minimum of a 1 inch (25.4 mm) flange. Fasteners shall penetrate through the external wall covering with sufficient embedment length to provide a minimum of 300 lbs of withdrawal resistance. Where panels are attached to masonry or masonry/stucco, they shall be attached using vibration-resistant anchors having a minimum ultimate withdrawal capacity of 1,500 pounds. Alternatively, attachments may be designed to resist the components and cladding loads determined in accordance with the provisions of ASCE 7. These systems shall meet the requirements of Section 1609.1.2.4 below. ~~Attachment in accordance with Table 1609.1.2 with corrosion resistant attachment hardware provided and anchors permanently installed on the building is permitted for buildings with a mean roof height of 45 feet (13 716 mm) or less where Vult does not exceed 180 mph (80 m/s) Vasd, determined in accordance with Section 1609.3.1 does not exceed 140 mph (63 m/s).~~

2. Glazing in Risk Category I buildings as defined in Section 1604.5, including greenhouses that are occupied for growing plants on a production or research basis, without public access shall be permitted to be unprotected.

3. Glazing in Risk Category II, III or IV buildings located over 60 feet (18 288 mm) above the ground and over 30 feet (9144 mm) above aggregate surface roofs located within 1,500 feet (458 m) of the building shall be permitted to be unprotected.

4. Exterior balconies or porches under existing roofs or decks enclosed with screen or removable vinyl and acrylic panels complying with Section 2002.3.3 shall not be required to be protected and openings in the wall separating the unit from the balcony or porch shall not be required to be protected unless required by other provisions of this code.

TABLE 1609.1.2
WIND-BORNE DEBRIS PROTECTION FASTENING SCHEDULE FOR WOOD STRUCTURAL PANELS[a, b, c, d]

FASTENER TYPE	FASTENER SPACING (inches)		
	Panel Span ≤ 4 feet	4 feet < Panel Span ≤ 6 feet	6 feet < Panel Span ≤ 8 feet
No. 8 wood-screw-based anchor with 2-inch embedment length	16	10	8
No. 10 wood-screw-based anchor with 2-inch embedment length	16	12	9
$^1/_4$-inch diameter lag-screw-based anchor with 2-inch embedment length	16	16	16

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound = 4.448 N, 1 mile per hour = 0.447 m/s.

a. This table is based on a V_{asd}, determined in accordance with Section 1609.3.1 of 140 mph and a 45-foot mean roof height.

b. Fasteners shall be installed at opposing ends of the wood structural panel. Fasteners shall be located a minimum of 1 inch from the edge of the panel.

c. Anchors shall penetrate through the exterior wall covering with an embedment length of 2 inches minimum into the building frame. Fasteners shall be located a minimum of $2^1/_2$ inches from the edge of concrete block or concrete.

d. Where panels are attached to masonry or masonry/stucco, they shall be attached using vibration-resistant anchors having a minimum ultimate withdrawal capacity of 1,500 pounds.

1609.1.2.1 Louvers. Louvers protecting intake and exhaust ventilation ducts not assumed to be open that are located within 30 feet (9144 mm) of grade shall meet requirements of ANSI/AMCA 540 or shall be protected by an impact resistant cover complying with the large missile test of ASTM E 1996 or an approved impact-resistance standard. Louvers required to be open for life safety purposes such as providing a breathable atmosphere shall meet the requirements of AMCA 540.

1609.1.2.2. Application of ASTM E 1996. The text of Section 6.2.2 of ASTM E 1996 shall be substituted as follows:

6.2.2 Unless otherwise specified, select the wind zone based on the strength design wind speed, *Vult*, as follows:

6.2.2.1 *Wind Zone 1*—130 mph ≤ ultimate design wind speed, *Vult* < 140 mph.

6.2.2.2 *Wind Zone 2*—140 mph ≤ ultimate design wind speed, *Vult* < 150 mph at greater than one mile (1.6 km) from the coastline. The coastline shall be measured from the mean high water mark.

6.2.2.3 *Wind Zone 3*—150 mph (58 m/s) ≤ultimate design wind speed, *Vult* ≤ ~~160~~ 170 mph (63 m/s), or 140 mph (54 m/s) ≤ ultimate design wind speed, *Vult* ≤ ~~160~~ 170 mph (63 m/s) and within one mile(1.6 km) of the coastline. The coastline shall be measured from the mean high water mark.

6.2.2.4 *Wind Zone 4*— ultimate design wind speed, *Vult* > ~~160~~ 170 mph (63 m/s)

~~R~~1609.1.2.2.1 Modifications to ASTM E 1886 and ASTM E 1996.

Table 1 of ASTM E 1886 and ASTM E 1996 – revise the third column to read as follows:

Air Pressure Cycles
0.2 to 0.5 P_{pos}[1]
0.0 to 0.6 P_{pos}
0.5 to 0.8 P_{pos}
0.3 to 1.0 P_{pos}
0.3 to 1.0 P_{neg}[2]
0.5 to 0.8 P_{neg}
0.0 to 0.6 P_{neg}
0.2 to 0.5 P_{neg}

Notes:

1. P_{pos}= 0.6 x positive ultimate design load in accordance with ASCE 7.
2. P_{neg} = 0.6 x negative ultimate design load in accordance with ASCE 7.

1609.1.2.4 Impact resistant coverings.

1609.1.2.4.1 ~~Impact resistant coverings shall be tested at 1.5 times the design pressure (positive or negative) expressed in pounds per square feet as determined by the Florida Building Code, Building Section 1609 or ASCE 7, for which the specimen is to be tested. The design pressures, as determined from ASCE 7, are permitted to be multiplied by 0.6.~~

Impact resistant coverings shall be tested for resistance to uniform static air pressure using ASTM E330

or TAS 202 and resistance to uniform cyclic air pressure using ASTM E1996, TAS 202 or TAS 203 at the pressures defined in Table 1609.1.4.X. These pressures are defined for Vult = 181 mph (80.9 m/s) or equivalently Vasd = 140 mph (62.6 m/s). For Vult larger than 181 mph, the pressures in the table shall be multiplied by the squared ratio of the wind speeds:

$$p_{Vult} = p_{181\,mph}\left(\frac{V_{ult}}{181}\right)^2 \qquad \textbf{(Equation 16-X)}$$

The loads shown in the table are based on an Effective Wind Area of 10 square feet (0.93 square meters). For larger Effective Wind Areas, the values in Table 1609.1.X may be adjusted to consider the area-dependent external pressure coefficients shown in Figure 30.4-1 in ASCE 7. Topographic effects may also be considered following the guidelines set forth in ASCE 7.

Table 1609.1.4.X. WIND LOAD REQUIREMENTS FOR IMPACT RESISTANT COVERINGS (Vult = 181 mph)

Height	Ultimate Neg. Pressure[A]			Ultimate Pos. Pressure[A]			ASD Neg. Pressure[B]			ASD Pos. Pressure[B]			Height
(ft)	B	C	D	B	C	D	B	C	D	B	C	D	(ft)
15	-65	-95	-116	+48	+71	+86	-39	-57	-69	+29	+43	+52	15
20	-70	-101	-122	+52	+76	+91	-42	-61	-73	+31	+45	+54	20
25	-75	-106	-126	+56	+79	+94	-45	-64	-76	+33	+47	+57	25
30	-79	-110	-131	+59	+82	+97	-47	-66	-78	+35	+49	+58	30
40	-85	-117	-137	+64	+88	+102	-51	-70	-82	+38	+52	+61	40
45	-88	-120	-140	+66	+90	+105	-53	-72	-84	+40	+54	+63	45
50	-91	-123	-143	+68	+92	+107	-55	-74	-85	+41	+55	+64	50
60	-96	-128	-147	+72	+95	+110	-57	-76	-88	+43	+57	+66	60
70	-100	-132	-151	+75	+98	+113	-60	-79	-91	+45	+59	+68	70
80	-104	-136	-155	+78	+101	+116	-62	-81	-93	+47	+61	+69	80
90	-108	-139	-158	+80	+104	+118	-64	-83	-95	+48	+62	+71	90
100	-111	-142	-161	+83	+106	+120	-66	-85	-96	+50	+64	+72	100
120	-117	-148	-166	+87	+110	+124	-70	-88	-99	+52	+66	+74	120
140	-122	-153	-171	+91	+114	+127	-73	-91	-102	+55	+68	+76	140
160	-127	-157	-175	+95	+117	+130	-76	-94	-105	+57	+70	+78	160
180	-131	-161	-178	+98	+120	+133	-79	-96	-107	+59	+72	+80	180
200	-135	-164	-182	+101	+123	+136	-81	-98	-109	+61	+74	+81	200
250	-144	-172	-189	+108	+129	+141	-86	-103	-113	+64	+77	+84	250
300	-152	-179	-195	+113	+134	+145	-91	-107	-117	+68	+80	+87	300
350	-159	-185	-200	+119	+138	+149	-95	-111	-120	+71	+83	+89	350
400	-165	-190	-205	+123	+142	+153	-99	-114	-123	+74	+85	+92	400
450	-171	-195	-209	+127	+146	+156	-102	-117	-125	+76	+87	+93	450
500	-176	-199	-213	+131	+149	+159	-105	-119	-127	+79	+89	+95	500

[A]Proof load in ASTM E330, Test load in TAS 202-94
[B]Test load in ASTM E330, Design Pressure in TAS 202-94, P_{pos} and P_{neg} in ASTM E1996 and Design Wind Load in TAS 203-94

1609.1.2.4.2 Impact resistant coverings. Impact resistant coverings shall be labeled in accordance with the provisions of Section 1710.8.

1609.1.3 Optional exterior door component testing. Exterior side-hinged door assemblies shall have the option to have the components of the assembly tested and rated for impact resistance in accordance with the following specification: SDI 250.13.

1609.1.4 The wind-borne debris regions requirements shall not apply landward of the designated contour line in Figure 1609A or 1609B. A geographical boundary that coincides with the contour line shall be established.

1609.1.5 Testing to allowable or nominal loads. Where testing for wind load resistance is based on allowable or nominal wind loads, the design wind loads determined in accordance with ASCE 7 or Section 1609 are permitted to be multiplied by 0.6 for the purposes of the wind load resistance testing.

1609.2 Definitions. The following words and terms shall, for the purposes of Section 1609, have the meanings shown herein.

HURRICANE-PRONE REGIONS. Areas vulnerable to hurricanes defined as:

1. The U. S. Atlantic Ocean and Gulf of Mexico coasts where the basic wind speed for Risk Category II buildings is greater than 115 mph (40 m/s) and
2. Hawaii, Puerto Rico, Guam, Virgin Islands and American Samoa.

WIND-BORNE DEBRIS REGION. Areas within hurricane-prone regions located:

1. Within 1 mile (1.61 km) of the coastal mean high water line where the ultimate design wind speed Vult is 130 (48 m/s) or greater; or
2. In areas where the ultimate design wind speed Vult is 140 mph (53 m/s) or greater.

For Risk Category II buildings and structures and Risk Category III buildings and structures, except health care facilities, the windborne debris region shall be based on Figure 1609A. For Risk Category IV buildings and structures and Risk Category III health care facilities, the windborne debris region shall be based on Figure 1609B.

WIND SPEED, V_{ult}. Ultimate design wind speeds.

WIND SPEED, V_{asd}. Nominal design wind speeds.

1609.3 Basic wind speed. The ultimate design wind speed Vult, in miles per hour, for the development of the wind loads shall be determined by Figures 1609A, 1609B and 1609C. The ultimate design wind speed Vult for use in the design of Risk Category II buildings and structures shall be obtained from Figure 1609A. The ultimate design wind speed Vult for use in the design of Risk Category III and IV buildings and structures shall be obtained from Figure 1609B. The ultimate design wind speed Vult for use in the design of Risk Category I buildings and structures shall be obtained from Figure 1609C. The exact location of wind speed lines shall be established by local ordinance using recognized physical landmarks such as major roads, canals, rivers and lake shores wherever possible.

1609.3.1 Wind speed conversion. When required, ultimate design wind speeds of Figure 1609A, B and C shall be converted to nominal design wind speeds, Vasd, using Table 1609.3.1 or Equation 16-32.

$$V_{asd} = V_{ult}\sqrt{0.6} \qquad \textbf{(Equation 16-32)}$$

where:

V_{asd} = nominal design wind speed
V_{ult} = strength design wind speeds determined from Figures 1609A, 1609B, or 1609C.

Appendix C. Experimental Configuration for Phase 2 Research

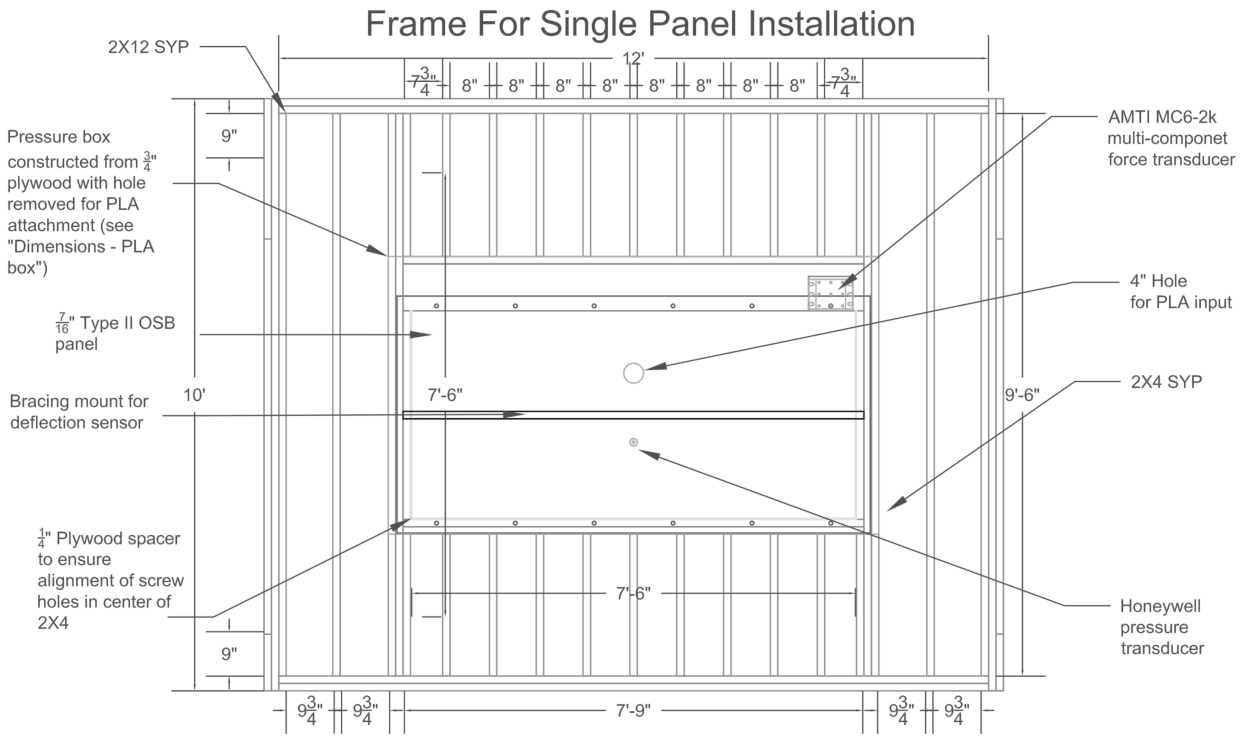

Figure 1. Wall assembly to test single panel installations onto light frame wood construction and same with brick veneer (mounting assembly not shown)

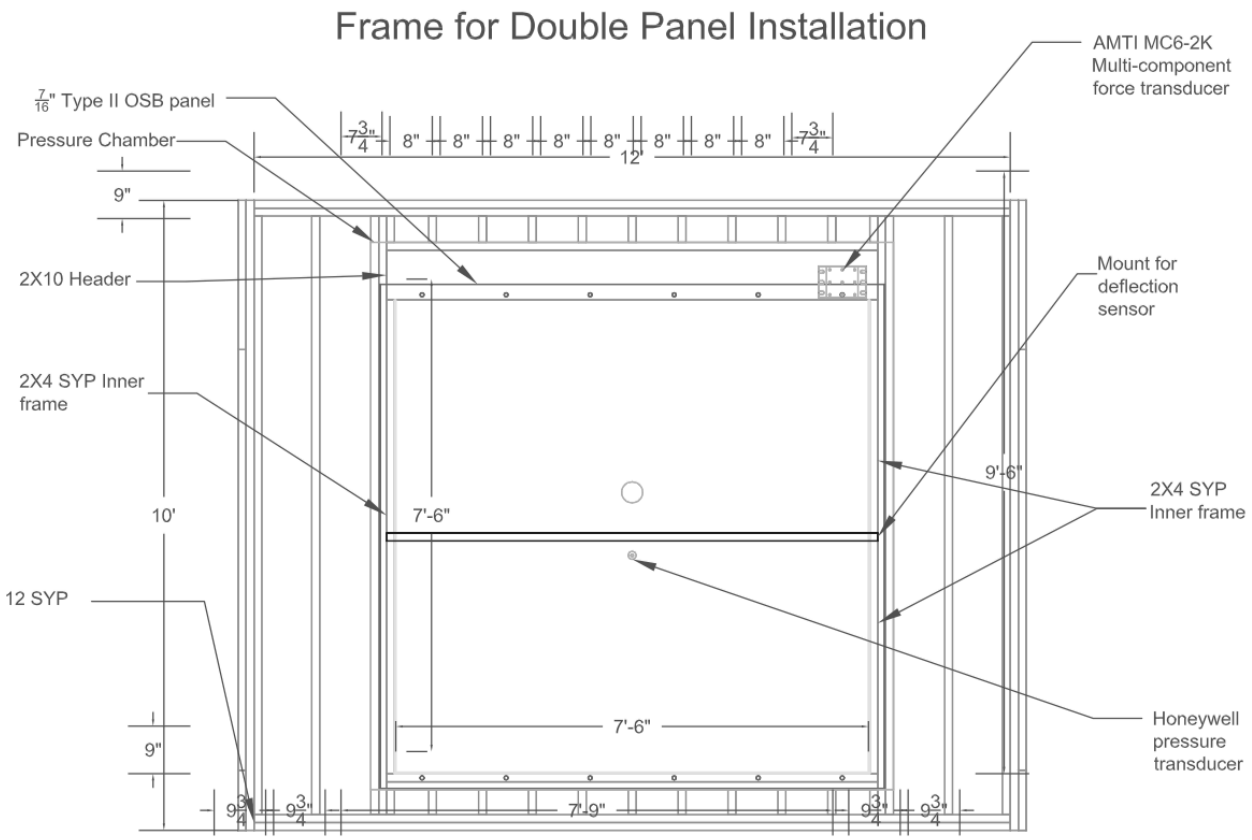

Figure 2. Wall assembly to test double panel installations onto light frame wood construction and same with brick veneer (mounting assembly not shown)