CONFIDENTIAL

LABORATORY TEST REPORT:

# CYCLIC TESTING OF PLYLOX™ CLIPS FOR INSTALLATION AND FASTENING OF WOOD STRUCTURAL PANEL WINDOW AND DOOR OPENING PROTECTION IN HURRICANE REGIONS

Report No.: P03-243-061803

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Prepared for

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## INTRODUCTION

Plylox™ clips provide an alternative method to secure wood structural panels to recessed window and door openings for protection against wind borne debris as optionally required in the building codes noted in Table 1. The applicable wind borne debris protection fastening schedule for wood structural panels is also noted in Table 1.

**TABLE 1**
**APPLICABLE BUILDING CODES**

| BUILDING CODE | FASTENING PROVISION |
|---|---|
| 1999Standard Building Code (SBC) | Appendix J (Table J103) |
| 2001 Florida Building Code (FBC) | Section 1606.1.4 (Table (1606.1.4) |
| SBCCI SSTD 10-99 standard | Section 604 (Table 604) |
| 2000 International Residential Code (IRC) | Section R301.2.1.2 (Table R301.2.1.2) |
| 2000 International Building Code (IBC) | Section 1609.1.4 (Table 1609.1.4) |

Furthermore, provision is made to accept alternative wood structural panel fastening methods, such as Plylox™ clips, as follows:

> "... other attachments designed to resist the component and cladding loads in accordance with the provisions of 1606.2.5" (SBC, Section J103, p461)
>
> "Attachments shall be designed to resist components and cladding loads determined in accordance with Table 1606.2B" (FBC, Section 1606.1.4, p16.5)
>
> "... other attachments designed to resist the component and cladding loads in accordance with Table 602A1, 602A2, or 602A3" (SSTD 10-99, Section 604, p158)
>
> "Attachments ... shall be designed to resist the components and cladding loads determined in accordance with the provisions of the International Building Code." (IRC, Section R301.2.1.2, p38).
>
> "Attachments shall be designed to resist the components and cladding loads determined in accordance with the provisions of Section 1609.6.5." (IBC, Section 1609.1.4, p309).

Initial testing of pressure load and large missile impact has been documented in NAHB Research Center Report P03-243-022503. This previous testing established use criteria in order to meet the various static design wind pressure loads identified in the building codes. The previous testing also demonstrated the ability of the Plylox clips to remain in place after large missile impacts. The purpose of this present test was to investigate the performance of the clips under cyclic wind pressure loading.

The application of results from this test program in combination with the previous report is intended to:

1. Provide adequate performance data for building code evaluation (i.e., code evaluation report).

2. Provide data for refinement of manufacturer installation instructions commensurate with required performance (e.g., table showing clip spacing vs. wind speed zone and opening span).

3. Identify appropriate limitations to and guidance for successful end-use.

All of the tests reported herein were conducted by the NAHB Research Center, Inc., at their laboratory facility in Upper Marlboro, MD. The test program was completed during the week of June 2, 2003.

## PRODUCT DESCRIPTION

***General*** - Plylox™ clips are designed for simple installation and attachment of wood-structural panels to recessed window and door openings made of wood, stucco, or brick materials. They provide a simple method of "boarding-up" for protection of windows and doors against wind-borne debris in hurricanes. A picture of the type of clip tested in this program is shown in Figure 1 along with the dimensions measured as received. The clip is designed to work with wood structural panels (i.e., oriented strand board or plywood) with thicknesses ranging from 7/16 inch to 3/4 inch. Another type of Plylox™ clip is also available for attachment of wood structural panels to aluminum frame windows, but it is not addressed in the scope of this report.

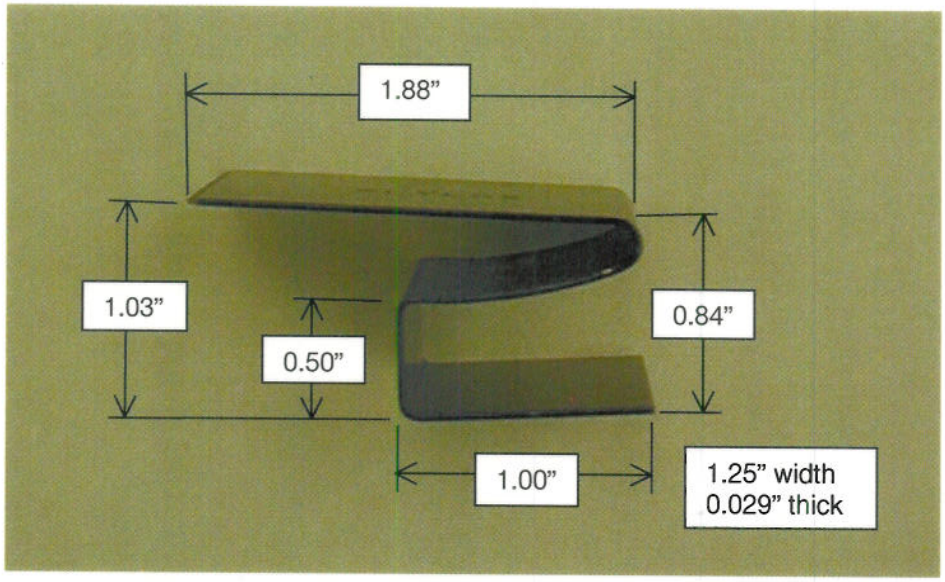


**Figure 1. Photograph of a Plylox™ clip with dimensions as recieved.**

The shape of Plylox™ clip is designed to provide a leveraging action that increases the holding force of the clip as suction pressure on the panel increases. The clip is installed with a modest force fit into a recessed window or door opening to create an initial gripping action of the toothed leg of the clip. The initial gripping action is established by a spring force created by the toothed leg of the clip when a properly sized panel with clips is inserted into the opening (see Installation Procedure below). This establishes an initial embedment of the clip's teeth into the recessed opening's surface material (i.e.,

wood, stucco, or brick). As suction force is applied to the panel, the compression force on the toothed leg of the clip increases proportionately and further embeds the teeth into the recessed opening substrate. Inward acting forces (positive pressure and wind debris impact) are resisted by the panel bearing on the perimeter frame of the window or door.

***Installation Procedure*** - Detailed installation instructions are found in the manufacturer's literature. The installation process involves a simple process of cutting a wood structural panel to fit within a recessed window or door opening made of brick, stucco, or wood. The panel dimensions are cut approximately 1/4" less than the rough opening. Once the panel is cut to proper dimension, the correct number of clips are applied to the panel's vertical edge at the prescribed spacing. (A proposed table for this purpose is included in the previous report. The clip spacing is determined according to design wind speed zone and by panel span (i.e., window or door width). Once prepared with the clips in place, the panel is inserted into the recessed window or door opening. Removal requires modest prying of the toothed leg of the clips on one side of the panel to release it from the window or door recess.

***Materials*** - The Plylox™ clip is cold-formed from strapping (banding) steel by Signode to the shape shown in Figure 1. The specifications of the Signode steel material (as provided by Plylox™) are as follows:

| | |
|---|---|
| PRODUCT DESCRIPTION | Part No. 1419 MAG<br>Product No. 2X1668<br>Finish PW |
| WIDTH (in.) | 1.255 maximum<br>1.250 nominal<br>1.245 minimum |
| THICKNESS (in.) | 0.031 maximum<br>0.029 nominal<br>0.028 minimum |
| BREAK STRENGTH (lbs) | 4900 minimum<br>5400 typical<br>6390 maximum |
| ELONGATION (%) | 6.5 minimum<br>7 typical |
| DUCTILITY (Bends) | 2 minimum |

The thickness of sampled clip specimens used in this test program were measured and found to have an average thickness of 0.0304 inches with a coefficient of variation (COV) of 2 percent and a minimum thickness of 0.0294 inches for a sample size of six. Tensile tests were not conducted due to the inability to make suitable coupons from the clips.

## EVALUATION APPROACH

### MATERIAL SAMPLING

Plylox™ clips used in the testing program were randomly selected from the manufacturer's warehouse (Friendswood, TX) by a NAHB Research Center, Inc., quality assurance field representative. Clips were sampled from three different lots (manufacturing dates).

### TEST PLAN

The test plan focused on the negative pressure cycles as specified in ASTM E1886-02. Only the negative pressure cycles were run since the test was only to determine the ability of the clips to remain in place under the cyclic pressure loading. Since the installation technique causes the panel to find a fixed stop on the window frame, it is not possible for the clips to come loose due to positive pressure. By design, the clips offer no significant resistance to positive pressure allowing the panel to seat against the underlying window frame structure. Also by design, the clips grip engages with the application of negative pressure. The panel was a standard OSB material that is explicitly approved in the code for wind borne debris protection. This testing utilized the same clips that where utilized in the large missile impact testing previously reported.

The test was conducted on a nominal 4' x 4' panel with two Plylox clips on each vertical edge (24" OC spacing). The design load was determined in the previous test report to be 97.4 lbs per clip when two clips were used on each edge. For a 4-clip attachment, this provides a total design load capacity of 390 lbs applied as a uniform pressure load on the specimen. Thus, the application of this test is used to confirm the design value for the clip under cyclic pressure for confirmation of clip installation guidelines (i.e., spacing vs. wind speed and opening size) determined in NAHB Research Center Report P03-243-022503 based on static pressure testing.

The test protocol specified in Section 11.4.2 of ASTM E1886-02 and Section 5.4 of ASTM E1996-02 calls for the following negative load cycling based on the clip's design value:

0.3P - 1.0P = 117 lbs - 390 lbs (50 cycles)
0.5P - 0.8P = 195 lbs - 312 lbs (1,050 cycles)
0.0P - 0.6P = 0 lbs - 234 lbs (50 cycles)
0.2P - 0.5P = 78 lbs - 195 lbs (3,350 cycles)

Attachment to standard brick was chosen as worst case for the test. The previous pressure tests had demonstrated that the clips were most likely to fail by slipping on the brick surface compared to wood or stucco.

The test configuration is shown in Figures 2 and 3. Figure 4 is a close up of a typical clip/brick attachment. The brick was mounted to a wooden frame braced in a vertical position. The panel was installed in the frame with the clips bearing on the bricks. An air

bag (4' x 4' x approximately 6") was installed behind (on the interior side) of the debris panel. A second stiffened panel (load panel) was installed behind the air bag sandwiching the bag between the panels. The load panel was connected to a hydraulic cylinder. A load cell was installed on the cylinder to measure the force exerted on the air bag by the load panel. The hydraulic cylinder was operated by a servo controlled valve and computer controller programmed to use the load cell output to generate the cycles and pressure swings noted above. The average cycle time was approximately two seconds.

**Figure 2. Test Frame with panel mounted to brick with Plylox™ clips.**

**Figure 3. Hydraulic cylinder & load panel used to apply cyclic load to an air bag placed between the loading apparatus and the test specimen.**

**Figure 4. Clip attachment detail (Mark (not visible in the photo) on the Tyvek tape was used to monitor location of the clip).**

## Test Results

The panel attached by the Plylox clips stayed in place throughout the entire pressure cycle regime. No significant movement of any of the clips was observed during the cyclic tests. After completion of all the cycles, the panel was loaded to failure which occurred at 790 lbs. The failure mode was clip slippage. Thus, the failure load per clip was 197.5 lbs which demonstrates a safety factor of slightly greater than 2 (after cyclic testing) relative to the design value of 97 lbs/clip determined from numerous static pressure tests and use of a safety factor of 1.5 in accordance with standard practice as reported in NAHB Research Center Report P03-243-022503.

## CONCLUSIONS

Plylox clips, as tested in NAHB Research Center Reports P03-243022503 and P03-243-061603, when installed according to the spacings provided in Table 5 of report # P03-243022503, meet or exceed the requirements for attachment of wood structural panels for window and door protection against wind-borne debris as required in 1999 Standard Building Code (SBC), the 2001 Florida Building Code (FBC), the SBCCI SSTD 10-99 Standard, the 2000 International Residential Code (IRC) and the 2000 International Building Code (IBC) for hurricane-prone regions.

## REFERENCES

[1] ASTM E1886-02 *Standard Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Storm Shutters Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials*, American Society of Testing and Materials, West Conshohocken, PA. 2002.

[2] ASTM E1996-02 Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors, and Storm Shutters Impacted by Windborne Debris in Hurricanes, American Society of Testing and Materials, West Conshohocken, PA. 2002.

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## NOTICE

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