HURRICANE LOSS REDUCTION
FOR HOUSING IN FLORIDA

A Research project of the
International Hurricane Research Center
At Florida International University
Funded by the Florida department of Community Affairs
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FINAL REPORT

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PREPARED BY
THE INTERNATIONAL HURRICANE RESEARCH CENTER
FLORIDA INTERNATIONAL UNIVERSITY
Miami, FL 33199

Volume 3
Chapter 3

Research and Development on Hurricane Loss Reduction Devices and Techniques for Site-built Housing

Scope of Work:

Work under this topic will focus on three areas as follows:

3.1 <u>Continuation of Structural Testing on at Five of the Areas Listed Below:</u>

(a) Role of various fasteners and fastening schedules in the performance of connection of roof sheathing panels to their supporting structure under hurricane wind conditions;

(b) Performance of roof to wall connections.

(c) Performance of various roof covering materials, and expand previous test by introducing new damage components. For example the outdoor testing of roofing assemblies using airboats to generate the appropriate wind loads will be modified by adding a source of water spray in order to study the contribution of wind driven water [rain] to potential damage to the roof.

This test will help in assessing the performance of various materials in reducing or preventing roof leaks and water penetration, providing credible data in the capability of specific combination of building components in hurricane loss reduction;

(d) Improve the roof covering tests by adding a scanning pressure system to measure the pressure distribution over roofing components. This research will complement work done to determine the wind flow over specific roof shape. Results will help in devising methods to better assess the performance of various roof coverings and assemblies. Assess the influence of various housing components such as dormers, parapets etc. over adjacent areas of the roof, and their contribution to potential damage under hurricane conditions. This work may also include assessing the role of roof overhang on gable ends in the sequence of damage leading to potential breaching of the envelope.

(e) Instrument flat roof housing units to gather empirical data on stress induced by hurricane conditions. This work will use a prototype instrument developed at FIU for specific use on a flat roof. The objective of this work is to calibrate via empirical methods that data collected from model tests. This may eventually lead to recommendations for improved building design or construction methods.

(f) Development of prototype loss-reduction devices for roof covering.

3.2 Evaluation of Effectiveness of Hurricane Loss Reduction Program

IHRC will evaluate the effectiveness of the various components of the hurricane loss reduction program in meeting the specific objectives of the same. This evaluation will be carried out by way of qualitative surveys of the various parties engaged through the Hurricane Loss Reduction Project and remote surveys of the target audiences for each of these parties. One additional objective of this work would be the creation of a repository of knowledge that could contribute a foundation for future work.

The main objective of this evaluation will be to provide the Department, as well as the legislature through the instrument of the annual report, with an objective picture of how effective the program has been in promoting hurricane loss reduction and in creating a public culture that accepts and/or promotes various hurricane loss reduction devices and techniques.

This evaluation will also help the state in identifying specific areas where educational/training and/or outreach efforts may be needed to improve the effectiveness of the program, by assessing how much users of or contributors in various components benefit from the program or know about it.

3.3 Research Feasibility of Programs to Create Incentives for or Improve Performance of Hurricane Loss Reduction Techniques for Site-built Housing

The IHRC will assess the feasibility of developing initiatives involving financial institutions and insurers in combining various components for potential hurricane loss reduction into programs of incentives for developers or homeowners to adopt the same. These programs might work along the lines of those that have been developed my financial institutions and insurers to create incentives for the adoption of energy efficient building methods.

Specifically the IHRC proposes to research existing programs in other areas and assess their application to the issue of hurricane loss reduction.

Research Titles and Players:

3.1a Roof Sheathing Fastener Study

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3.1b **Roof to Wall Connections Subjected to Combined Loads**

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3.1c **Performance of Roof-Coverings**

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3.1d **Investigation of Influence of Architectural Features on Wind Loads**

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3.1e **<u>Field Measurements of Wind Loads on Flat Roofs</u>**

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3.1f **<u>Gable End Overhang</u>**

Department of Civil Engineering, Clemson University
Timothy Reinhold
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3.2a **<u>HLMP Evaluation Project: The Targeted Survey of Building Professionals</u>**

Department of Landscape Architecture and Urban Planning, Texas A&M University
Walter Gillis Peacock

Institute for Public opinion Research, Florida International University
Hugh Gladwin

3.2b **<u>HLMP Evaluation Project: The Hurricane Loss Mitigation Baseline Survey</u>**

Department of Landscape Architecture and Urban Planning, Texas A&M University
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Institute for Public opinion Research, Florida International University
Hugh Gladwin

3.3 **<u>Feasibility of Incentives Program to Improve Performance of Hurricane Loss Reduction Techniques for Site-built Housing</u>**

International Hurricane Research Center, Florida International University
Carolyn Anderson

3.1a ROOF SHEATHING FASTENER STUDY

Background

This area of research addresses Section 3.1 (a) of the Research Agenda submitted to DCA on July 12, 2002. This specific research track is about exploring the role of various fasteners and fastening schedules in the performance of the connection of roof sheathing panels to their supporting structure under hurricane wind conditions.

The IHRC team continued to build upon the foundation of work on this area during the 2001-2002 research year. This work has the objective of finding out if roof sheathing performance under hurricane winds could be improved by using fasteners and/or fastening schedules that are different than those prescribed by the current Florida Building Code for the High Velocity Hurricane Zone (HVHZ).

This research was carried out at the facilities of the Laboratory for Structural Mitigation (LSM), one of four research labs within the International Hurricane Research Center at FIU. IHRC Deputy Director Ricardo A. Alvarez was project director and Research Assistant Carolyn Anderson was project coordinator. Dr. Timothy Reinhold of Clemson University provided technical assistance, and Dr. Hugh Willoughby, Research Scientists at the IHRC, also assisted in the area of data analysis for this specific research track.

Based on the results obtained in the 2001-2002 research period[1] the IHRC Team decided to concentrate the 2002-2003 research effort on this area on assessing the improvement in roof sheathing performance when using 8d ring shank nails to substitute for the fastener and nailing schedule prescribed by the Florida Building Code in section 2322 High Velocity Hurricanes Zones Sheathing, Subsection 2322.2 Roof Sheathing.

Testing Protocol

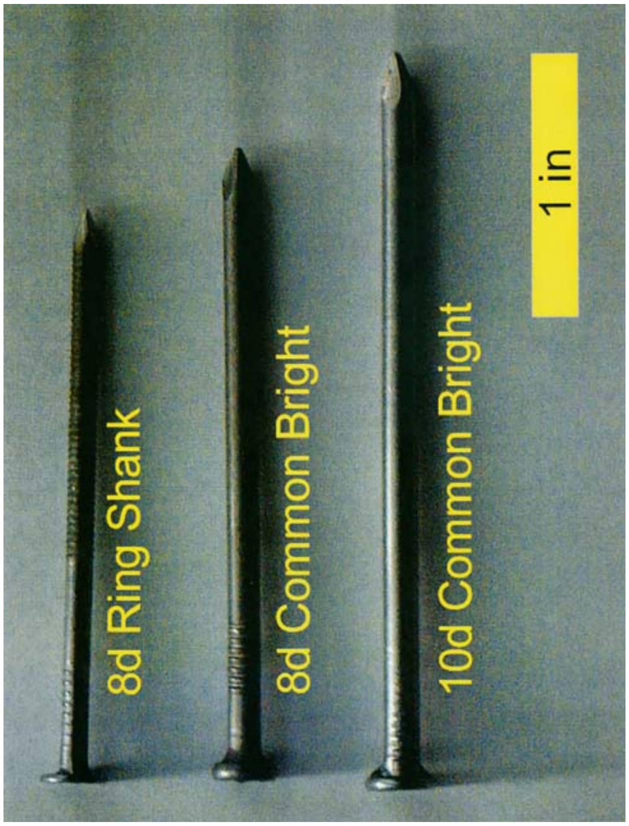
Test were conducted using the LSM’s vacuum chamber capable of testing full roof sheathing panels 4’ x 8’ in size. The vacuum chamber simulates the uplift pressure in pounds per square foot (psf) being applied to the roof panel by wind flowing over it. As a fluid wind increases its velocity as it flows around objects in its path. The trade off of such increase in wind velocity is a decrease in the wind pressure. Such reduction in wind pressure results in a negative (suction) load applied to the roof. This negative

[1] *Hurricane Loss Reduction for Housing in Florida* FINAL REPORT to the Florida Dept. of Community Affairs (DCA), Vol 3, pp 372-386 IHRC Research Report 2002, Alvarez, Ricardo A. et al

pressure is counteracted by the weight of the roof assembly and by the holding capacity of the fasteners connecting the sheathing to the roof structure. A precision guide was used to fabricate the test specimens in order to ensure consistent uniformity throughout the research period.

Test specimens consisted of nominal 5/8” thick CDX plywood fastened to structural members consisting of nominal 2”x4” lumber at 2’-0” on center. About 50% of the test panels had white wood and the other half used southern yellow pine (SYP) Nailing schedule was at 6” on center on the edges and on the field as prescribed by the 2001 Florida Building Code. Nails were hand driven. A total of ninety-one panels were tested. Thirty-five of the panels used the 2001 Florida Building Code 8d common bright nail at 6” on center. An additional thirty-six panels were built using 8d ring shank nails. Twenty-one other panels were built using 10d common bright nails at 6” on center on the field and at 4” on center at the edges to assess the performance and results of using a standard recommended by the “Blue Print for Safety” program sponsored by FLASH.

The result of these tests is that the IHRC Team actually compared the pullout capacity of three different nails: (a) 8d common bright, (b) 10d common bright, and (c) 8d ring shank nails. See Figure 1



Three types of nails were compared

FIGURE 1

Each panel test involved the following steps:

(1) Fabrication of the test specimen
(2) Inspection of specimen to detect overdriven nails.
(3) Marking cross members A through E from left to right.
(4) Mounting of test specimen on vacuum chamber
(5) Sealing specimen on chamber using 6 mil vinyl sheets and adhesive tape to ensure air-tightness of assembly.
(6) Measuring of moisture content in each cross member (2”x4”) using a digital electronic moisture meter. Moisture content was then recorded on a work sheet and also marked on the cross member itself.
(7) Activation of the vacuum pump until failure of specimen resulting in the vacuum seal being broken.
(8) Reading the pressure (psf) recorded at the time of failure. This information was then recorded in the work sheet.
(9) Identifying the type of failure for each fastener i.e. partial pullout, total pullout, head pull through etc. This information was then recorded on the worksheet.
(10) Saving some of the cross members from the failed specimen to use in nail pull-out test using a mechanical device.

Data Analysis

After completion of a full test series for a specific type of test specimen the data were analyzed using statistical functions to determine mean values and standard deviations for the pressures in pounds per square foot (psf) at the time of failure of each specimen. Subsequently to these data analysis results were expressed in graphic form by using bar charts.

Summary of Findings

The most important finding was the change in uplift capacity for the 5/8” plywood sheathing when using each of the three types of nails identified above (see Figure 1).

This research shows a significant improvement in the uplift capacity of the 5/8” plywood roof sheathing when using the 8d ring shank nail over panels using either the 8d common bright or the 10d common bright. These variations in uplift capacity were consistently higher for the 8d ring shank nail than for both the 10d common bright and the 8d common bright regardless of the type of wood used for the structural members and regardless of the moisture content in the wood. It is interesting to note however that important variations in performance were observed depending on the time elapsed from the time fabrication of the tests specimen was completed until the time of the actual test on the vacuum chamber. In cases where such elapsed time was longer than for other test specimens, the performance of roof panels using the 8d ring shank nail was much higher that that for panels with the 8d common bright. Intuitively this is an important finding for it shows panels with 8d ring shank nails improve in performance, as measured by their uplift capacity, as time goes on.

Another important finding is that no panel using the 8d common bright performed beyond 150 psf of wind pressure. In contrast, we had several instances of panels using the ring shank nail that surpassed 300 psf of wind pressure before failing.

For detailed data analysis please see Appendix B and Appendix C and at the end of this section. These appendixes respectively show a comparison of uplift capacities between the three types of nails, comparison of total pullout force required for each of the three types of nail when performing the mechanical nail pullout test, and a record of failed members and type of failure (complete vs partial). Appendix D, also included herein, is a copy of a research paper on the issue of “Improving Roof Performance under Hurricane Winds” [2] by Timothy A. Reinhold (Clemson University), Jose D. Mitrani (FIU), Ricardo A. Alvarez (IHRC-FIU) and Edward G. Sutt Jr. (Stanley Fastening Systems) distributed at the 2003 Governors Hurricane Conference.

Significance of Findings

The IHRC team considered these findings as truly significant for it could be argued that roof sheathing construction, hence roof performance, could be significantly improved in the HVHZ if usage of the 8d ring shank nail could become the standard prescribed by the Florida Building Code. This is especially significant when one considers the fact that the currently prescribed 8d common bright will only perform up to wind speeds consistent with a mid-range category 3 hurricane and not for all categories of exposure or for all heights of roofs, but roof sheathing built with the 8d ring shank nail appears capable of performing up to a high category 4 hurricane for all exposure categories and for roof heights accommodating most residential construction criteria.

In view of the importance of these findings the IHRC Team had a few questions that needed to be answered:

[2] *Design Guidelines for roof Sheathing Fastener Schedules in High Wind Areas*, June 2003, Reinhold, T.A., Mitrani, J.D., Alvarez, R.A., Sutt Jr., E.G. – 2003 Governors Hurricane Conference - Workshop on *Florida Universities – Partners in Hurricane Preparedness*

(1) Why isn't the 8d ring shank nail the standard for building roofs in the HVHZ in Florida?
(2) Is it because of cost?
(3) Is it because of technical issues involving the method of construction?
(4) Is it because the building industry does not consider the ring shank to be as effective as the 8d common bright or because roofers oppose it?
(5) Why hasn't the 8d ring shank nail been proposed as the standard in the Florida Building Code for the HVHZ?

The IHRC Team then set out to answer these questions. Following are the answers.

Cost and Effectiveness Study

On the issue of cost the IHRC team found that the vast majority of builders, by far, use power tools to drive nails for roof sheathing. Also that there are several makes and models of nail guns that have the capacity to accommodate various types and sizes of nails including both the 8d common bright and the 8d ring shank nails, consequently there is no need to use different nail guns than those currently in use by most builders.

Given the above the IHRC Team concluded that the main difference in cost between using the 8d common bright currently prescribed by the Florida Building Code and the superior 8d ring shank nail, would be the actual cost of materials. Meaning the cost of the nail itself.

The IHRC team researched the issue of the cost of the nails surveying various manufacturers and suppliers who supply in bulk to roofers and builders and found that the increase in cost on the average for South Florida would amount to only $0.35 per roofing square (100 square foot of roof). This means that for a house with 2,500 square feet of roof the total cost increase resulting from the use of the 8d ring shank nail would amount to $8.75.

Another finding by the IHRC Team on this issue of cost showed the following: (a)The Florida Building Code currently prescribes two sizes of common bright nails for roof sheathing in the HVHZ. The 8d (2-1/2") for use anywhere on the roof except the edges, and the 10d (3") for the roof edges. (b) this means that at some point in the construction of the roof sheathing a separate nail gun most be used or the one in use most be unloaded of the 8d nails and reloaded with 10d nails to do the edges of the roof. (c) The 8d ring shank nail clearly outperforms both the 8d and the 10d common brights, consequently only one size of a nail would be needed if when using the 8d ring shank nail. This means there will be no need to stop and reload or to use a different nail gun loaded with the longer nail. (d) More importantly, the 8d ring shank nail has a smaller diameter than the prescribed 8d common bright meaning more nails can be loaded into the nail gun. This means there is a slight, but important when considering volume of work, improvement in the efficiency of labor for more nailing can be done before stopping to reload the power tool. Given the cost of labor this increase in efficiency would result in a cost-reduction, because of increased productivity, for using the 8d ring shank nail. The IHRC Team submits that such cost-reduction for labor would be far more than the cost-increase for materials.

Proposed Modification to the Florida Building Code

Above finding have moved the IHRC Team to action. In April 2003 the IHRC submitted a proposal to modify the Florida Building Code by making the 8d ring shank nail the prescribed and only nail to be used for roof sheathing in the HVHZ in Florida. Sections to be modified include 2322.2, 2322.2.4, 2322.2.5, 2322.2.5.1 and 2322.2.5.2. Please see Appendix A at the end of this section.

Such proposal was assigned to the Technical Review Committee of the State Building Code Commission for review. The Technical Review Committee adopted a resolution recommending adoption of this proposed modification on June 17, 2003. This recommendation will be considered by the State Building Code Commission at its August 2003 meeting. The next step in the process after the august 2003 review would be for the State Legislature to adopt the approved modifications into the Law becoming effective with the 2004 Florida Building Code on July 1, 2004.

It is important to highlight that the IHRC consulted with the building industry through the Florida Home Builders Association (FHBA) and also with the Institute for Building and Home Safety (IBHS), to obtain their comments and opinions regarding the proposed building code modification. Both these organizations fully support the proposed modification. A representative of FHBA offered the following statement “how often do you get to improve your product while keeping the cost the same?”

The IHRC considers these actions as an excellent example of how the RCMP – Hurricane Loss Mitigation Program managed by DCA and funded by CAT Fund monies, is contributing to hurricane loss reduction through practical and cost-effective applications resulting from applied research.

APPENDIX A

PROPOSED MODIFICATION
TO THE FLORIDA BUILDING CODE
SECTION 2322.2 ROOF SHEATHING
SUBSECTIONS 2322.2.4, 2322.2.5,(2322.2.5.1, 2322.2.5.2)

SUBMITTED BY
The International Hurricane Research Center
Florida International University
April 2003

Proposed Modification to the Florida Building Code

Modification #: 856 **<u>Section 553.73, Fla Stat</u>**

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Code: Florida Building Code
Section #: 2322.2.4, 2322.2.5, 2322.2.5.1, 2322.2.5.2

Text of Modification [additions underlined; deletions ~~stricken~~]:

2322.4 Plywood panels shall be nailed to supports with 8d ring shank nails.

2322.2.5 Nail spacing shall be 6 inches (152 mm) on center at panel edges and at intermediate supports. Nail spacing shall be 4 inches (102 mm) on center at gable ends with either 8d ring shank nails or 10d common nails.

2322.2.5.1 Nails shall be hand driven 8d ring shank or power driven 8d ring shank nails of the following minimum dimensions: (a) 0.113 inch (2.9 mm) nominal shank diameter, (b) ring diameter of 0.012 inch (0.3 mm) over shank diameter, (c) 16 to 20 rings per inch, (d) 0.280 inch (7.1 mm) full round head diameter, (e) 2-3/8 inch (60.3 mm) nail length. Nails of a smaller diameter or length may be used only when approved by an Architect or Professional Engineer and only when the spacing is reduced accordingly.

2322.2.5.2 Nails at gable ends shall be hand driven 8d ring shank or power driven 8d ring shank nails of the following minimum dimensions: (a) 0.113 inch (2.9 mm) nominal shank diameter, (b) ring diameter of 0.012 inch (0.3 mm) over shank diameter, (c) 16 to 20 rings per inch, (d) 0.280 inch (7.1 mm) full round head diameter, (e) 2-3/8 inch (60.3 mm) nail length or as an alternative hand driven 10d common nails [(0.148 inch (3.8 mm) diameter by 3 inches (76 mm) long with 0.312 inch (7.9 mm) diameter full round head)] or power driven 10d nails of the same dimensions (0.148 inch diameter by 3 inches long with 0.312 inch diameter full round head). Nails of a smaller diameter or length may be used only when approved by an Architect or Professional Engineer and only when the spacing is reduced accordingly.

<u>Fiscal Impact Statement</u> [Provide documentation of the costs and benefits of the proposed modifications to the code for each of the following entities. Cost data should be accompanied by a list of assumptions and supporting documentation. Explain expected benefits.]:

A. Impact to local entity relative to enforcement of code:

Impact to local building code enforcement entity will be negligible. The reason for this is that while the type of nail is being changed the nailing schedule remains the same hence there will be no change to the roof inspection process. The entity would need to require samples of the nail or nails being used during the inspection process in order to verify that it or they meet the criteria prescribed by the code. Other than that there is nothing else that the local entity would need to do.

B. Impact to building and property owners relative to cost of compliance with code:

Negligible impact. There could be a very small cost increase in the materials [nails] used to fasten the roof sheathing to the roof structure. This minor increase in the cost of materials would be partially offset by an increase in labor productivity resulting from the smaller diameter of the 8d ring shank nails, when compared to the 8d common nails, which allows more nail to fit in the coil or magazine of the nailing gun, thus requiring fewer stops to reload the nailing gun. The contractor will probably pass any cost increase on to the building and property owners. Based on data from nail suppliers the cost increase may average $0.38 (38 cents) per roofing square (100 square feet of roof). Even if we ignore the improvement in labor productivity, this translates to a total of $7.60 for a house with a 2,000 square foot roof. Regarding the gable ends there could be an actual decrease in cost when the 8d ring shank nails are used instead of the 10d common nails. This reduction will result from the lower cost of the nails and also from the higher productivity in labor derived from the fact that there is no need to change nails when nailing the gable end sheathing.

C. Impact to industry relative to cost of compliance with code:

No adverse impact whatsoever. There is a positive impact due to higher productivity for power driven nailing. There is no additional labor for contractors using nailing guns since the nailing schedule remains the same. In fact there may be a slight reduction in cost as the 8d ring shank nail has a smaller diameter that the currently prescribed 8d common, and more nails can be loaded on the power tool reducing the number of times the roofer needs to stop to reload. There will be a very small increase in the cost of materials [nails].
An informal survey of various nail suppliers shows that 8d common nails can be purchased in coils for an average, in Miami-Dade County, of $25.51 for a box of 3,600 nails or a unit cost of $0.0071/nail. The 8d ring shank nails in coils, also in Miami-Dade County, can be purchased for an average of $55.97 for a box of 6,000 or a unit cost of $0.0093/nail.
A 4'x8' roof panel takes 45 nails under the prescribed nailing schedule. A roof square, 100 square feet, is equal to 3.125 panels and requires 140.6 nails to fasten it to the structure. Using the unit cost per nail given above the cost of nails to fasten one square of roof sheathing using 8d common nails is $0.99, and $1.30 when using 8d ring shank nails. The cost increase due to the cost of nails is 1.30 – 0.99 or 0.31. If we multiply this by a factor of 1.22 to account for taxes, overhead and profit we obtain 0.31 x 1.22 = 0.378 rounded up to $0.38 per square.

The total cost increase for a house with 2,000 square feet of roof (20 squares) is $0.38 x 20 = $7.60. This additional materials cost could be passed on to the homeowner. This minimal increase will be offset in cases when the 8d ring shank nails is also used at gable ends instead of changing to the 10d common nail.
The same equipment, nail gun, can be used for driving both types of nails therefore there is no additional equipment cost in most cases.

Rationale [Provide an explanation of why you would like this Proposed Modification to the Florida Building Code.]:

Implementing this proposed modification will significantly improve the performance of roofs under the impact of hurricane winds. Reducing the potential for damage to roofs is essential to preserving the integrity of the building envelope. Obtaining a significant improvement in performance and doing so at basically minimal to negligible cost increase, provides a rather generous benefit-cost ratio.
Building Code provisions, such as those adopted by the 2001 Florida Building Code, fall into two categories: (1) Performance criteria used to establish minimum design loads, and (2) Prescriptive requirement that, in the case of roof sheathing, establish minimum lumber and panel thickness and the type and spacing of fasteners.
Based on the wind load provisions of ASCE 7-98 the design wind speeds at 10 meter height in Florida range from 100 to 150 miles per hour. These wind speeds are used to calculate design wind loads on a per square foot basis for Exposure C (open exposed areas) and Exposure B (built-up areas). The design process allows for adjustments to be made in calculating design wind pressures for gable roof overhang.
Design uplift pressures for roof sheathing on building with roof slopes greater than 2 in 12 will range as indicated by the examples below:

EXAMPLE 1:

For Exposure B under the following conditions: (a) Roof height 15 feet to 40 feet, (b) Roof zones 2 an 3, (c) Gable end condition. Design wind pressure ranges from - 43.8 psf at 15 feet above ground under winds of 100 mph to -107 psf at 40 feet above ground and winds of 150 mph.

EXAMPLE 2:

For Exposure C under the following conditions: (a) Roof height 15 feet to 40 feet, (b) Roof zones 2 an 3, (c) Gable end condition. Design wind pressure ranges from – 53.2 psf at 15 feet above ground under winds of 100 mph to -146.4 psf at 40 feet above ground and winds of 150 mph.

Extensive roof sheathing fastening tests at Clemson University (Reinhold 2000 – 2002, McKinley 2001) and at the International Hurricane Center – Florida International University (Reinhold, Alvarez 2003) have compared the Mean Failure Pressure in psf for roof sheathing panels using both the 8d common and the 8d ring shank nails spaced at 6 inches as prescribed by the Florida Building Code. Sheathing consisted of 5/8 inch thick plywood attached to nominal 2x4 Southern Yellow Pine rafters.

The results of these tests were as follows:

1. **Mean ultimate uplift capacity for panels attached with 8d common nails at 6 inch spacing: 126 pounds per square foot**
2. **Mean ultimate uplift capacity for panels attached with 8d ring shank nails at 6 inch spacing: 292 pounds per square foot**

This shows a 131% improvement in performance when 8d ring shank nails are used instead of the currently prescribed 8d common nails.

Using data from these tests and a design procedure (Reinhold 2002) to calculate the allowable design uplift pressure for roof sheathing using both types on nails the following results are obtained:

1. **For 19/32 inch thick plywood sheathing using 8d common nails at 6 inch spacing: 58 psf**
2. **For 19/32 inch thick plywood sheathing using 8d ring shank nails at 6 inch spacing: 150 psf**

These results show that the currently prescribed 8d common nail would only meet allowable design uplift pressures for some limited roof conditions, roof heights, and only up to wind speeds of 120 mph.
In contrast these results show that sheathing attached with the proposed 8d ring shank nail would perform adequately under all roof conditions and heights, from 15 feet up to 40 feet, including gable ends in any exposure category as used in the 2001 Florida Building Code.

Based on the benefit-cost parameters and the results of comparative tests the simple proposed change would significantly improve roof construction in the High Velocity Hurricane Zone in Florida.

<u>Please explain how the proposed modification meets the following requirements</u>:

1. Has a reasonable and substantial connection with the health, safety, and welfare of the general public:

The proposed modification will reduce the potential for damage to housing and other buildings from the impact of hurricanes. This will in turn contribute to the protection of life and property. These benefits will be obtained at minimal to negligible cost to

the public. Therefore the proposed modification will substantially benefit the health, safety and welfare of the general public.

2. Strengthens or improves the code, and provides equivalent or better products, methods, or systems of construction:

The proposed modification strengthens and improves the code, and it also provides a better method of construction.

3. Does not discriminate against materials, products, methods, or systems of construction of demonstrated capabilities:

The proposed modification does not in any way discriminate against existing materials, products, methods or systems on construction. The proposed ring shank nails are readily available from suppliers throughout the country.

4. Does not degrade the effectiveness of the code:

On the contrary, the proposed modification improves the effectiveness of the code in meeting its mission of ensuring sound and affordable construction for the residents of Florida.

and 8.

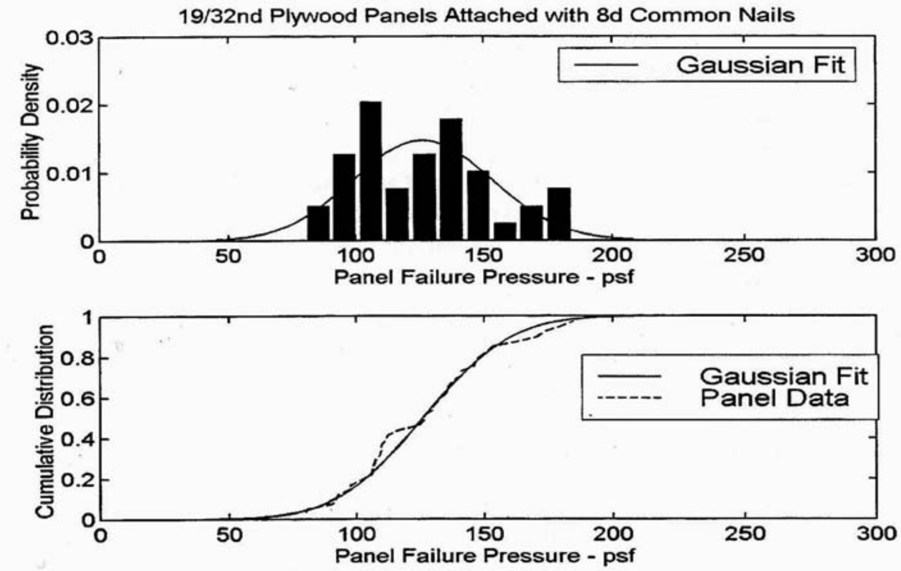


Figure 7. Comparison of Panel Uplift Capacity Results for 8d Common Nails with Normal or Gaussian Distribution

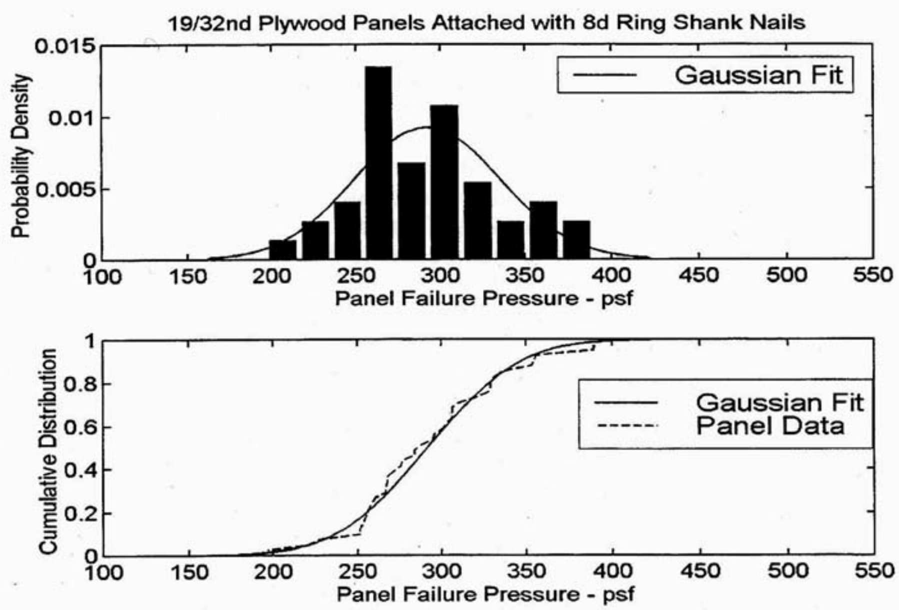


Figure 8. Comparison of Panel Uplift Capacity Results for 8d Ring Shank Nails with Normal or Gaussian Distribution

Form No. 2000-01 Effective date: 11/28/00

Section for DCA Only

Committee Action:

Committee Reason:

Commission Action:

Commission Reason:

APPENDIX B

ROOF SHEATHING PANEL TEST RESULTS
COMPARISON OF MODIFICATION OF
PANEL UPLIFT CAPACITY
USING THREE DIFFERENT FASTENERS
COMPARISON OF NAIL PULLOUT TESTS

The International Hurricane Research Center
Florida International University
June 2003

By HEW 15 July 2003

White Wood 8d Common Bright vs 8d Ring Shank

8d Common Bright
Mean = 106.4, SD = 13.0

8d Ring Shank
Mean = 220.8, SD = 55.8

T value -8.6308111358
P value 0.0000000354
Degrees of Freedom 20

MEANS DIFFERENT at BETTER THAN 1% CONFIDENCE

Southern Yellow Pine 8d Common Bright vs 8d Ring Shank

8d Common Bright
Mean = 128.7, SD = 18.2

8d Ring Shank
Mean = 217.2, SD = 39.3

T value -5.9695585059
P value 0.0003345717
Degrees of Freedom 8

MEANS DIFFERENT at BETTER THAN 1% CONFIDENCE

Southern Yellow Pine 8d Common Bright vs 10d Common Bright

8d Common Bright
Mean = 128.7, SD = 18.2

10d Common Bright
Mean = 174.7, SD = 49.5

T value -3.6627350059
P value 0.0063759838
Degrees of Freedom 8

MEANS DIFFERENT at BETTER THAN 1% CONFIDENCE

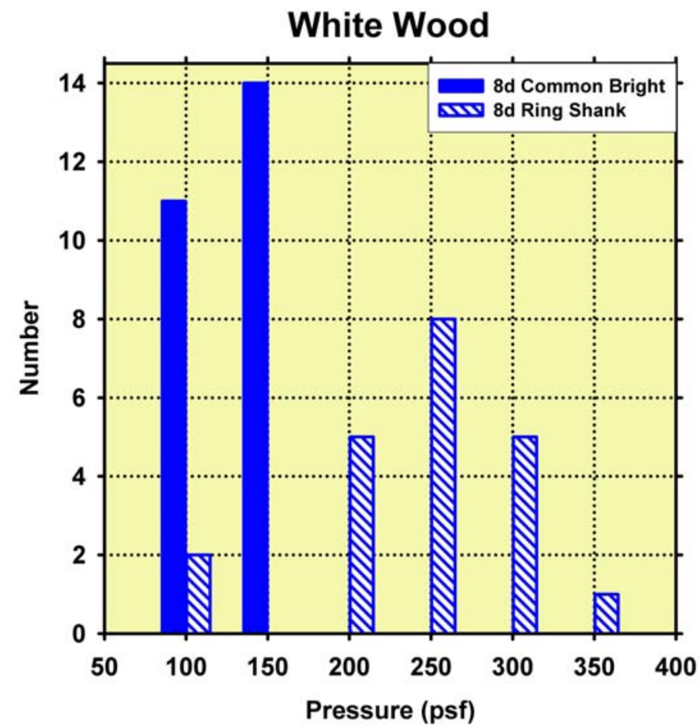
Southern Yellow Pine 8d Ring Shank vs 10d Common Bright

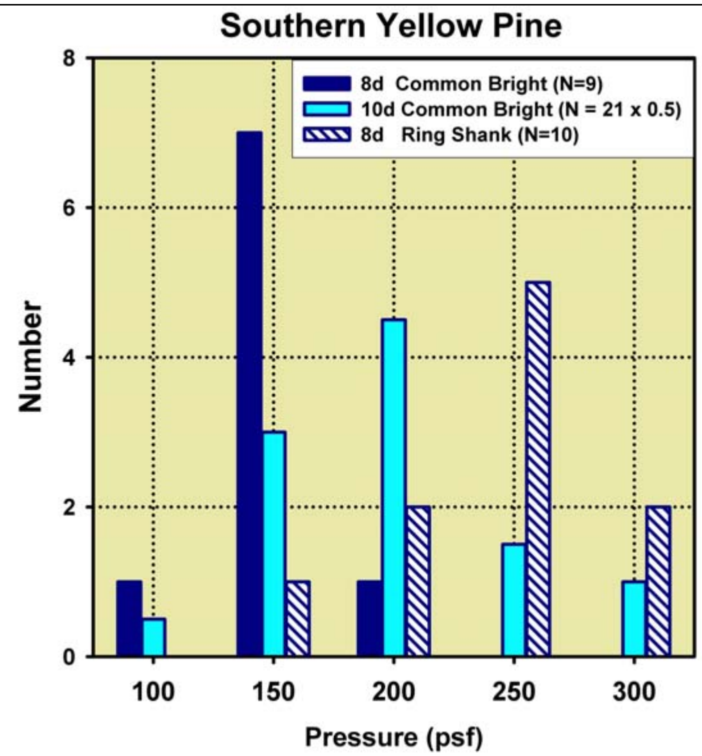
8d Ring Shank
Mean = 217.2, SD = 39.3

10d Common Bright
Mean = 174.7, SD = 49.5

T value 1.1590032724
P value 0.2762808737
Degrees of Freedom 9

MEANS NOT SIGNIFICANTLY DIFFERENT


White Wood
8d Common Bright
8d Ring Shank
Number
Pressure (psf)
0
2
4
6
8
10
12
14
50
100
150
200
250
300
350
400


Southern Yellow Pine
8d Common Bright (N=9)
10d Common Bright (N = 21 x 0.5)
8d Ring Shank (N=10)
Number
Pressure (psf)
0
2
4
6
8
100
150
200
250
300

By HEW 15 JUly 2003

8d Common Bright White Wood vs Southern Yellow Pine

White Wood

Mean = 106.4, SD = 13.0

Southern Yellow Pine

Mean = 128.7, SD = 18.2

T value 3.0586135129

P value 0.0156154314

Degrees of Freedom 8

MEANS DIFFERENT at BETTER THAN 2% CONFIDENCE

8d Ring Shank White Wood vs Southern Yellow Pine

White Wood

Mean = 220.8, SD = 55.8

Southern Yellow Pine

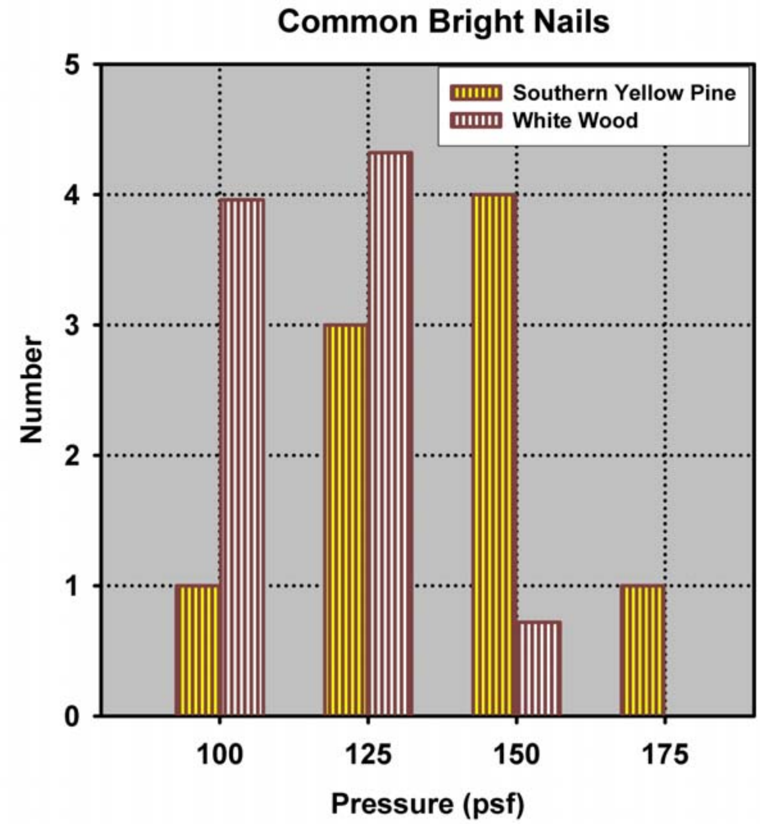
Mean = 217.2, SD = 39.3

T value -0.5994384311

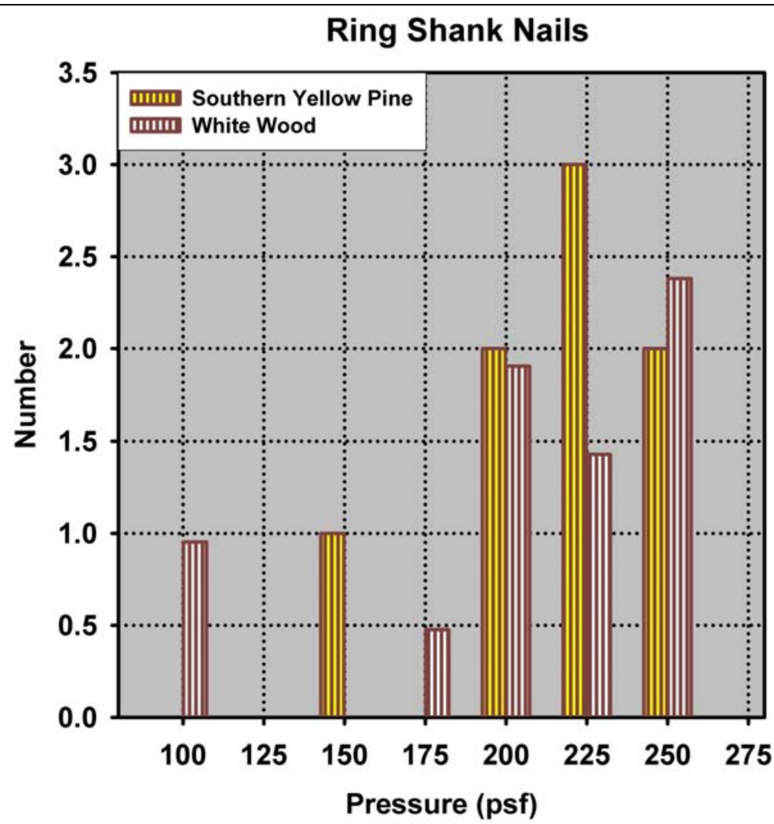
P value 0.5636643459

Degrees of Freedom 9

MEANS NOT SIGNIFICANTLY DIFFERENT



Common Bright Nails
Southern Yellow Pine
White Wood
Number
5
4
3
2
1
0
100
125
150
175
Pressure (psf)



Ring Shank Nails
Southern Yellow Pine
White Wood
Number
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
100
125
150
175
200
225
250
275
Pressure (psf)

Nail Pull-Out Tests by HEW 14JUL03

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Ring-Shank, White Wood VS Southern Yellow Pine

White wood

Mean = 411.9, SD = 51.9

Southern Yellow Pine

Mean = 422.6, SD = 95.2

T value   -0.6423138884

P value   0.5257150556

Degrees of Freedom   29

MEANS NOT SIGNIFICANTLY DIFFERENT

8d Common Bright, White Wood vs Southern Yellow Pine

White Wood

Mean = 169.9, SD = 32.3

Southern Yellow Pine

Mean = 214.4, SD = 56.54

T value   -3.6235050751

P value   0.0011001009

Degrees of Freedom   29

MEANS DIFFERENT at Better THan 1% Confidence

WHITE WOOD, Ring Shank vs Common Bright

Ring Shank

Mean = 411.9, SD = 51.9

Common Bright

Mean = 214.4, SD = 56.54

T value   21.0858007164

P value   0.0000000000

Degrees of Freedom   29

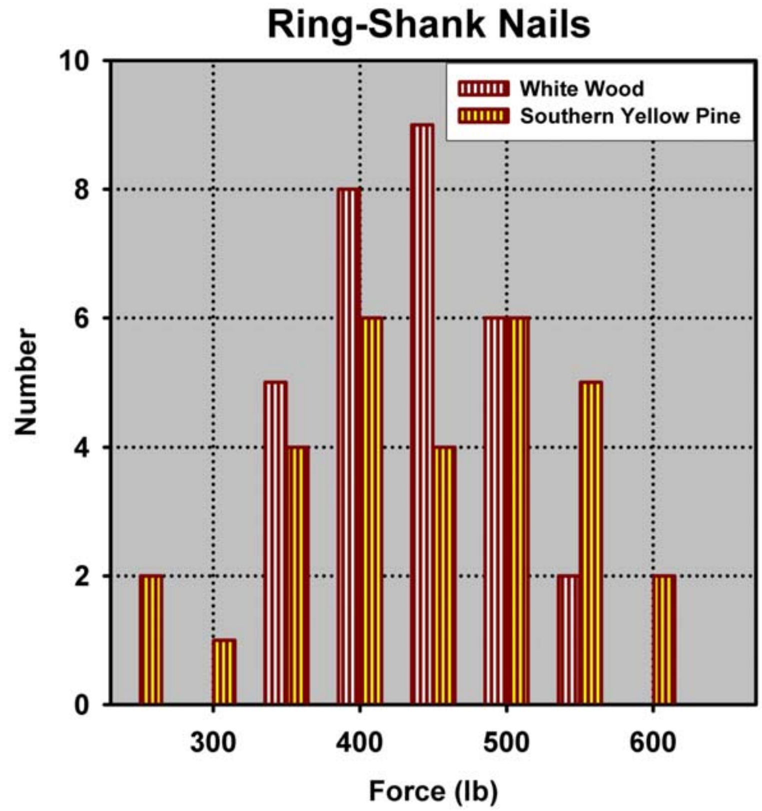
MEANS DIFFERENT at Better Than 1% Confidence

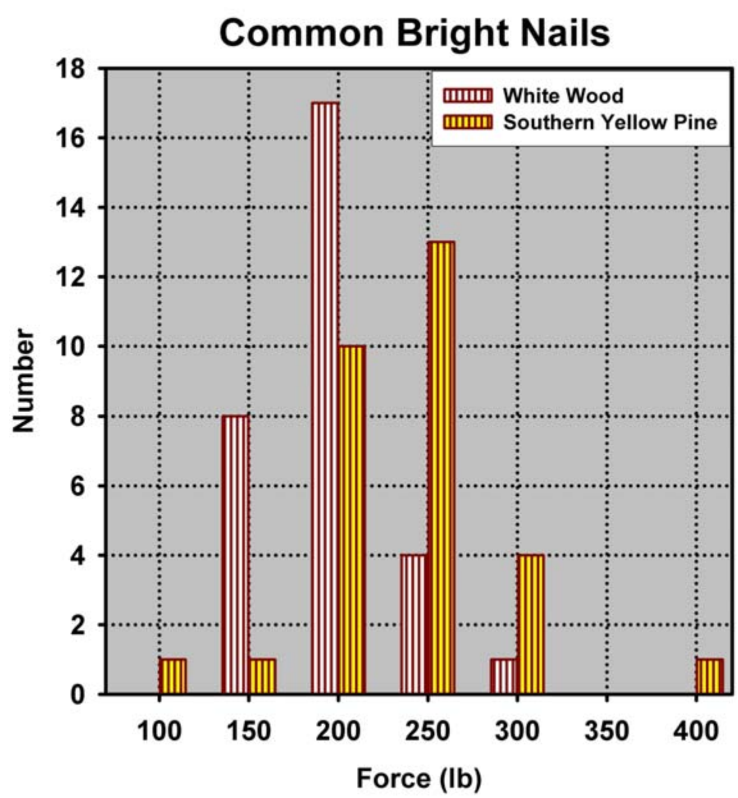
Southern Yellow Pine, Ring Shank vs Common Bright
Ring Shank
Mean = 422.6, SD = 95.2

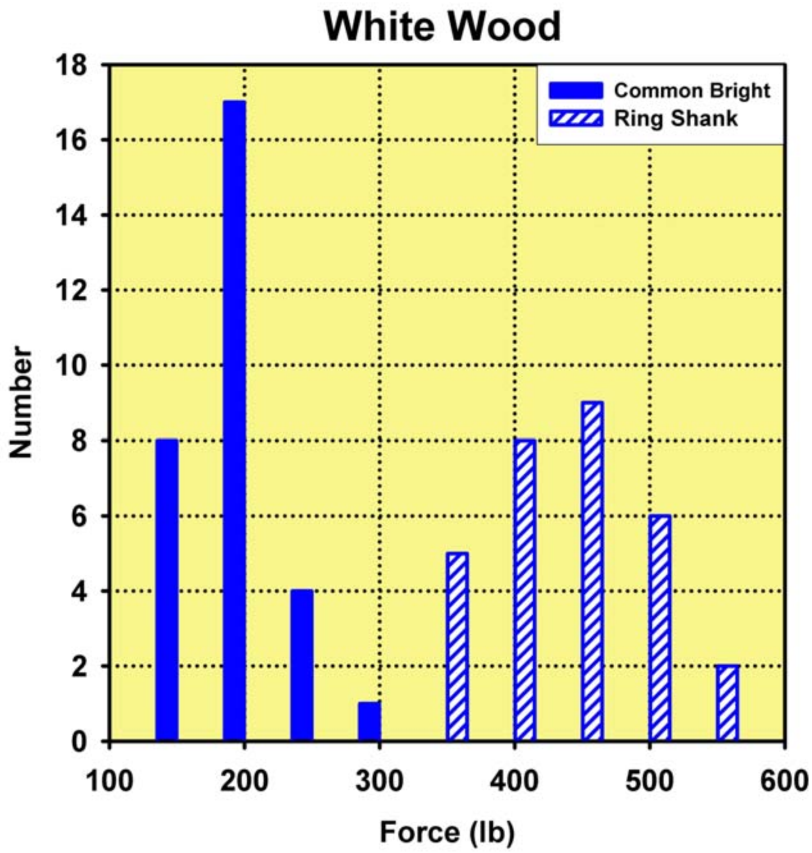
Common Bright
Mean = 214.4, SD = 56.54

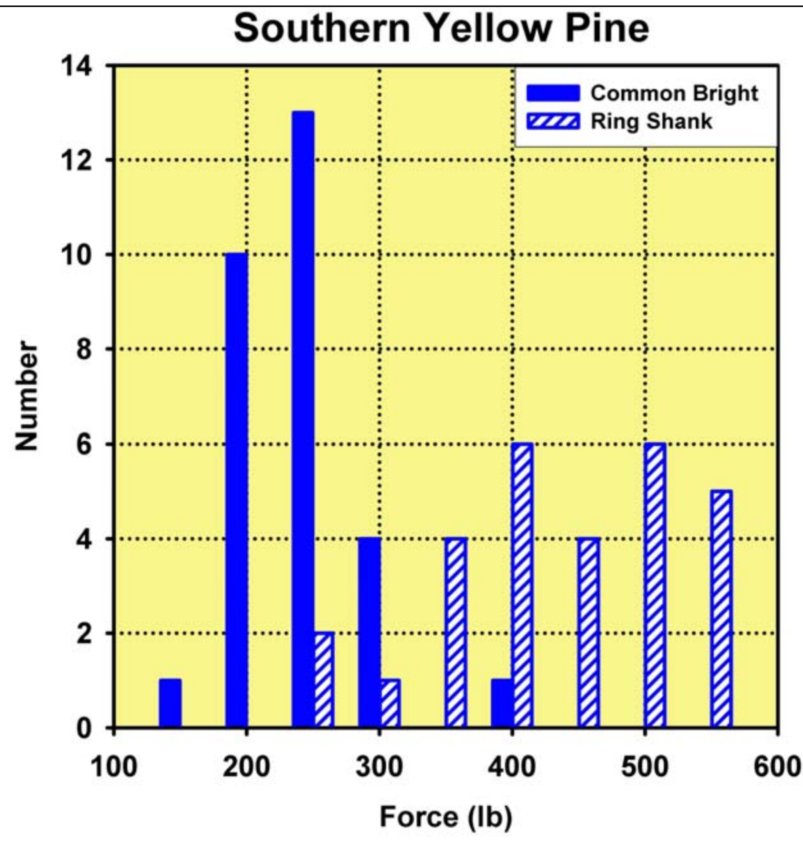
T value 9.6575489973
P value 0.0000000001
Degrees of Freedom 29

MEANS DIFFERENT at Better Than 1% Confidence


Ring-Shank Nails
White Wood
Southern Yellow Pine
Number
Force (lb)
10
8
6
4
2
0
300
400
500
600


Common Bright Nails
White Wood
Southern Yellow Pine
Number
Force (lb)
18
16
14
12
10
8
6
4
2
0
100
150
200
250
300
350
400


White Wood
Common Bright
Ring Shank
Number
Force (lb)
0
2
4
6
8
10
12
14
16
18
100
200
300
400
500
600


Southern Yellow Pine
Common Bright
Ring Shank
Number
Force (lb)
0
2
4
6
8
10
12
14
100
200
300
400
500
600

APPENDIX C

ROOF SHEATHING PANEL TEST RESULTS
COMPARISON OF FAILURE MODE
BY STRUCTURAL MEMBER
AND BY TYPE OF FAILURE

The International Hurricane Research Center
Florida International University
June 2003

Hurricane Loss Reduction Project
FIU Roof Sheathing Panel Test (2002-2003)
Common Brite Nails (8-D White Wood)

Test	Member **A**	Member **B**	Member **C**	Member **D**	Member **E**
CB 25	9.40%	10.90%	9.20%	8.70%	9.40%
CB 24	9.90%	9.90%	9.70%	9.20%	10.60%
CB 23	9.50%	10.10%	9.40%	9.90%	10.40%
CB 22	9.00%	9.90%	10.90%	9.80%	10.20%
CB 21	7.80%	8.70%	9.10%	8.70%	9.10%
CB 20	8.90%	9.10%	7.90%	9.10%	8.00%
CB19	9.90%	9.10%	7.30%	8.30%	9.10%
CB 18	8.30%	8.60%	8.60%	9.10%	9.30%
CB 17	12.10%	10.20%	10.70%	9.90%	9.90%
CB 16	7.70%	9.40%	8.60%	8.60%	9.10%
CB 15	8.60%	7.70%	9.10%	9.30%	9.60%
CB 14	10.60%	11.60%	9.20%	8.20%	10.90%
CB 13	9.10%	9.30%	9.10%	9.60%	9.30%
CB 12	9.90%	9.10%	9.60%	4.90%	9.10%
CB 11	7.90%	9.10%	9.40%	8.40%	8.20%
CB 10	10.10%	9.90%	10.90%	11.10%	9.50%
CB 09	10.70%	10.70%	10.90%	10.00%	10.20%
CB 08	8.20%	9.80%	8.90%	9.80%	8.30%
CB 07	8.90%	8.40%	10.00%	8.80%	9.30%
CB 06	9.10%	9.90%	9.30%	8.80%	9.10%
CB 05	7.90%	8.20%	9.70%	8.60%	8.60%
CB 04	9.40%	10.20%	11.20%	10.70%	10.50%
CB 03	10.90%	8.70%	11.40%	10.10%	11.10%
CB 02	10.70%	10.40%	10.20%	10.70%	9.80%
CB 01	8.70%	9.10%	8.00%	9.50%	8.50%

Legend

Complete Failure (>5 nails)
Partial Failure (<5 nails)

Hurricane Loss Reduction Project

FIU Roof Sheathing Panel Test (2002-2003)

Common Brite Nails (8-D Southern Yellow Pine)

Test	Member **A**	Member **B**	Member **C**	Member **D**	Member **E**
CB 34	11.60%	8.40%	10.40%	10.60%	11.50%
CB 33	12.40%	11.60%	11.60%	8.40%	10.90%
CB 32	10.60%	11.90%	11.20%	11.60%	12.40%
CB 31	11.80%	11.20%	11.70%	12.20%	11.90%
CB 30	11.90%	12.20%	11.90%	10.00%	12.00%
CB 29	11.40%	13.80%	12.30%	13.50%	11.10%
CB 28	12.20%	13.50%	11.90%	8.30%	13.30%
CB 27	12.20%	12.60%	12.20%	10.90%	11.20%
CB 26	11.80%	12.50%	10.40%	11.80%	10.40%

Legend

Complete Failure (>5 nails)

Partial Failure (<5 nails)

Hurricane Loss Reduction Project
FIU Roof Sheathing Panel Test (2002-2003)
Ring Shank Nails (8-D White Wood)

Test	Member **A**	Member **B**	Member **C**	Member **D**	Member **E**
RS 25	8.50%	8.50%	8.40%	9.10%	8.90%
RS 24	9.40%	8.80%	9.70%	9.10%	8.20%
RS 23	9.10%	9.40%	7.90%	9.10%	8.50%
RS 22	9.10%	8.20%	7.90%	8.40%	8.10%
RS 21	9.40%	8.10%	9.10%	8.20%	9.10%
RS 20	10.40%	9.10%	9.10%	8.70%	8.60%
RS 19	9.10%	8.20%	8.30%	7.60%	8.60%
RS 18	10.30%	7.90%	8.30%	8.20%	9.10%
RS 17	9.10%	8.20%	8.00%	8.70%	9.10%
RS 16	7.60%	8.20%	8.10%	8.00%	8.50%
RS 15	9.10%	8.60%	8.00%	7.90%	7.50%
RS 14	9.10%	8.50%	8.20%	8.60%	8.80%
RS 13	9.10%	8.60%	8.60%	9.50%	9.10%
RS 12	8.60%	9.50%	8.20%	8.60%	7.60%
RS 11	8.20%	8.90%	8.20%	8.40%	7.90%
RS 10	8.60%	9.60%	8.60%	8.40%	8.10%
RS 09	9.90%	8.30%	8.40%	8.50%	7.90%
RS 08	8.10%	9.40%	8.60%	8.80%	8.20%
RS 07	9.10%	8.50%	7.70%	8.80%	8.50%
RS 06	9.10%	9.10%	8.80%	9.30%	8.40%
RS 05	8.70%	8.30%	790.00%	9.50%	8.60%
RS 04	8.70%	8.50%	8.50%	8.20%	9.60%
RS 03	8.60%	8.60%	8.60%	8.30%	8.40%
RS 02	8.10%	10.00%	8.20%	8.80%	8.20%
RS 01	8.40%	8.20%	8.60%	8.30%	8.60%

Legend

Complete Failure (>5 nails)
Partial Failure (<5 nails)

Hurricane Loss Reduction Project

FIU Roof Sheathing Panel Test (2002-2003)

Ring Shank Nails (8-D Southern Yellow Pine)

Test	Member **A**	Member **B**	Member **C**	Member **D**	Member **E**
RS 35	12.20%	9.30%	11.70%	11.90%	11.60%
RS 34	11.20%	11.40%	11.30%	11.60%	11.90%
RS 33	11.40%	12.20%	12.00%	12.40%	9.90%
RS 32	13.00%	12.00%	13.40%	11.90%	12.30%
RS 31	11.60%	13.50%	11.90%	11.90%	12.20%
RS 30	11.70%	10.20%	9.60%	10.60%	13.00%
RS 29	11.60%	11.80%	11.40%	12.60%	11.90%
RS 28	11.40%	11.90%	11.40%	11.40%	12.20%
RS 27	12.20%	12.20%	11.40%	11.30%	15.80%
RS 26	10.90%	8.20%	12.50%	11.70%	12.20%

Legend

Complete Failure (>5 nails)
Partial Failure (<5 nails)

Hurricane Loss Reduction Project

FIU Roof Sheathing Panel Test (2002-2003)

Common Brite Nails 10-D (Southern Yellow Pine)

Blue Print For Safety Standards

	Member **A**	Member **B**	Member **C**		Member **D**	Member **E**
Test	Line **A**	Line **B**	Line **C**	Line **D**	Line **E**	Line **F**
CB 21-10	13.5%	13.5%		13.0%	13.2%	11.4%
CB 20-10	13.3%	13.6%		14.5%	13.1%	13.1%
CB 19-10	12.3%	12.8%		14.1%	13.0%	12.5%
CB 18-10	14.6%	10.6%		13.2%	14.1%	13.4%
CB 17-10	14.5%	15.3%		14.8%	13.5%	12.5%
CB 16-10	11.8/%	12.9%		13.1%	13.8%	13.4%
CB 15-10	13.1%	12.5%		13.0%	14.2%	12.6%
CB 14-10	11.9%	12.6%		11.4%	12.4%	11.6%
CB 13-10	12.6%	12.4%		9.1%	13.2%	12.5%
CB 12-10	13.5%	12.2%		13.1%	12.7%	11.3%
CB 11-10	13.1%	10.4%		13.8%	11.9%	12.0%
CB 10-10	15.0%	13.1%		13.6%	12.6%	14.1%
CB 09-10	13.8%	13.6%		13.4%	10.3%	12.2%
CB 08-10	13.1%	11.4%		13.5%	13.5%	12.7%
CB 07-10	11.9%	15.3%		13.2%	13.7%	11.7%
CB 06-10	12.5%	11.9%		12.3%	11.9%	13.4%
CB 05-10	12.3%	11.9%		13.0%	14.5%	13.5%
CB 04-10	12.2%	9.3%		7.6%	13.3%	7.4%
CB 03-10	12.4%	13.1%		10.4%	13.3%	13.4%
CB 02-10	13.7%	7.4%		13.5%	14.5%	12.8%
CB 01-10	12.8%	13.2%		15.7%	12.4%	12.4%

Legend

Complete Failure (>7 nails)

Partial Failure (<7 nails)

APPENDIX D

IMPROVING ROOF PERFORMANCE UNDER HURRICANE WINDS

Paper Presented at the
2003 Governors Hurricane Conference

The International Hurricane Research Center
Florida International University
June 2003

Design Guidelines for Roof Sheathing Fastener Schedules in High Wind Areas

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ABSTRACT: The widespread loss of roof sheathing during Hurricane Andrew led to significant revisions to nailing schedules in most building codes and standards for high wind areas. Over the years since Hurricane Andrew, Clemson University and the International Hurricane Center (IHC) at Florida International University have conducted separate and joint testing of literally hundreds of sheathing panels. The data includes individual nail withdrawal values as well as panel tests in vacuum chambers. Enough data has been collected to establish that: 1.) Single fastener ultimate withdrawal capacities for smooth shank nails, based on nominal species density values, are often substantially lower than those implied by the *National Design Specification for Wood Construction* (NDS); 2.) Single fastener ultimate withdrawal capacities for various ring shank nails used in the tests, based on nominal species density values, are generally equal to or greater than those implied by the NDS; 3.) Both the individual fastener withdrawal capacities and panel failure capacities follow the normal distribution; 4.) Analysis methods based on individual fastener capacities and tributary area methods can provide reasonable estimates of design capacities provided they are revised downward for system/multiple vulnerable fastener effects; 5.) Head pull-through can limit the connection capacity. This paper presents a set of design guidelines for selecting appropriate 8d fastener spacing, based on NDS allowable withdrawal capacities and nominal species density values. These guidelines are then used to develop a nailing schedule that is appropriate for houses with mean roof heights of 40-feet or less that are located in South Florida.

KEYWORDS: Fasteners, Nails, Fastener Schedules, Roof Sheathing, Hurricanes, Wind Loads

INTRODUCTION

Background

When plywood and other structural roof sheathing products were introduced into the marketplace their attachment to roof and wall structural members was based more on concerns about warping and the shear capacity of the products as diaphragms than on their capacity to resist wind induced uplift loads. Consequently, the same minimum nailing patterns for roof sheathing attachment were specified in building codes for areas subjected to widely different windstorm conditions such as Miami, Florida and Minneapolis, Minnesota. In the aftermath of Hurricane Andrew, the minimum nailing patterns were updated in many building codes and deemed-to-comply documents.

It has been well established that the capacities of roof sheathing attachments are linked to the tributary areas of the fasteners used to attach the sheets (Cunningham 1993, Sutt 2000). While recent analytical and experimental studies suggest that there is some local sharing of loads between adjacent fasteners, the mean failure capacity is closely linked to (but lower than) the capacities of the fasteners with the largest tributary areas. Finite element analyses have further supported this approach (Cunningham 1993, Mizzell 1994). These finite element analyses have also shown, however, that certain fasteners can attract more load than that calculated using tributary areas, particularly when the spacing of fasteners on interior members is 12-inches on center. Mizzell demonstrated this by measuring loads in the fasteners. As the number of fasteners used to attach a panel increases, the difference between the tributary area and finite element analyses are reduced. Cunningham concluded that the tributary area approach was adequate for design purposes.

Cunningham proposed a design methodology for calculating panel uplift capacity that is based on *National Design Specification for Wood Construction* (NDS) allowable capacities of individual fasteners and the largest tributary areas for fasteners in a panel. He conducted a limited number of panel tests as a means of verifying his analysis and supplemented the panel tests with a series of nail withdrawal tests. He was able to demonstrate good agreement between the calculated panel uplift capacities and the test results when he adjusted the panel capacity calculations so that they were based on the actual nail withdrawal results rather that the NDS values. The reason the adjustments were necessary was that 6d common nail withdrawal capacities were only about 2.5 times the NDS allowable while 8d common nail withdrawal capacities were about 5.35 times the NDS allowable and 8d ring shank nails had an average withdrawal capacity that was 7.35 times the NDS allowable value (Cunningham 1993). The allowable withdrawal capacities for nails in the NDS are typically about one-fifth of the average ultimate test values (NDS Commentary 1999). Therefore if the NDS values had been used without any adjustment, the measured panel uplift capacity for panels attached with 6d nails would have been much lower than the calculated value, while the uplift capacity for panels attached with 8d ring shank nails would have been substantially higher than calculated. *The 2001 Florida Building Code* nailing schedules for the High Velocity Hurricane Zone (HVHZ is composed of Dade and Broward Counties) are consistent with Cunningham's recommendations for nailing schedules in high wind areas. Because Cunningham's assumed average 8d fastener withdrawal capacities were consistent with or higher than the NDS average withdrawal values (5 or more times the NDS allowable values), these recommendations are valid only if the actual performance of fasteners, in the framing being used, is comparable to or higher than the ultimate capacities implied by the NDS values.

Cunningham's tests were conducted using Douglas Fir-Larch (DFL) lumber. Subsequent panel tests with Southern Yellow Pine (SYP) and nominal ½-inch (15/32-inch actual) plywood panels have been conducted by a number of researchers at Clemson University (Kallem 1996, Sutt 2000) and have produced panel test results that vary significantly from the predicted panel capacities obtained using NDS values. Most of the test results have revealed substantially lower panel uplift capacities than those expected using Cunningham's procedure and NDS withdrawal values. The current study was motivated by these variations in results and the fact that nominal 5/8-inch (actual 19/32-inch) thick sheathing, for which very little actual test data is available, is specified in the HVHZ in the *2001 Florida Building Code*.

Additional debates about panel uplift capacities have centered on the relationship between panel capacities developed from uniform quasi-static loading and the actual performance of panels in a real high wind loading environment where wind loads are not likely to act uniformly over the entire panel and the magnitude of the loading is expected to change rapidly with time. The two potential effects, non-uniform loading and cyclic loading are expected to have opposite effects on actual performance. The variation in loading over the panel surface may well result in less severe loading of the panel than that exerted by a uniform pressure distribution. However, cyclic loads nearly always result in failures at lower load levels than those required to cause failure under a simple increase in load to failure (a single cycle). As a first step, it is important to establish a reliable design procedure that at least handles the quasi-static uniform load case.

Finally, head pull-through failures can contribute to or control the ultimate uplift capacity of roof panel connections. Unfortunately, the NDS does not address nail head pull-through and the *Load and Resistance Factor Design Manual for Engineered Wood Construction* (LRFD) only mentions the issue in passing and does not provide any guidance for estimating head pull-through capacities. Head pull-through failures have been frequently observed when ring-shank nails or screws have been used to attach nominal ½-inch plywood and Oriented Strand Board (OSB). Monte Carlo based simulations that account for statistics on both fastener withdrawal and head pull-through capacities have yielded reasonable estimates of mean panel uplift capacities but poorer estimates of variability in panel uplift capacities (Sutt 2000). In the panel tests conducted as part of this study, head pull-through failures were extremely rare even when ring-shank nails were used to attach the sheathing. This supports suggestions that 5/8-inch sheathing is a good choice in high wind areas.

Over the years a number of fastener types, sizes and spacing have been used to attach a variety of types and thickness of wood structural panels. In some cases, such as gable roof overhangs, commonly used prescriptive designs and construction methods can create situations where roof sheathing performs poorly in a severe windstorm. Despite the movement towards a statewide building code in Florida, fastener sizes, types and schedules allowed for sheathing connections still vary widely throughout the state. Some new recommendations, such as those being promoted by FLASH (Federal Alliance For Safe Homes), suggest that 10d nails be installed at 4-inch spacing along the edges of panels (a 4-inch spacing is also required for sheathing attachment along the edge of gable ends in the HVHZ regions of the 2001 FBC). The use of a smaller nail spacing for fasteners installed on the gable end truss is warranted. However, a general decrease in nail spacing along the edges of the panels does little or nothing to increase the uplift capacity of the panel, as failure modes are initiated on the interior spans of the panels.

Objectives and Scope

The first objective of this research was to conduct studies of panel attachments and the resulting uplift capacities that are specific to the thickness of sheathing and types of fasteners being specified for the HVHZ in Florida. The second objective was to develop a design procedure for estimating panel uplift capacities.

The research conducted included testing of individual fasteners and full panels. Load information, including time histories of simultaneous loads on the top and bottom surfaces of gable roof overhangs, was used to improve loading information for the design of fastener schedules for gable overhangs. The test results and resulting analysis suggest that nailing schedules currently specified in the HVHZ are not adequate if nail withdrawal capacities are substantially lower than those resulting from the use the NDS withdrawal equation. Results of this study and of a number of other recent studies have demonstrated that withdrawal capacities of smooth shank nails in SYP are consistently being overestimated by the NDS withdrawal equation while the values for ring-shank nails in SYP are consistent with or higher than values given by the NDS withdrawal equation. Based on this research, the IHC has proposed new nailing schedules to the *Florida Building Commission* for the HVHZ.

Review of Building Code Provisions for Roof Sheathing Attachment

Building code provisions can be grouped in two categories. One category is the performance criteria that are used to establish minimum design loads. The performance criteria of choice for wind loads are the provisions of the American Society of Civil Engineers' standard ASCE 7-98. These wind load provisions have been adopted in the *2001 Florida Building Code* as well as most other US model building codes. The second category of provisions includes the various prescriptive requirements that provide specifications for minimum member sizes, maximum member spacing and minimum connection details. In the case of roof sheathing, these provisions include requirements for minimum lumber or panel thickness and the type and spacing of fasteners.

Performance Criteria for Wind Uplift Resistance of Roof Sheathing

The wind load provisions of ASCE 7-02 were used to calculate the design wind loads on a per square foot basis for exposed sites (exposure C) and built up areas (exposure B) for 3-second gust design wind speeds at 10 meters height ranging between 100 and 150 miles per hour. These speeds cover the entire range of design wind speeds in ASCE 7-98 for hurricane prone regions. Two adjustments to ASCE 7-02 provisions were made in calculating design wind pressures for gable roof overhangs. The first adjustment involves increasing the uplift pressure coefficient on the gable overhang by adding a value of GCp of 1.0 to the roof uplift coefficients, except for zone 3 when roof slopes are between 7 and 27 degrees, rather than using the ASCE 7-02 overhang uplift coefficients. This modification is slightly more conservative than the ASCE 7-02 overhang provisions for all cases except zone 3 for roofs with slopes between 7 and 27 degrees. The ASCE 7-02 provisions list an overhang coefficient of –3.7 for zone 3 and roof slopes between 10 and 30 degrees while listing a base coefficient of –2.6. The resulting increase in the uplift coefficient is –1.1 instead of the -1.0 used for the other cases. The adjustment in overhang uplift coefficients listed above is based on results of detailed studies of net uplift on gable ends (McKinney 2001). The second adjustment is based on the assumption that the gable overhang is 1-foot, which is the maximum overhang typically allowed before prescriptive requirements instruct the builder to use outriggers to support the gable overhang. Since it is assumed that the spacing of rafters or trusses is 2-feet, the tributary area for the fasteners on the gable end wall consists of the 1-foot overhang and 1-foot of the roof between the two end trusses or rafters. Consequently, the design pressures for fasteners attaching sheathing to the gable end wall are based on the average of the gable overhang pressure and the pressure on the roof adjacent to the overhang.

Tables 1 and 2 provide a detailed listing of the design pressures for buildings with different mean roof heights located in areas subject to the design wind speeds listed at the top of the tables. Table 1 provides results for houses located in a built up area (exposure B) while Table 2 provides results for houses located in an open exposure (exposure C). Results are also presented for buildings designed as enclosed structures and buildings designed as partially enclosed. Since the HVHZ requires opening protection, this relates to issues of opening protection in areas outside the HVHZ. The wind loads are based on pressure coefficients for buildings with roof slopes between 2.5 in 12 and 6 in 12. ASCE 7-98 gives lower pressure coefficients for roofs with slopes greater than 27 degrees (greater than 6 in 12 slope) but those values are based on very little data. The study by McKinney suggests that there is some reduction in uplift coefficients as the roof slope increases but not nearly as much reduction as that given in ASCE 7-02. Consequently, it is recommended that these wind loads and the resulting nailing schedules be used for all roof slopes greater than 7 degrees (2 in 12 slope or greater).

The design pressures for roof edge and corner zones (zones 2 and 3) on an enclosed building without overhangs, for roofs with slopes greater than 2 in 12, range from 42 psf for a 15-ft. mean roof height in exposure B terrain with a 100 mph design wind speed to 142 psf for a 40-ft. mean roof height in exposure C terrain with a 150 mph design wind speed. Similarly, the design pressures on gable roof overhangs for roofs with slopes greater than 2 in 12, range from 48 psf for a 15-ft. mean roof height in exposure B terrain with a 100 mph design wind speed to 160 psf for a 40-ft. mean roof height in exposure C terrain with a 150 mph design wind speed.

Table 1. Design Uplift Pressures for Roof Sheathing on Buildings with Roof Slopes Greater than 2 in 12 – Exposure B (Built Up Terrain)

Roof Zone & Condition	Roof Height (feet)	Design Wind Speed (3-second gust) - mph					
		100	110	120	130	140	150
Zone 1 - enclosed	15 - 30	-16.5	-19.9	-23.7	-27.8	-32.2	-37.0
Zone 1 – partial encl.	15 - 30	-22.1	-26.7	-31.8	-37.3	-43.3	-49.7
Zone 2 - enclosed	15 - 30	-28.6	-34.6	-41.2	-48.4	-56.1	-64.4
Zone 2 – partial encl.	15 - 30	-34.3	-41.5	-49.4	-57.9	-67.2	-77.1
Zone 3 - enclosed	15 - 30	-42.3	-51.2	-61.0	-71.6	-83.0	-95.3
Zone 3 - partial encl.	15 - 30	-48.0	-58.1	-69.1	-81.1	-94.0	-108.0
Zone 2 – Gable End	15 - 30	-33.5	-40.5	-48.3	-56.6	-65.7	-75.4
Zone 3 – Gable End	15 - 30	-48.0	-58.1	-69.1	-81.1	-94.0	-108.0
Zone 1 - enclosed	35	-17.2	-20.8	-24.7	-29.0	-33.6	-38.6
Zone 1 – partial encl.	35	-23.0	-27.9	-33.2	-38.9	-45.1	-51.8
Zone 2 - enclosed	35	-29.9	-36.1	-43.0	-50.5	-58.5	-67.2
Zone 2 – partial encl.	35	-35.7	-43.2	-51.5	-60.4	-70.1	-80.4
Zone 3 - enclosed	35	-44.2	-53.4	-63.6	-74.6	-86.6	-99.4
Zone 3 - partial encl.	35	-50.0	-60.5	-72.1	-84.6	-98.1	-112.6
Zone 2 – Gable End	35	-34.9	-42.3	-50.3	-59.1	-68.5	-78.6
Zone 3 – Gable End	35	-50.0	-60.5	-72.1	-84.6	-98.1	112.6
Zone 1 - enclosed	40	-17.9	-21.6	-25.7	-30.2	-35.0	-40.2
Zone 1 – partial encl.	40	-24.0	-29.0	-34.5	-40.5	-47.0	-54.0
Zone 2 - enclosed	40	-31.1	-37.6	-44.8	-52.5	-60.9	-70.0
Zone 2 – partial encl.	40	-37.2	45.0	-53.6	-62.9	-72.9	-83.7
Zone 3 - enclosed	40	-46.0	-55.6	-66.2	-77.7	-90.1	-103.4
Zone 3 - partial encl.	40	-52.1	-63.0	-75.0	-88.0	-102.1	-117.2
Zone 2 – Gable End	40	-36.4	-44.0	-52.4	-61.5	-71.3	-81.9
Zone 3 – Gable End	40	-52.1	-63.0	-75.0	-88.0	102.1	-117.2

Table 2. Design Uplift Pressures for Roof Sheathing on Buildings with Roof Slopes Greater than 2 in 12 – Exposure C (Open Terrain)

Roof Zone & Condition	Roof Height (feet)	Design Wind Speed (3-second gust) - mph					
		100	110	120	130	140	150
Zone 1 - enclosed	15	-20.0	-24.2	-28.8	-33.8	-39.2	-44.9
Zone 1 – partial encl.	15	-26.8	-32.5	-38.6	-45.3	-52.6	-60.3
Zone 2 - enclosed	15	-34.8	-42.1	-50.1	-58.8	-68.2	-78.2
Zone 2 - partial encl.	15	-41.6	-50.4	-59.9	-70.3	-81.6	-93.6
Zone 3 - enclosed	15	-51.4	-62.2	-74.0	-86.9	-100.8	-115.7
Zone 3 - partial encl.	15	-58.3	-70.5	-83.9	-98.5	-114.2	-131.1
Zone 2 – Gable End	15	-40.7	-49.2	-58.6	-68.8	-79.8	-91.6
Zone 3 – Gable End	15	-58.3	-70.5	-83.9	-98.5	-114.2	-131.1

Table 2. (Continued) Design Uplift Pressures for Roof Sheathing on Buildings with Roof Slopes Greater than 2 in 12 – Exposure C (Open Terrain)

Roof Zone & Condition	Roof Height (feet)	Design Wind Speed (3-second gust) - mph					
		100	110	120	130	140	150
Zone 1 - enclosed	20	-21.2	-25.6	-30.5	-35.7	-41.5	-47.6
Zone 1 – partial encl.	20	-28.4	-34.4	-40.9	-48.0	-55.7	-63.9
Zone 2 - enclosed	20	-36.8	-44.5	-53.0	-62.2	-72.2	-82.8
Zone 2 - partial encl.	20	-44.1	-53.3	-63.5	-74.5	-86.4	-99.1
Zone 3 - enclosed	20	-54.4	-65.9	-78.4	-92.0	-106.7	-122.5
Zone 3 - partial encl.	20	-61.7	-74.6	-88.8	-104.3	-120.9	-138.8
Zone 2 – Gable End	20	-43.1	-52.1	-62.0	-72.8	-84.4	-96.9
Zone 3 – Gable End	20	-61.7	-74.6	-88.8	-104.3	-120.9	-138.8
Zone 1 - enclosed	25	-22.1	-26.7	-31.8	-37.3	-43.3	-49.7
Zone 1 – partial encl.	25	-29.7	-35.9	-42.7	-50.1	-58.1	-66.7
Zone 2 - enclosed	25	-38.5	-46.5	-55.4	-65.0	-75.4	-86.5
Zone 2 - partial encl.	25	-46.0	-55.7	-66.3	-77.8	-90.2	-103.6
Zone 3 - enclosed	25	-56.9	-68.8	-81.9	-96.1	-111.5	-127.9
Zone 3 - partial encl.	25	-64.4	-78.0	-92.8	-108.9	-126.3	-145.0
Zone 2 – Gable End	25	-45.0	-54.4	-64.8	-76.0	-88.2	-101.2
Zone 3 – Gable End	25	-64.4	-78.0	-92.8	-108.9	-126.3	-145.0
Zone 1 - enclosed	30	-23.0	-27.9	-33.2	-38.9	-45.1	-51.8
Zone 1 – partial encl.	30	-30.9	-37.4	-44.5	-52.3	-60.6	-69.6
Zone 2 - enclosed	30	-40.1	-48.5	-57.7	-67.8	-78.6	-90.2
Zone 2 - partial encl.	30	-48.0	-58.1	-69.1	-81.1	-94.0	-108.0
Zone 3 - enclosed	30	-59.3	-71.7	-85.4	-100.2	-116.2	-133.4
Zone 3 - partial encl.	30	-67.2	-81.3	-96.7	-113.5	-131.7	-151.1
Zone 2 – Gable End	30	-46.9	-56.8	-67.6	-79.3	-92.0	-105.6
Zone 3 – Gable End	30	-67.2	-81.3	-96.7	-113.5	-131.7	-151.1
Zone 1 - enclosed	35	-23.7	-28.7	-34.2	-40.1	-46.5	-53.4
Zone 1 – partial encl.	35	-31.9	-38.6	-45.9	-53.9	-62.5	-71.7
Zone 2 - enclosed	35	-41.3	-50.0	-59.5	-69.8	-81.0	-93.0
Zone 2 - partial encl.	35	-49.4	-59.8	-71.2	-83.6	-96.9	-111.3
Zone 3 - enclosed	35	-61.1	-73.9	-88.0	-103.3	-119.8	-137.5
Zone 3 - partial encl.	35	-69.2	-83.8	-99.7	-117.0	-135.7	-155.8
Zone 2 – Gable End	35	-48.4	-58.5	-69.6	-81.7	-94.8	-108.8
Zone 3 – Gable End	35	-69.2	-83.8	-99.7	-117.0	-135.7	-155.8
Zone 1 - enclosed	40	-24.4	-29.6	-35.2	-41.3	-47.9	-55.0
Zone 1 – partial encl.	40	-32.8	-39.7	-47.3	-55.5	-64.3	-73.8
Zone 2 - enclosed	40	-42.5	-51.5	-61.3	-71.9	-83.4	-95.7
Zone 2 - partial encl.	40	-50.9	-61.6	-73.3	-86.1	-99.8	-114.6
Zone 3 - enclosed	40	-62.9	-76.1	-90.6	-106.3	-123.3	-141.6
Zone 3 - partial encl.	40	-71.3	-86.3	-102.7	-120.5	-139.7	-160.4
Zone 2 – Gable End	40	-49.8	-60.2	-71.7	-84.1	-97.6	-112.0

Zone 3 – Gable End	40	-71.3	-86.3	-102.7	-120.5	-139.7	-160.4

Since prescriptive requirements for high wind design typically cover a range of terrain exposures and roof heights, the prescriptive requirements for the HVHZ should be adequate to provide protection from sheathing uplift failure for wind loads of up to about 142 psf for enclosed buildings and the attachment of the sheathing to the gable end wall should be capable of resisting wind uplift loads of about 160 psf. If a safety factor of 2.0 is used, the typical target ultimate uplift capacities should be 284 psf and 320 psf, respectively.

Prescriptive Criteria for Roof Sheathing Attachment in the High Velocity Hurricane Zone

The *2001 Florida Building Code* includes specific provisions for roof sheathing and the attachment of roof sheathing in the HVHZ. The requirements include the following:

1. Plywood sheathing shall be Exposure 1 with a minimum nominal thickness of 19/32-inch.
2. Plywood panels shall be nailed to the supports using 8d common nails. The nails shall be spaced 6-inches on center at the panel edges and at the intermediate supports.
3. Nail spacing shall be 4-inches on center at gable ends with 10d common nails.
4. 8d common nails used for sheathing attachment can be either hand or power driven and must have a diameter of 0.131-inches, a length of 2.5-inches, and a full head with a minimum head diameter of 0.281-inches.
5. 10d nails used for sheathing attachment at the gable ends can be either hand or power driven and must have a diameter of 0.148-inches, a length of 3.0-inches, and a full head with a minimum diameter of 0.312 inches.

Test Program and Results

Two series of panel uplift tests were conducted using nominal 5/8-inch (actual 19/32-inch) thick CDX plywood attached using fasteners installed at 6-inch spacing. The first series consisted of a number of sets of 3 to 7 panels, where the influence of nail size and type was investigated. Tests were also conducted to determine individual fastener withdrawal capacities from the lumber used to construct each specimen. Summary results from the panel tests are listed in Table 3. The head diameters of the 8d fasteners were 0.281 inches. Use of 8d ring shank nails nearly doubled the uplift capacity of the 5/8-inch roof sheathing as compared to the panels attached with 8d common bright or 8d galvanized nails. A single missing fastener along the edge of the panel (series 13 versus series 3) resulted in no reduction in uplift capacity, while two missing fasteners along the edge (series 23 versus series 3) resulted in an 18 percent reduction in average uplift capacity. Clearly, none of the panels attached with smooth shank nails provided any meaningful factor of safety over the design load for the HVHZ zone for roof panels on an enclosed building even if it was located in exposure B and did not have an overhang.

A second series of panel tests was conducted for two sets of 40 specimens using a 6-inch spacing of 8d smooth and 8d ring shank nails, respectively. Results of these tests provided much more reliable estimates of the standard deviation of panel uplift capacities and showed that the panel uplift resistance capacities closely followed the normal distribution for each type of fastener. The distributions of panel capacities are shown in Figures 1 and 2. The panels attached with smooth shank nails exhibited a mean ultimate uplift capacity that corresponded to a pressure of 126 psf with a coefficient of variation of 21.4 percent. The mean ultimate uplift capacity of the panels connected with the ring shank nails corresponded to a pressure of 292 psf with a coefficient of variation of 15 percent. These ring shank nails had a shank diameter of 0.113 inches, a ring diameter of 0.125 inches, and a head diameter of 0.32 inches.

Table 3. Summary of Roof Panel Uplift Test Results

Panel Series Number	Type of Nail Diameter/Length/(Ring Diameter)	Number of Panels Tested	Mean Failure Pressure (psf)	Std. Dev. of Failure Pressure (psf)	Number of Nail Pullout Tests	Mean Nail Pullout (lbs)	**Standard** Deviation of Nail Pullout (lbs)
1	8D Common Bright 0.131 / 2.5	7	127	23.8	125	175	47
2	8D Galvanized 0.137 / 2.5	7	116	24.8	118	225	95
3	10D Coated Galvanized 0.120 / 3.0	7	108	14.4	101	167	40
4	10D Sinkers 0.121 / 2.883	6	125	20.6	96	178	81
6	8D Ring Shank 0.113 / 2.375 / (0.120)	7	231	38.2	87	373	82
13	10D Coated Galvanized (1 missing) 0.120 / 3.0	3	108	13.6	57	120	50
23	10D Coated Galvanized (2 missing) 0.120 / 3.0	3	89	16.5	57	126	56

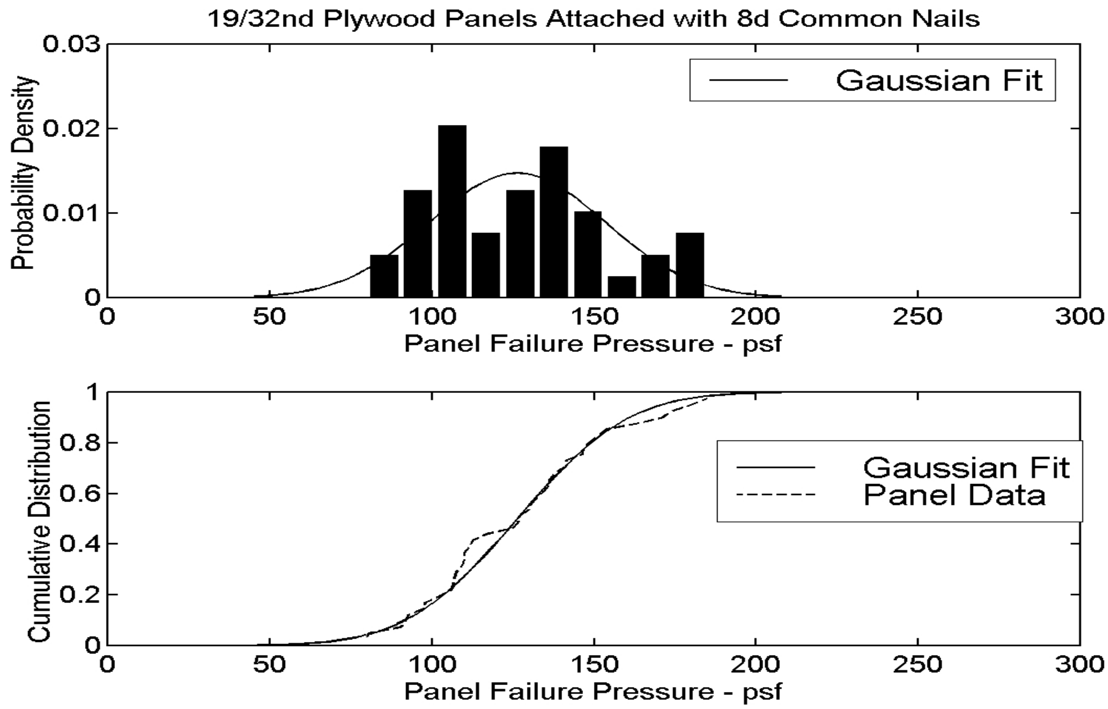

Figure 1. Comparison of Panel Uplift Capacity Results for 8d Common Nails with Normal or Gaussian Distribution

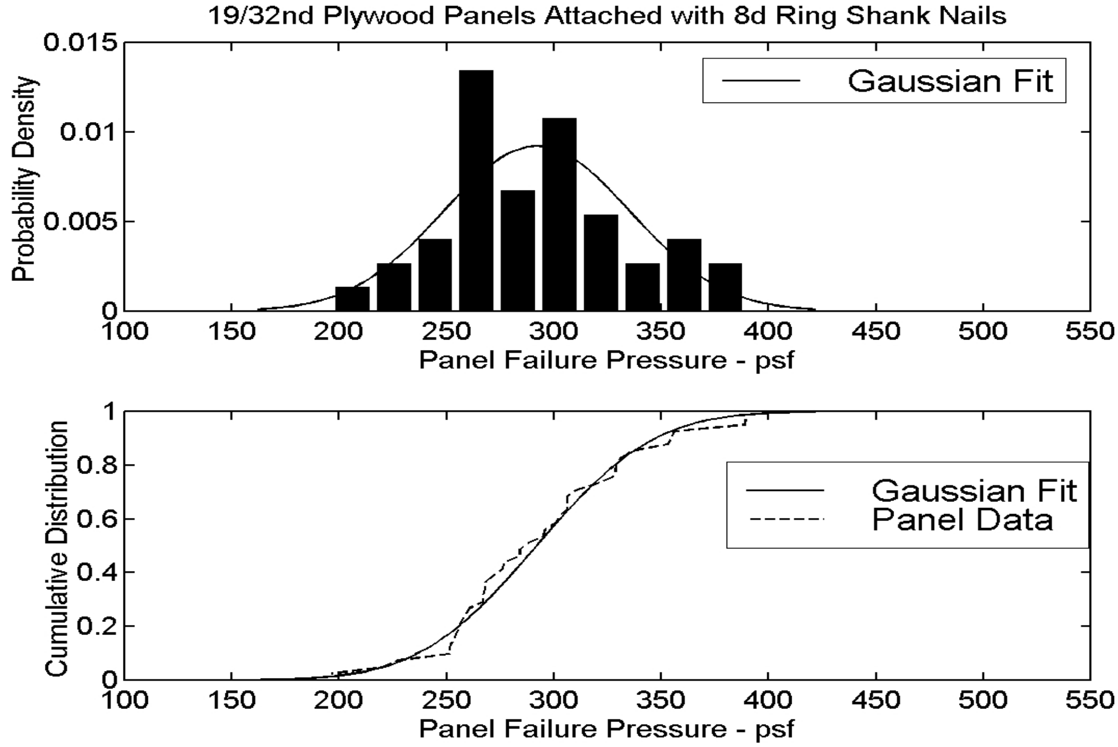

Figure 2. Comparison of Panel Uplift Capacity Results for 8d Ring Shank Nails with Normal or Gaussian Distribution

Discussion of Results

A review of the results obtained by Cunningham indicates that the failure capacity he obtained for a single 5/8 panel tested with 8d common nails at a 6-inch spacing was between 194 and 218 psf. The 194 psf value corresponds to the initiation of failure while the 218 psf value corresponds to a substantial failure of the panel attachment. These results are much higher than the average failure capacity of 126 psf obtained for the 40 panels tested during this study. The difference in results can be traced to the difference in individual fastener withdrawal capacities. Cunningham conducted 40 fastener withdrawal tests. The average fastener withdrawal capacity was found to be 272 pounds per inch of embedment of the fastener. This value was reported to be about 5.35 times the NDS design value. Using a nominal specific gravity for SYP of 0.55, the NDS design value is 41 pounds per inch of embedment for the 8d common nails used in the testing conducted as part of this research. The mean nail pullout capacity per inch of penetration obtained from 125 nail withdrawal tests in the SYP used for construction of the test specimen in this study was about 92 pounds per inch which is only about 2.25 times the NDS design value.

A similar review of nail pullout capacities for ring shank nails shows a much closer agreement in capacities. Cunningham's single 5/8-inch panel attached with 8d ring shank nails at a 6-inch spacing had a failure capacity between 330 psf and 397 psf, with the lower value corresponding to the initiation of failure. The 40 19/32 inch plywood panels attached to SYP lumber with 8d ring shank nails at 6-inch spacing that were tested as part of this study yielded an average ultimate uplift capacity of 292 psf. Cunningham conducted 40 nail withdrawal tests for his ring shank nails and found the average withdrawal capacity to be about 348 pounds per inch. This was reported to be about 7.35 times the NDS design value. The mean nail pullout capacity per inch of penetration obtained from 87 nail withdrawal tests in the SYP used in this study was about 209 pounds per inch. This is about 5.1 times the NDS design value. Significantly, the lumber used to construct the panels attached with the 8d common nails and the 8d ring shank nails were randomly pulled from the same bundle of SYP 2x4s.

The wide variation in nail withdrawal capacities, as compared to the NDS design values, is not a new or isolated phenomenon. Cunningham reported that the average withdrawal capacities of 6d nails that were a part of his test program provided only about 2.5 times the NDS design withdrawal capacity. No explanation was given for the differences between the various withdrawal capacities as compared with the NDS values. Table 4 provides further examples of the variability in panel capacities and particularly the variation in fastener withdrawal capacity in relation to the NDS design values. It is possible that the density of the SYP lumber was lower than the nominal density assumed. However, a designer will typically assume the nominal value of wood density.

Table 4. Summary of Panel and Nail Withdrawal Capacities from a Variety of Tests

Framing Type	Sheathing Thickness (inches)	Fastener Type	Fastener Dia. (ring dia.) / Len. (in/in)	Fastener Spacing Edge & Interior (in)	# of Tests	Failure Pressure (psf)	Nail Withdrawal (lbs/in)	NDS Design (lbs/in)	Ratio Nail / NDS
SYP	19/32	8d Com.	0.131 / 2.5	6 & 6	7	127	91.8	41	2.24
SYP	19/32	8d Gal.	0.137 / 2.5	6 & 6	7	116	117.8	42	2.80
SYP	19/32	10d Coat	0.120 / 3.0	6 & 6	7	108	69.4	38	1.83
SYP	19/32	10d Sink	0.121 / 2.9	6 & 6	6	125	77.7	38	2.04
SYP	19/32	8d Ring	0.113(0.12) / 2.4	6 & 6	7	231	209.4	37	5.66
DFL	15/32	6d Com.	0.113/ 2.0	6 & 6	1	120	123.5	49	2.50
DFL	5/8	8d Com.	0.131/ 2.5	6 & 6	1	194	272.1	51	5.35
DFL	5/8	8d Ring	0.138(UK)/ 2.5	6 & 6	1	330	348.4	47	7.35
SYP	15/32	8d Com.	0.131 / 2.5	6 & 12	7	79	114	41	2.78
SYP	15/32	#8 Screw	0.111 / 1.9	6 & 12	7	169*	772	109	7.08
SYP	15/32	8d Com	0.131 / 2.5	6 & 6	6	153	93.4	41	2.28
SYP	15/32	8d Ring	0.113(0.12) / 2.4	6 & 6	7	158*	283.1	37	7.65
SYP	19/32	8d Ring	0.113(0.12) / 2.4	6 & 6	6	326	283.1	37	7.65

* The panel uplift capacities for these tests using 15/32-inch sheathing were limited by head pull through.

The data obtained with DFL lumber are from the study by Cunningham (Cunningham 1993). All the remaining data are from tests conducted at Clemson University. With the exception of the 8d common nail withdrawal capacities obtained by Cunningham, all of the smooth shank nail tests that were conducted in support of panel tests produced mean withdrawal capacities that are on average 2.25 times the NDS design values. The ring shank nails, manufactured by various suppliers, and screws have consistently produced withdrawal values that are about 6.5 or more times the NDS design values. It is also clear that when high capacity fasteners are used with thinner sheathing (15/32-inch versus 19/32-inch) the panel uplift capacities may well be limited by head pull-through capacities. In order to account for possible nail head pull-through in 15/32-inch sheathing material it is recommended that the ultimate withdrawal capacity be limited to 240 pounds for 8d fasteners with typical 8d head sizes (0.28-inches).

Design Guidelines

Any design procedure needs to begin with the NDS design values for nails or spikes since these values are readily available to the designer. These values are listed on a per-inch of penetration basis as a function of wood specific gravity and nail diameter in the NDS. Values can also be calculated from the equation:

$$W=1380*G^{5/2}*D$$

W is the design withdrawal capacity per inch of penetration, G is the specific gravity of the wood and D is the diameter of the nail in inches. For ring shank nails, D is the diameter of the rings.

Having selected or calculated the value of W, compute the total NDS design withdrawal capacity by multiplying W by the length of nail embedded in the structural member (nail length minus thickness of the sheathing). In order to estimate typical ultimate withdrawal capacities based on the nominal SYP density, multiply the total NDS design withdrawal values by 2.25 for smooth shank nails and by 6.5 for ring-shank nails. Divide the typical ultimate withdrawal capacities by the largest tributary area for a fastener. Then, in order to account for the difference between individual fastener capacities and capacities for complete panels, divide by 1.5 to obtain typical ultimate capacities for the panel. The 1.5 factor is the typical ratio of ultimate fastener capacity, computed on a per square foot basis for the fasteners with the largest tributary areas, divided by the average panel uplift capacity from full panel vacuum chamber tests. Finally, divide this value by the desired safety factor to obtain the allowable design pressure for the selected nailing schedule. This procedure can be expressed in equation form as:

$$\text{Design Pressure} = W*(L-T)*U_{wf} / (A*1.5*FS)$$ (see note below)

Where, L is the length of fastener in inches, T is the thickness of the sheathing in inches, U_{wf} is the ultimate withdrawal factor defined as the ratio between the typical ultimate withdrawal capacity and the NDS design value based on nominal wood density (2.25 for smooth shank nails and 6.5 for ring-shank nails in SYP), A is the largest tributary area for fasteners in square feet, and FS is the desired factor of safety.

The equation can be turned around to provide a means for calculating allowable nail spacing on interior members as follows:

$NS = W*(L-T)*U_{wf}*144 / (DP*RS*1.5*FS)$ (see note below)

Where NS is the nail spacing in inches, RS is the rafter spacing in inches, DP is the design pressure in pounds per square foot, and the other variables are as defined above.

Note: In order to account for possible head pull-through, the value of $W*(L-T)*U_{wf}$ should be limited to 240 pounds for typical 8d fasteners in 15/32-inch sheathing material and to 500 pounds for typical 8d fasteners in 19/32-inch sheathing.

CONCLUSIONS

If a safety factor of two is selected, the equation listed above would yield an allowable design pressure of 58 psf for 8d smooth shank nails (0.131-inch diameter by 2.5-inch long) installed at a 6-inch spacing on 19/32-inch sheathing. This is in good agreement with the results of the 40 panels tested with 8d smooth shank nails at 6-inch spacing (allowable design pressure of 63 psf). The 58 psf design pressure is exceeded for a gable roof house with mean roof height greater than 25 feet in an exposure C location for a design wind speed of 100 mph. For an exposure B location, the design pressure would be exceeded for a gable roof house with mean roof height greater than 35 feet for a design wind speed of 110 mph and any roof height for design wind speeds of 120 mph or greater. Thus the use of 8d smooth shank nails at a 6-inch spacing does not provide adequate protection for may houses even in the lowest wind zones specified in Florida and certainly not for any houses in high-wind hurricane prone regions, such as the HVHC. In contrast, for the same safety factor, the equation listed above would yield an allowable design pressure of 149 psf for 8d ring-shank nails (0.125-inch ring diameter by 2.375-inch long) installed at a 6-inch spacing on 19/32-inch sheathing. This is also in good agreement with the results of the 40 panels tested with 8d ring-shank nails at 6-inch spacing (allowable design pressure of 146 psf). The 149 psf design pressure is adequate for enclosed gable roof houses with mean roof heights up to 40 feet in an exposure C location for a design wind speed of 150 mph. The estimated cost of switching to 8d ring-shank nails from 8d smooth shank nails is about $8.00 for a typical 2000 square foot house.

When it comes to the gable end overhang, the use of 10d smooth shank nails (0.148-inch diameter by 3.0-inch long) installed at a 4-inch spacing produces an allowable design pressure of 124 psf. While this value is more than double the allowable design pressure for the 8d nails at 6-inch spacing, it is not adequate for buildings in exposure C with mean roof height greater than 20 feet and a design wind speed of 150 mph. Use of the 8d ring-shank nails at 4-inch spacing along the last gable truss would provide an allowable design pressure of 224 psf. This capacity is considerably higher than the design uplift pressure of 160 psf for zone 3 overhangs on houses with mean roof height up to 40 feet in Exposure C for a design wind speed of 150 mph. Thus the switch to 8d ring-shank nails with a 6-inch spacing in the field of the roof and around the perimeter of the roof; and, a 4-inch spacing attaching the sheathing to the last gable truss would provide adequate margins for homes with mean roof heights up to 40 feet in exposures B and C in the HVHZ region. Note that ASCE 7-02 has removed the exposure D classification for the hurricane coastline because of the expected roughness of the sea close to shore in a major hurricane. Thus, the switch to 8d ring-shank nails will be suitable for any house with mean roof height up to 40 feet in any exposure in the HVHZ region. In addition, it will allow use of the same nail and tools for all the fasteners instead of switching to 10d nails at the gable ends of the roof.

The only potential hiccup in the switch is that there is no national standard for the manufacture of ring-shank nails. Consequently, the IHC code change proposal includes specifications that the minimum shank diameter be 0.113-inches and that the diameter of the rings be a minimum of 0.012-inches larger than the un-deformed shank diameter. This ensures that the rings provide a substantial grip on the wood.

The bad news is that the current prescriptive requirements for sheathing attachment in the HVHZ provide an inadequate margin of safety against roof sheathing uplift failure. The good news is that a simple switch to an 8d ring-shank nail can provide the needed margins of safety with a minimal cost impact to the building industry.

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APPENDIX E

<u>NAIL CHART</u>

The International Hurricane Research Center
Florida International University
June 2003

3.1b ROOF TO WALL CONNECTIONS SUBJECTED TO COMBINED LOADS

Background

The IHRC Team emphasizes, whenever possible, research involving testing of full scale building assemblies. This approach produces results that are an accurate and credible representation of reality. Extrapolating from these results to actual applications is a simple and straightforward process. The IHRC Team believes this method will foster the development of practical hurricane loss reduction methods and techniques that will be supported by building design, construction and code professionals.

One specific area of research the IHRC Team has engaged in focuses on the connection of roof assemblies to the walls of the house. This connection is critical to the integrity of the building envelope, a tremendously important consideration when a house suffers the impact of a hurricane.

Connections between roof trusses or rafters and walls are required to transmit a complex set of loads from the roof structural system into the walls which then transmit these loads to the foundations. In general, the connections experience uplift loads on the roof that are transmitted into the walls, shear forces developed through the roof diaphragm action and out-of-plane loads on the walls. During the 2001-2002 research year, load interaction diagrams were developed for two common types of hurricane straps used in wood frame construction. The interaction diagrams demonstrated that the hurricane strap connections could be designed for a combined set of loads using a vector combination of the design, allowable or ultimate loads. During the 2002-2003 research period, these studies have been extended to connections between roof framing members and masonry walls. The testing of these connections using masonry walls is especially relevant to the housing industry in Southeast Florida and other areas where CBS construction is prevalent. A total of five different connectors were evaluated through testing of 20 reinforced masonry walls.

Objectives and Scope

The objective of this research was to develop load interaction diagrams for use in the design of roof-to-wall connections between masonry walls and wood frame roof structural members, when they are subjected to combinations of uplift, shear and out-of-plane loading. This objective was met through the execution of a series of full-scale roof-to-wall system tests. Roof-to-wall connections for poured-in-place reinforced concrete tie beams (Dade and Broward County construction) and for CMU grout filled reinforced bond beams (masonry construction in much of the rest of the State of Florida) were tested. A total of twenty walls were constructed using five different types of straps commonly used in the State of Florida. Since the cost to construct and test the masonry walls was much higher than that associated with the construction and testing of the wood frame walls investigated in the 2001-2002 period, it was only possible to construct and test a limited number of walls. Consequently, the tests focused on various combined load cases and single direction loading was generally not investigated.

Modifications to the Test Apparatus

During the 2001-2002 period the IHRC Team developed and built a test apparatus or testing roof-to-wall connections using light frame wood construction. As such it included a steel beam at the base where the wood frame wall could be anchored to the test apparatus and all the forces generated were internal to the reaction frame. In order to facilitate construction and testing of masonry walls, it was necessary to modify the test apparatus so that the walls could be cast in place on a large outdoor concrete slab and the reaction frame could than be moved to each wall for testing.

The modifications involved moving the steel beam at the base of the test apparatus back out of the plane of the wall and modifying the base of the test apparatus so that steel wheels could be installed when it was time to move the wall. The process for moving the reaction frame involved jacking up the four corners of the test apparatus, inserting plates with steel wheels into slots on the base of the test apparatus and then lowering the frame onto the wheels. The test apparatus was then jockeyed into place so that the wall was aligned with the loading jacks for uplift and shear. The test apparatus was then jacked up again, the wheels were removed and the apparatus was lowered onto the concrete slab. Since the test apparatus was not attached to the base of the wall, it was blocked against the wall to prevent movement of the test apparatus during testing. Figure 1 shows the bare reaction frame test apparatus supported by its steel wheels amongst a number of the reinforced masonry walls. Figure 2 shows the test apparatus nestled up against on of the wall specimen following testing using a spreader beam that facilitated proportional loading in uplift and shear. The proportional loading apparatus was used on the first couple of walls tested but was abandoned because the hydraulic ram and 20-kip load cell had insufficient capacity to support the loads required to cause failure of the connections. The remaining walls were tested using two independent hydraulic rams, one for uplift and one for shear. Drag struts used to apply shear loads in the plane of the wall and the anchorage of the rafter tails for resisting out-of-plane loads are shown in Figure 3.

Figure 1. Bare Reaction Frame Supported on Steel Wheels for Movement to Test Specimen.

Figure 2. Combined Load Test Apparatus in Position Following Test of Wall Using Proportional Uplift and Shear Loading Attachment.

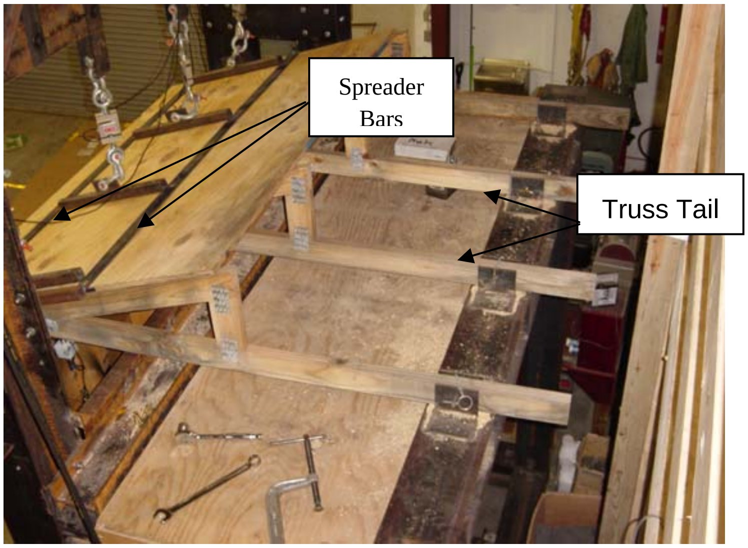


Figure 3. Spreader Bars for Applying Shear Loads to Sheathing and Rafter Tail Anchorage to Resist Out of Plane Loading from Air Bags.

When independent vertical and lateral loads are applied as illustrated in Figure 3, the vertical load on the test specimen is applied through the hydraulic ram shown at the top center of the reaction frame. The load is applied to the roof structure through a loading tree that is linked to brackets that are attached with lag screws to the roof truss members. These vertical loads are applied directly above the hurricane straps and the system simulates the action of uplift on the roof sheathing that is subsequently passed through the hurricane straps and into the walls. Since the focus of these tests is the reaction of the hurricane straps, this load approach provides a reasonable simulation of the actual uplift loading on the straps. A hydraulic ram that is aligned with the level of the roof sheathing is used to apply lateral loads to the roof structure. This is accomplished through two steel bars that act as drag struts across the roof and are attached with lag screws to the top of each truss. It was necessary to use a pivot connection in attaching the lateral ram in order to prevent damage to the ram when the roof failed in uplift. The reaction wall and airbag are located directly behind the wall specimen. Secondary supports and a pin connection system is provided at the back of the reaction frame so that the trusses will not shift forward when the air bag is inflated. When air bag pressures were included in the tests, it was necessary to use a forklift to block the reaction frame against the wall specimen in order to prevent movement of the reaction frame.

Construction of Wall Specimen

Twenty reinforced concrete masonry wall specimens were constructed following the prescriptive criteria in the Florida Building Code. An emphasis was placed on ensuring that the walls were strong enough to force the failure into the hurricane strap roof-to-wall connection. All wall specimens consisted of wall segments 7-feet, 4-inches wide with a finished height of 8-feet, 8-inches. They were constructed from 8-inch thick CMU units that were vertically reinforced with 3 #6 bars, one in each of the end cells of the wall segment and one in a line of cells at the middle of the wall. The walls were anchored to the test slab using 3 #5 bars, epoxy grouted into the slab using a 6-inch embedment length and extending 36-inches into the wall. The development length of the lap splice between the #5 bars in the slab and the #6 bars in the CMU cells was 36-inches. The vertical cells with the reinforcing were fully grouted.

The primary difference between the walls developed for the High Velocity Hurricane Zone prescriptive requirements and those for the remainder of the state were at the tops of the walls. The HVHZ walls used reinforced concrete tie beams, 12-inches tall with 4 #6 bars as longitudinal reinforcing in the tie beam. The walls built to reproduce reinforced masonry wall connections for the remainder of the state used 8-inch tall CMU bond beam units with a single #6 bar running through the bond beam. In each wall, the vertical reinforcing was bent at 90 degrees with a 36-inch development length in the lap splice along the length of the CMU bond beam or reinforced concrete tie beam. The walls were further laterally reinforced using 9-gage ladder type reinforcing on alternate mortar joints. The 4 #6 bars in the reinforced concrete tie beams, two in the top and two in the bottom of the beam, were bound together using #3 ties at 12-inches on center as shown in Figure 4. In Figure 4, the reinforcing cage for the reinforced concrete tie beam has been lifted up and out of the way in preparation for grouting of the cells with the vertical reinforcing. Figure 5 shows the top of the CMU bond beam walls with the reinforcing in place before grouting of the vertical reinforcing and the CMU bond beam.

Figure 4. Reinforcing Cage and Formwork for Casting Reinforced Concrete Tie Beams for HVHZ Walls.

Figure 5. Reinforcing Bars in Top of CMU Bond Beam.

Compression tests were performed on the mortar used to lay the CMU units, the grout used to grout the cells with the vertical reinforcing and the CMU bond beam, and the concrete used to pour the reinforced concrete tie beams. The average mortar compressive strength based on 6 samples was 5077 psi with a low of 4464 psi and a high of 5555 psi. The average grout compressive strength based on 3 cubes was 4693 psi with a low value of 4129 psi and a high value of 5023 psi. The grout had a slump of 10 inches. Two 6-inch cylinders were tested of the concrete used in the reinforced concrete tie beams. The average compressive strength of the concrete was 3329 psi with a high value of 3516 psi and a low value of 3141 psi. The concrete had a slump of 4 to 5 inches.

Six of the CMU bond beam walls were outfitted with Simpson Strong-Tie HETA 20 hurricane straps and four were outfitted with Simpson Strong-Tie HETAL 20 hurricane straps. Five of the reinforced concrete tie beams were outfitted with Simpson Strong-Tie HETAL 20 hurricane straps, three were outfitted with NU VUE Industries NVSTA 20 hurricane straps and two were outfitted with NU VUE Industries NVHTA 20 hurricane straps.

During the grouting of the CMU bond beams, the hurricane straps were held in place using blocks of wood attached to the edges of the CMU blocks as shown in Figure 6. The hurricane straps used in the reinforced concrete tie beams were held in place using wood blocks that were nailed to the top edges of the formwork as shown in Figure 7. Figure 8 shows a completed wall with a reinforced concrete tie beam and the NVHTA 20 hurricane straps.

Figure 6. Simpson Strong-Tie HETAL 20 Placement in CMU Bond Beam Before Grouting of Bond Beam.

Figure 7. Simpson Strong-Tie HETAL 20 Placement in Reinforced Concrete Tie Beam.

Figure 8. NU VUE Industries NVHTA 20 Hurricane Straps in Finished Reinforced Concrete Tie Beam Wall.

Performance of Hurricane Straps for Masonry Walls Under Combined Loading Conditions

The test program included a total of 20 tests on an assortment of straps for two types of wall bond beams / tie beams. Because of the limited number of test specimen, it was not possible to tests a particularly wide range of load combinations for each type of strapping. Table 1 provides a listing of the results from the twenty tests. Typically, allowable values are based on the minimum of the ultimate capacity divided by three, the load at $1/8^{th}$ inch deflection or the design load from the NDS for the nails used to attach the straps. Allowable loads have been estimated for these tests by simply dividing the ultimate value by three. Vertical deflections were also monitored during the tests and the load corresponding to $1/8^{th}$ inch vertical deflection is also reported in Table 1 when available. The loads corresponding to $1/8^{th}$-inch vertical displacement were greater than $1/3^{rd}$ of the ultimate uplift capacity. For lateral loads, the magnitude of the displacements depended, for some straps, on whether the load tended to push the truss towards the strap or pull the truss away from the strap. This was particularly true for the HETAL 20 straps where a plate is integrated into one side of the strap. The direction of loading relative to the side of the truss where the strap was anchored is also listed in Table 1.

In all of these tests a major failure occurred when one of the straps fractured. None of the reinforced concrete tie beams or CMU bond beams suffered any damage. However, in some cases, the lateral loads may be limited to values lower than those listed in Table 1 if the load was applied such that the truss tended to pull away from the strap. Lateral deflections at the midpoint of the truss tail above the wall were measured during the tests. However, these measurements included a significant amount of roll in the truss since no blocking was installed between the trusses.

The combinations of allowable uplift and shear forces listed in Table 1 that are based on the loads at failure divided by 3 are plotted against each other in Figures 9 through 13 to produce interaction diagrams. Also plotted in these figures are two curves based on various combinations of allowable uplift and shear derived from the manufacturer's published allowable uplift and shear capacities. The straight dashed line shown in each graph is derived from a linear combination of the published allowable values for uplift and shear as expressed by:

$$\text{(Design Uplift/Allowable Uplift)} + \text{(Design Shear/Allowable Shear)} < 1.0$$

It is clear from these graphs that this relationship provides a conservative definition of the allowable loading under combined load effects. The actual failure surface is probably better represented as a vector combination as shown by the curved solid line.

That vector combination can be expressed by:

$$[\text{(Design Uplift/Allowable Uplift)}^2 + \text{(Design Shear/Allowable Shear)}^2]^{1/2} < 1.0$$

Table 1. Results of Combined Load Tests for Masonry Wall Roof-to-Wall Strapping.

Type of Strap	Type of Wall Bond Beam	Lateral Pressure On Wall	Uplift per Connector at Failure	Allowable Uplift (Uplift at Failure/3)	Shear per Connector at Failure	Allowable Shear (Shear at Failure/3)	Direction of Load Application (Relative to Strap)	Uplift at 1/8th-inch vertical deflection
HETA 20	U Bond Beam	None	1847	616	1791	597	Away	1800
		None	1956	652	1935	645	Away	1800
		None	3194	1065	792	264	Away	2031
		150 psf	3167	1056	909	303	Away	2403
		None	3263	1088	589	196	Away	2431
		150 psf	3130	1043	996	332	Away	?
HETAL 20	CMU Bond Beam	None	3129	1043	2245	748	Towards	2875
		None	3605	1202	1089	363	Towards	3217
		150 psf	3432	1144	787	262	Towards	2513
		None	3755	1252	618	206	Towards	3295
HETAL 20	RC Tie Beam	None	2744	915	525	175	Away	?
		None	3619	1206	375	125	Away	3540
		None	2607	869	766	255	Away	2181
		150 psf	2916	972	1000	333	Away	?
		None	2740	913	998	333	Away	2317
NVSTA 20	RC Tie Beam	None	3263	1088	1771	590	Away	2141
		150 psf	3667	1222	893	298	Away	2900
		None	3573	1191	322	107	Away	3025
NVHTA 20	RC Tie Beam	None	4649	1550	2397	799	NA	?
		None	5550	1850	0	0	NA	4751

In a few selected cases, the tests included a 150 psf lateral load applied to the wall using an airbag. With an 8-foot tall and a 6-foot wide airbag, the average out of plane load applied to the straps based on tributary area considerations was 900 pounds per connector. The flexural rigidity of the reinforced masonry wall may have directed more than half of the lateral load to the base so that the actual average load on the strapping may have been slightly lower than 900 pounds. Nevertheless, this relatively large out of plane loading did not appear to reduce the ability of the strapping to resist uplift and shear forces as indicated by the solid circle symbols on the graphs in Figures 9 through 13.

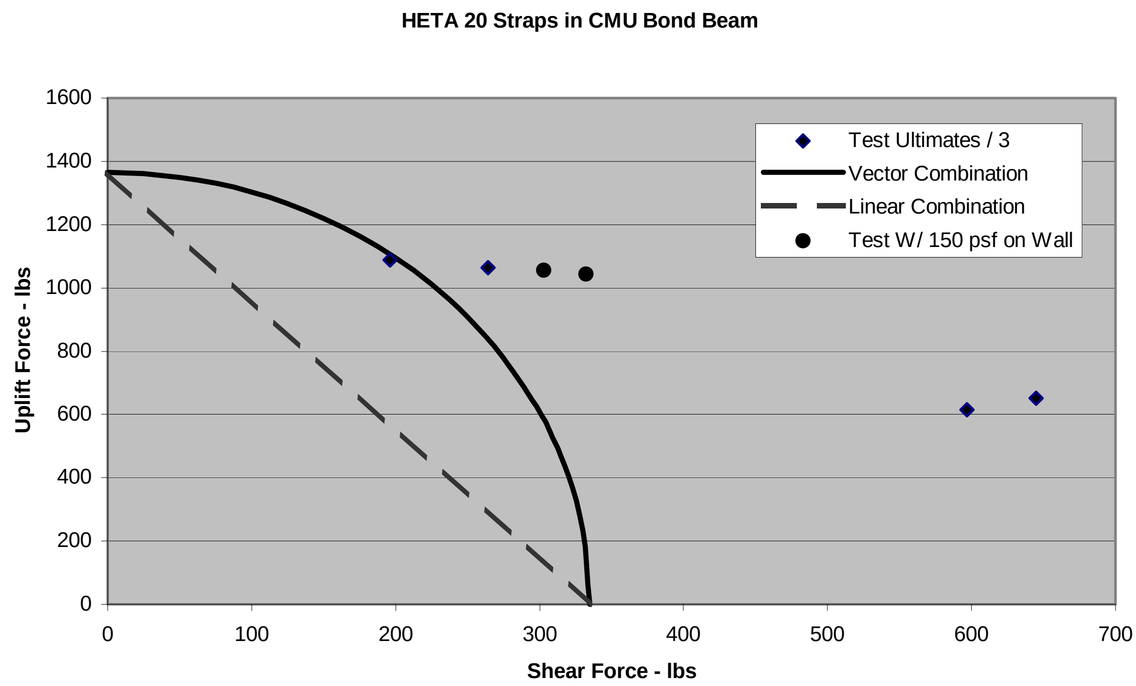


Figure 9. Load Interaction Diagram for HETA 20 Straps installed in CMU Bond Beams.

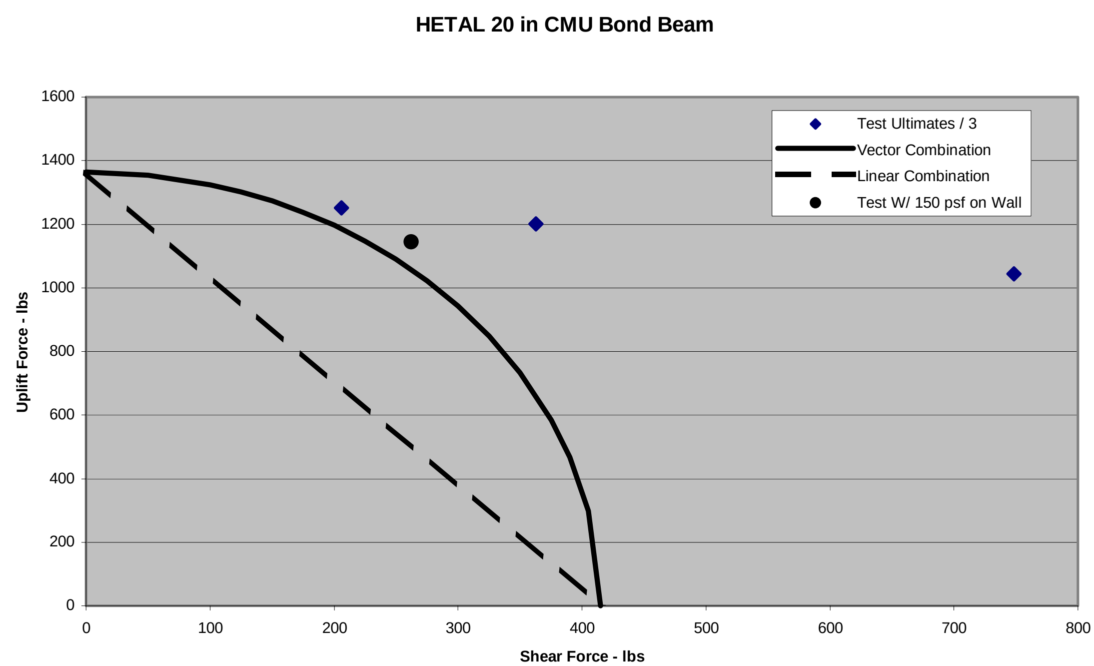


Figure 10. Load Interaction Diagram for HETAL 20 Straps installed in CMU Bond Beams.

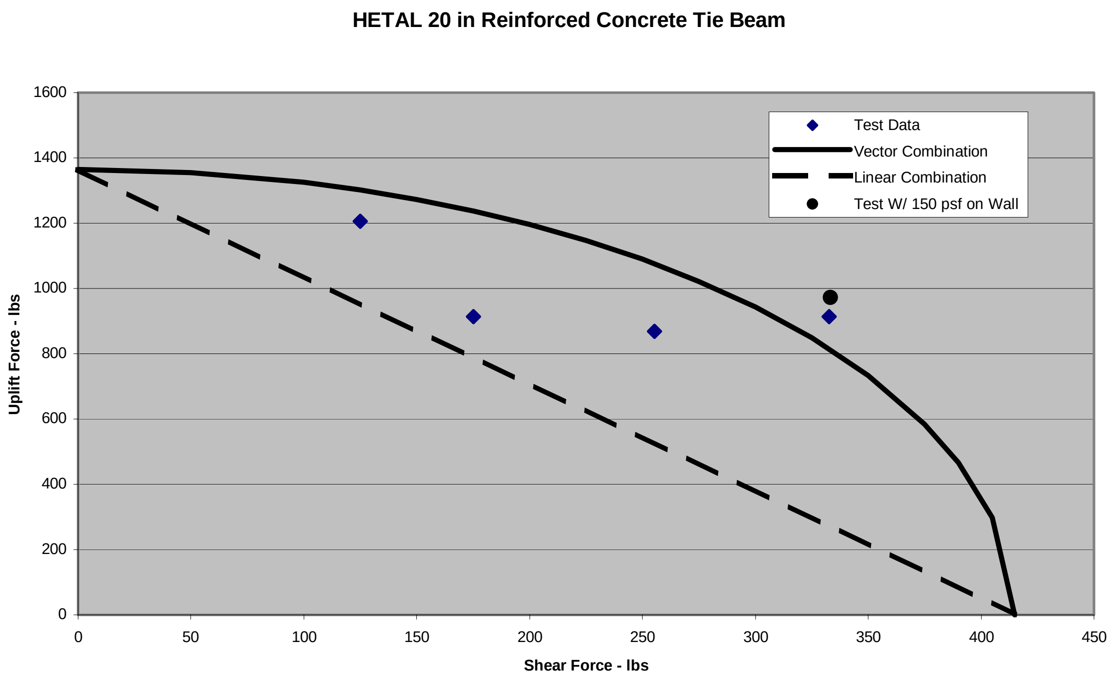


Figure 11. Load Interaction Diagram for HETAL 20 Straps installed in Reinforced Concrete Tie Beams.

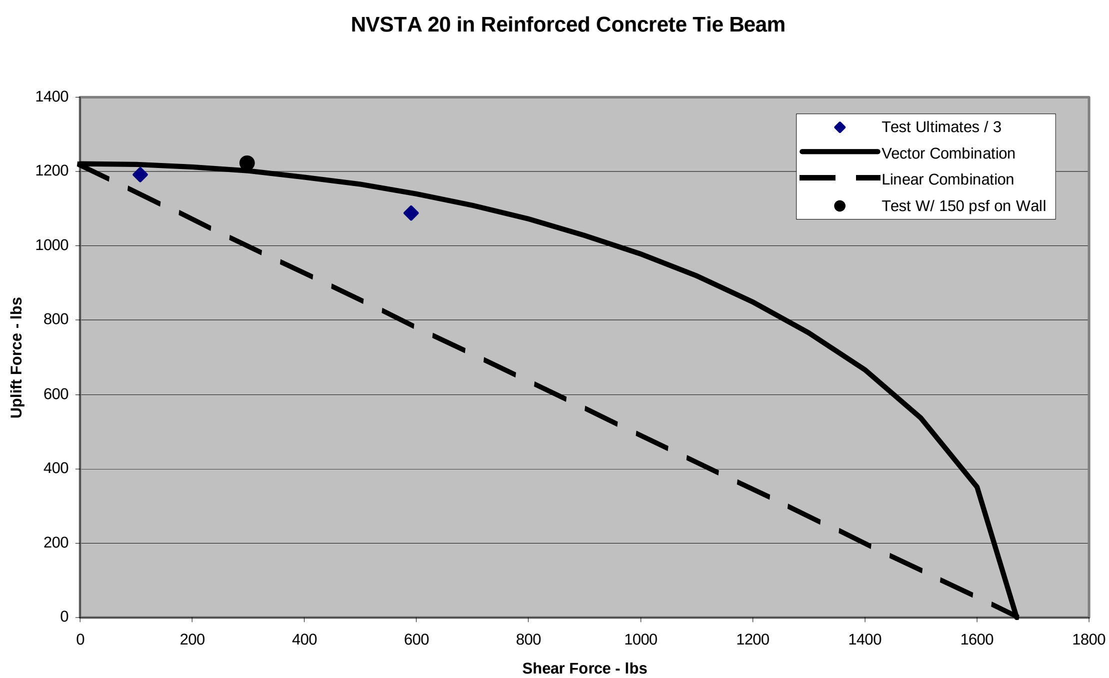


Figure 12. Load Interaction Diagram for NVSTA 20 Straps installed in Reinforced Concrete Tie Beams.

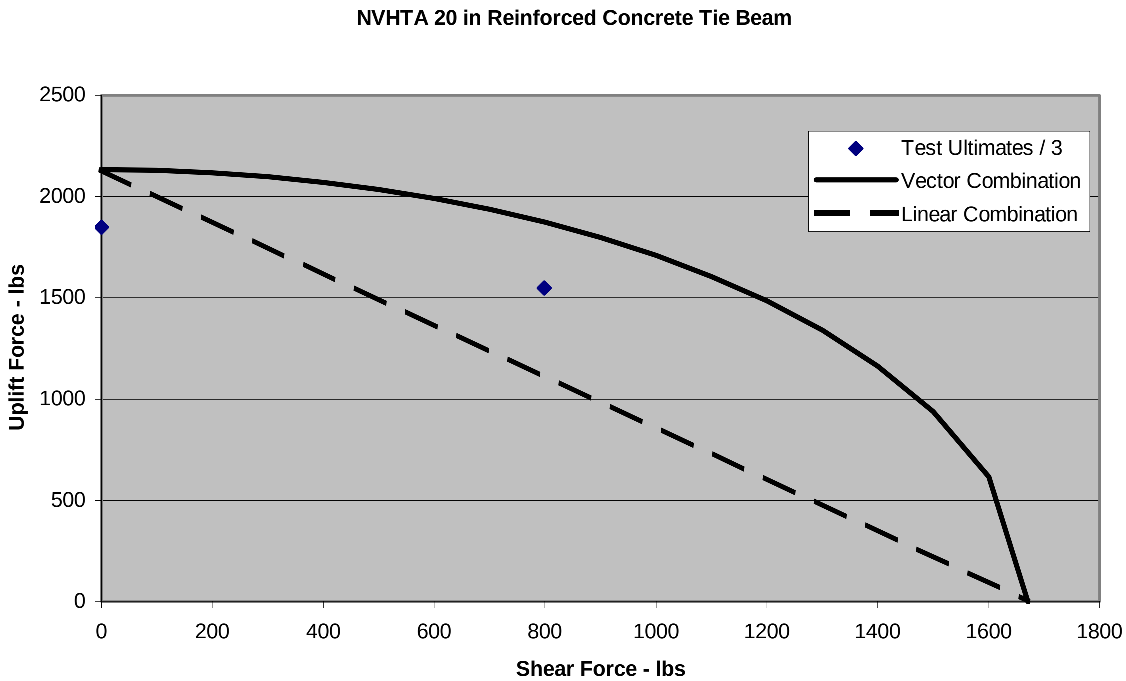


Figure 13. Load Interaction Diagram for NVHTA 20 Straps installed in Reinforced Concrete Tie Beams.

By adjusting the allowable uplift and shear values slightly from the published values, it is possible in Figures 14 through 18 to illustrate how well the vector relationship models the interaction diagrams. The one case that tends to only weakly support the relationship is the case of the HETAL 20 straps in the reinforced concrete tie beam. It appears that the loading of the trusses, such that they were pulled away from the straps and seats, reduced the lateral and uplift capacities more than for the other straps where loads were also applied away from the side of the truss where the straps were attached.

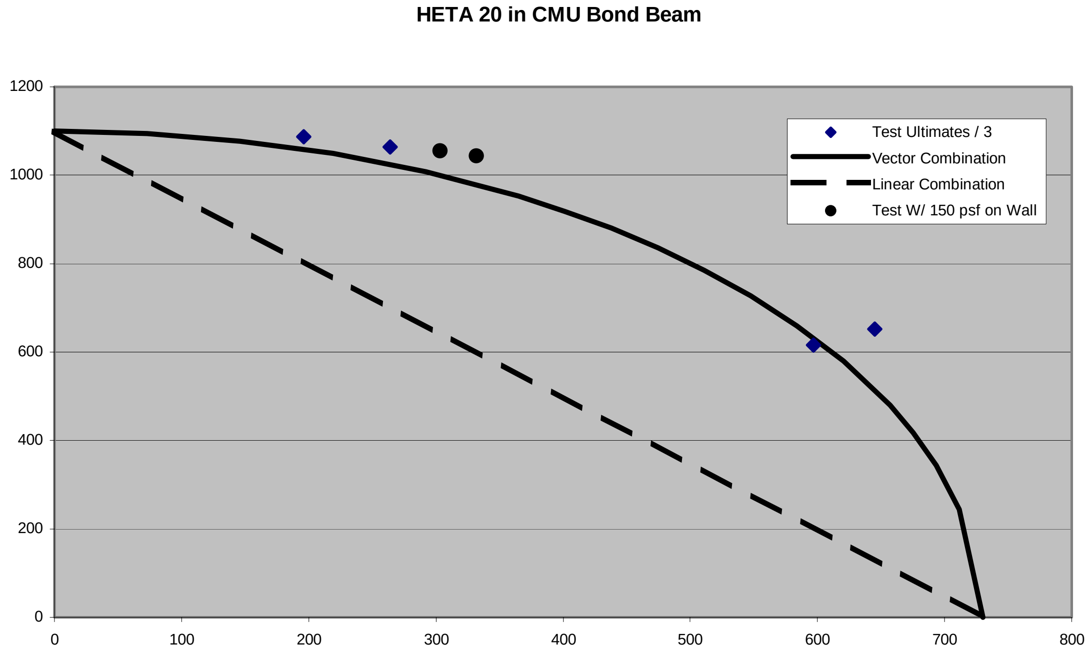


Figure 14. Load Interaction Diagram with Modified Allowable Loads for HETA 20 Straps installed in CMU Bond Beams.

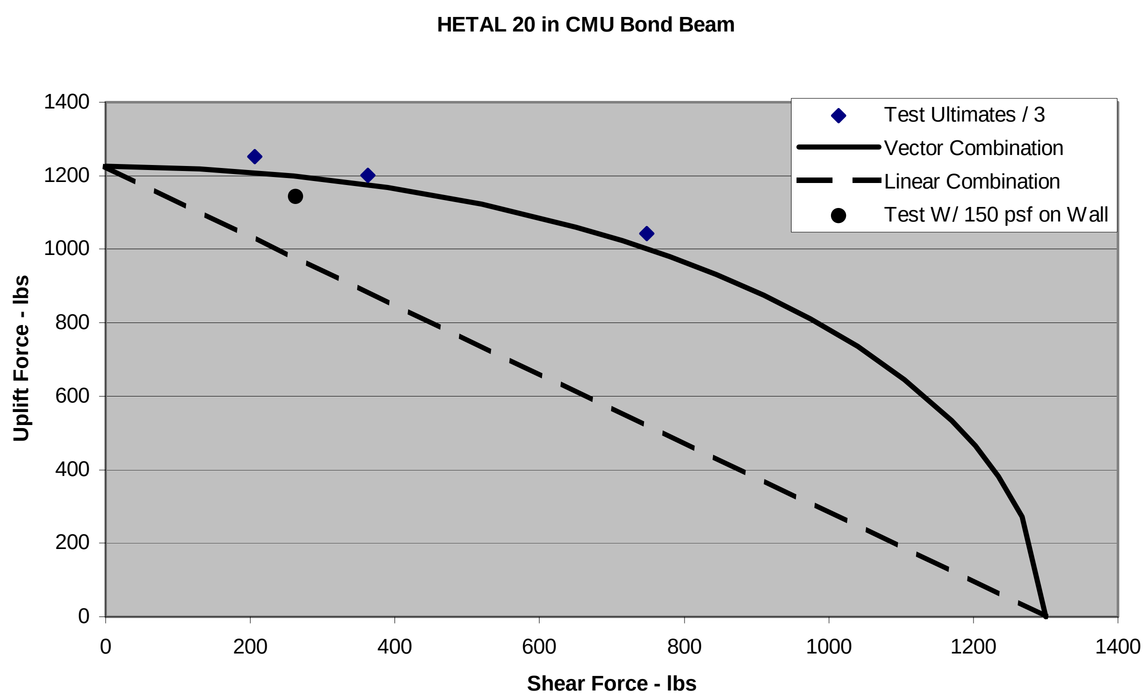


Figure 15. Load Interaction Diagram with Modified Allowable Loads for HETAL 20 Straps installed in CMU Bond Beams.

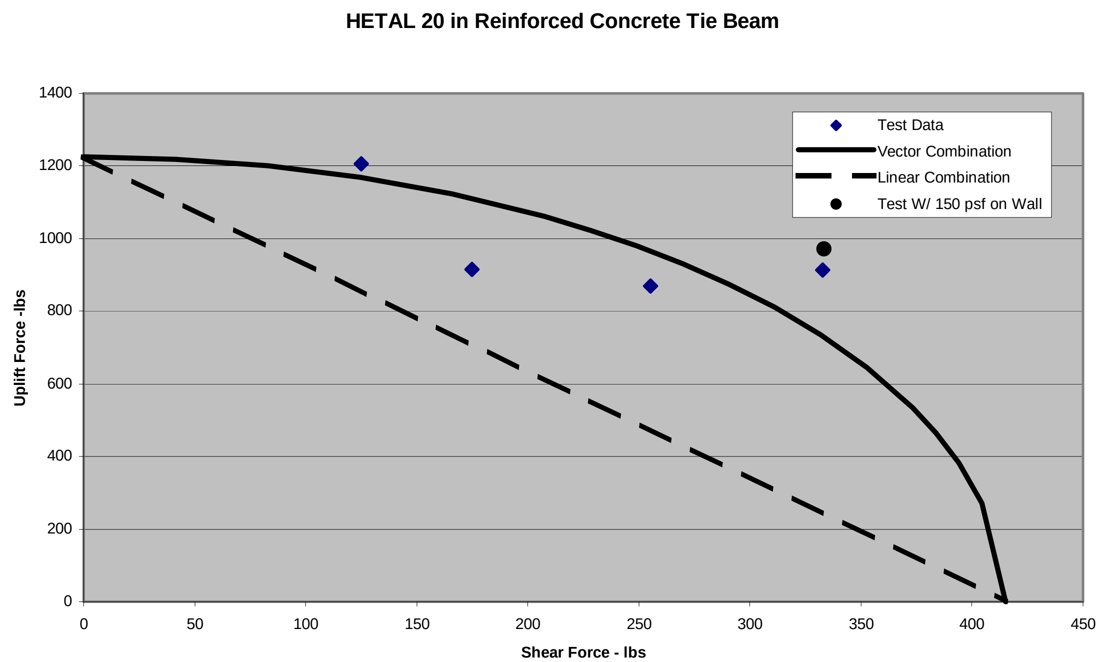


Figure 16. Load Interaction Diagram with Modified Allowable Loads for HETAL 20 Straps installed in Reinforced Concrete Tie Beams.

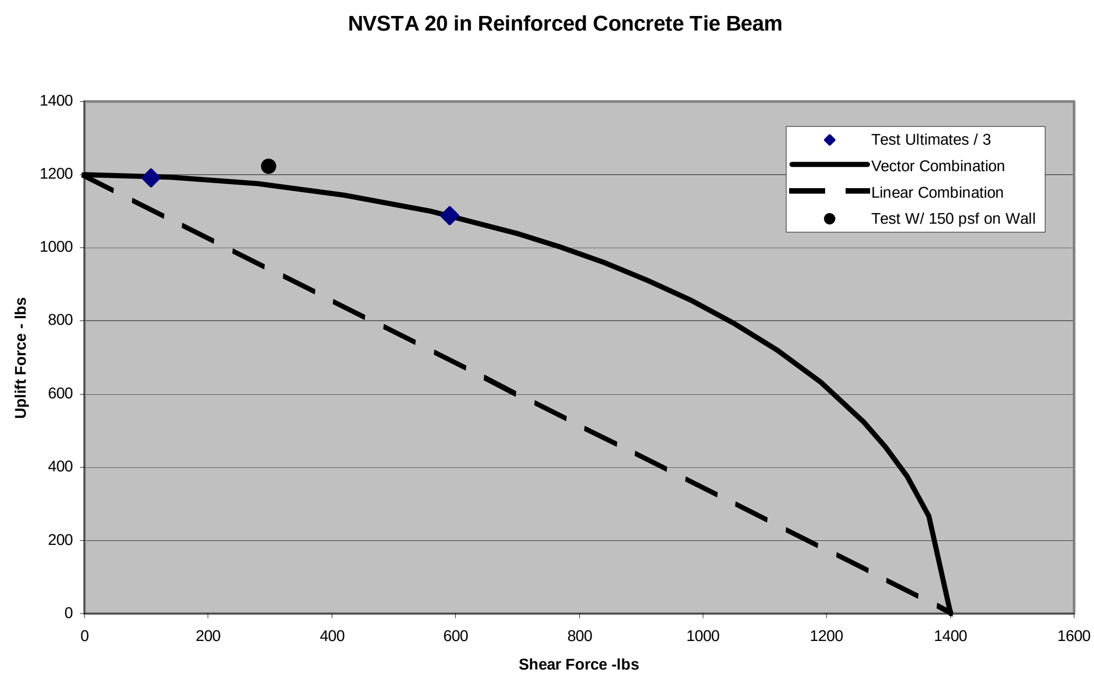


Figure 17. Load Interaction Diagram with Modified Allowable Loads for NVSTA 20 Straps installed in Reinforced Concrete Tie Beams.

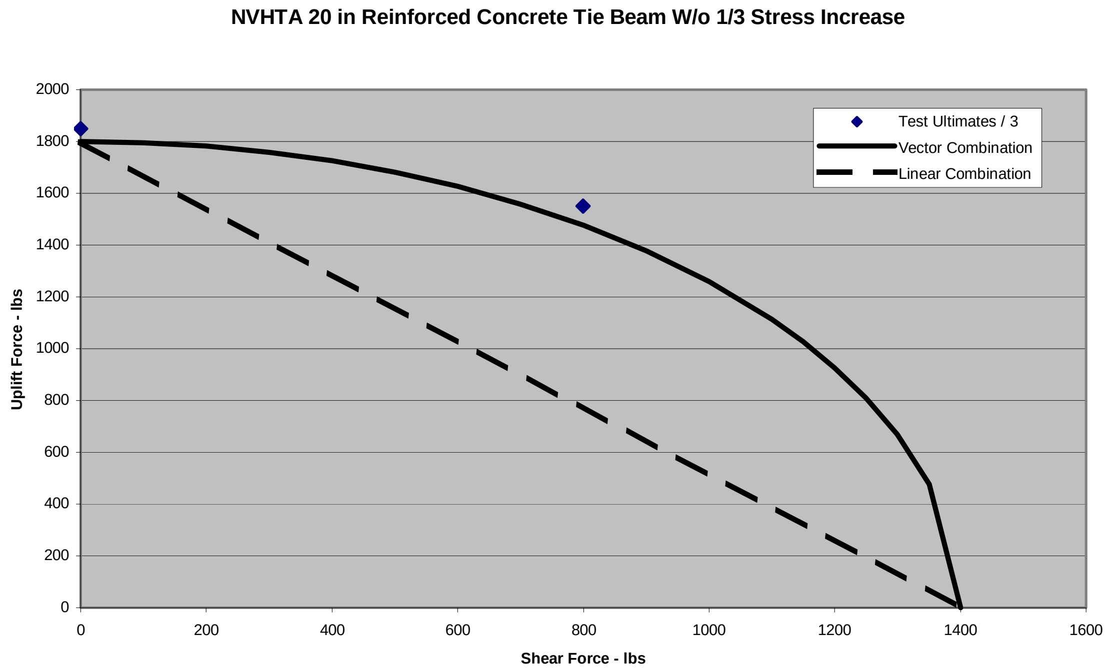


Figure 18. Load Interaction Diagram with Modified Allowable Loads for NVHTA 20 Straps installed in Reinforced Concrete Tie Beams.

The combined load relationships exhibited by the data obtained from these tests indicates that typical hurricane strapping commonly being used throughout the State of Florida may have greater capacities for resisting combined loads than designers are currently allowed to use. Specifically, the SBCCI evaluation report for the NVHTA and NVSTA straps states that the uplift, shear and out of plane loading capacities listed in the evaluation report cannot be combined. It further states, “The connectors shall be subjected to loads in one direction only.” Similarly, the 2003 Simpson Strong-Tie catalog is silent when it comes to designing masonry connectors for combined loading. In the wood fastener section it does include an equation for treating combined loads that follows the linear model illustrated by the dashed lines in Figures 9 through 18. These results parallel the findings from the tests conducted during year two for hurricane straps used in wood frame walls.

These findings, if they are further expanded and corroborated, can lead to more economical roof strapping designs that are easier to build, reduce costs and still provide adequate safety margins.

Should these forecast be realized, this would be another example of how the Hurricane Loss Mitigation Program – RCMP and the research work of the IHRC contribute cost-effective solutions, toward the objective of hurricane loss mitigation.

3.1c PERFORMANCE OF ROOF COVERINGS

Background and Objectives

Roof coverings are part of the first line of defense against wind induced damage in a hurricane. In hurricane Andrew, nearly all of the properties filing claims for losses suffered damage to roof coverings. Today, the High Velocity Hurricane Zone requirements for product approval of roof coverings and the detailed methods of installation are widely regarded as the most stringent and most likely to perform well in a major hurricane event. Nevertheless, little is known about the true loading conditions imposed when roof samples are subjected to TAS 100, “Testing Procedure for Wind and Wind Driven Rain Resistance of Discontinuous Roof Systems,” and TAS 107, “Test Procedure for Wind Resistance Testing of Non-Rigid, Discontinuous Roof System Assemblies.” The basic assumption appears to be that the critical case for shingle performance is tab lifting for winds blowing directly over the shingle tabs. TAS 107 is aimed at evaluating roof shingles for these types of loading. The Asphalt Roofing Manufacturer’s Association has proposed a simple tab uplift test that would replace TAS 107. However, this proposal has not yet received widespread support and TAS 107 or a similar ASTM test currently remains the test of choice. Part of the argument for a tab lift type of test lies in the expectation that the shingles form a porous covering that results in equalization of pressures between the top and bottom surfaces of the shingles, thus reducing the loads on the shingles. The wind loads imposed on the roofing shingles in a TAS 107 type test need to be determined as part of the effort to try to understand the potential differences between TAS 107 and a tab uplift test.

Furthermore, despite the fact that shingles are frequently lost from gable ends of roofs in strong winds, no test exists for evaluating shingle performance for these conditions. Instead, enhanced performance is sought through minimizing the shingle overhang along the edges of the roof and through cementing of the shingles around the perimeter of the roof to the metal drip edge and underlayment. The latter step effectively creates a non-porous membrane around the edge of the roof that may make it more susceptible to uplift loads associated with the large suction forces imposed by winds separating over the roof. If the shingle layer is not as porous from a wind pressure standpoint as expected, and in areas along the edges where the shingles are cemented to the decking, the nails and adhesives must provide adequate strength to resist the uplift forces imposed by local wind effects as well as the larger scale suction loads associated with the overall flow separation over the roof. The current research program on the performance of roof coverings is intended to question and probe the issues that affect the performance of porous roof coverings and to obtain basic scientific data that will help to establish the validity and limitations of the current test methods and point towards possible modifications and simplifications, if improvements are warranted.

The first steps in this program have centered on developing a more thorough understanding of the physics involved in the current test protocols. To that end, facilities have been created that are suitable for reproducing the current test protocols with an emphasis on carrying out measurements that help to define the actual loading conditions being imposed on the test specimen in the TAS 107 and TAS 100 tests.

High Velocity Wind Testing of Shingles (TAS 107)

A wind tunnel facility suitable for conduct of the TAS 107 test protocol was designed and constructed in FY 02. Shakedown testing of the facility and modification of the drive section to include a honeycomb flow straightener was completed in FY 03 along with testing to determine wind pressure variations over the edges of a typical three-tab shingle and an architectural shingle. The wind tunnel test facility is shown in Figure 1. The variation in the flow across the orifice, with the honeycomb in place, is less than 1.5% of the mean velocity. This is well within the bounds of a 5% variation specified in TAS 107.

Figure 1. TAS 107 Wind Tunnel.

Wind speeds are monitored using a Pitot Tube mounted in the top center of the orifice that is connected to a Certified Setra Electronic Manometer.

Once the suitability of the test facility was established, exploratory tests were conducted using TAS 107 test specimen covered with 3-tab and architectural shingle samples that had already passed the TAS testing and been certified for use in the HVHZ. As opposed to the standard two-hour pass/fail testing with the wind tunnel blowing wind at 110 mph over the sample, a series of pressure tests were conducted. Results are presented for the architectural shingle specimen. A drawing of the shingle layout on the portion of the test specimen where the instrumentation was located is presented in Figure 2. The pressure tests involved the installation of pressure taps as outlined in the enlarged sketch of the instrumented area, Figure 3. A photograph of the section of the architectural shingle specimen with the pressure taps is shown in Figure 4. Three taps (8, 9, and 16 – see Figure 3) were installed in such a way that they measured the pressure in the layer between the felt paper and the bottom of the shingles. Five taps (6, 7, 11, 12, and 13 – see Figure 3) were installed so that they measured the pressures between the layers of shingles. Tap 13 is on the windward side of the adhesive sealing strip that seals down the edge of the shingle and 12 is just on the downwind side of the adhesive sealing strip. Taps 2, 3, 4, 5, 10, 14, and 15 (see Figure 3) are installed so that they measure the pressures on the top surface of the shingles.

Pressures at each tap location were measured at wind speeds of 70 and 110 mph. Table 1 presents mean pressure coefficients obtained at each tap location for each wind speed. The mean pressure coefficients are nearly identical for the two wind speeds indicating that Reynold's Number effects are not an issue and that it is possible to measure pressures between the various layers using conventional pressure tap technology with actual roof shingle specimen. Testing conducted in support of the ARMA tab uplift test used an artificial shingle specimen with pressure taps and lines embedded in the specimen. The successful measurements also suggest that a test building could be outfitted with pressure taps to measure the wind pressure distributions across the shingles in natural winds.

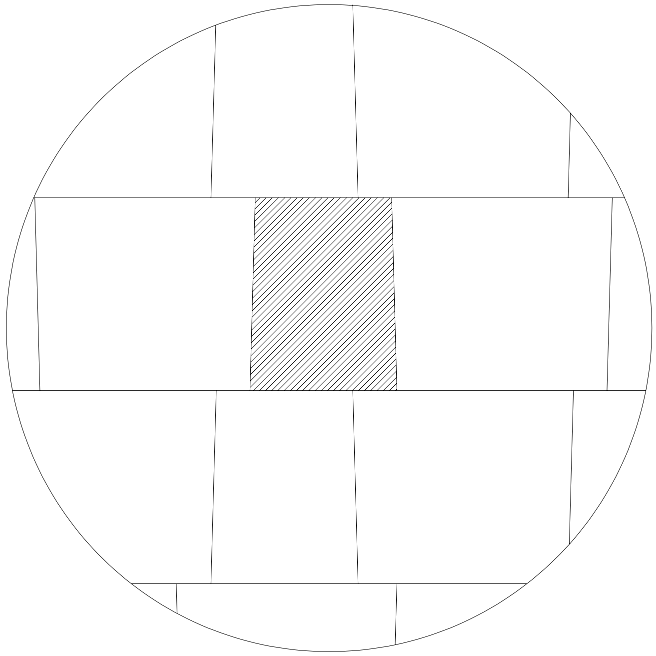


Figure 2. Drawing of TAS 107 Test Specimen Showing the Layout of the Architectural Shingles and the Location of the Instrumented Section.

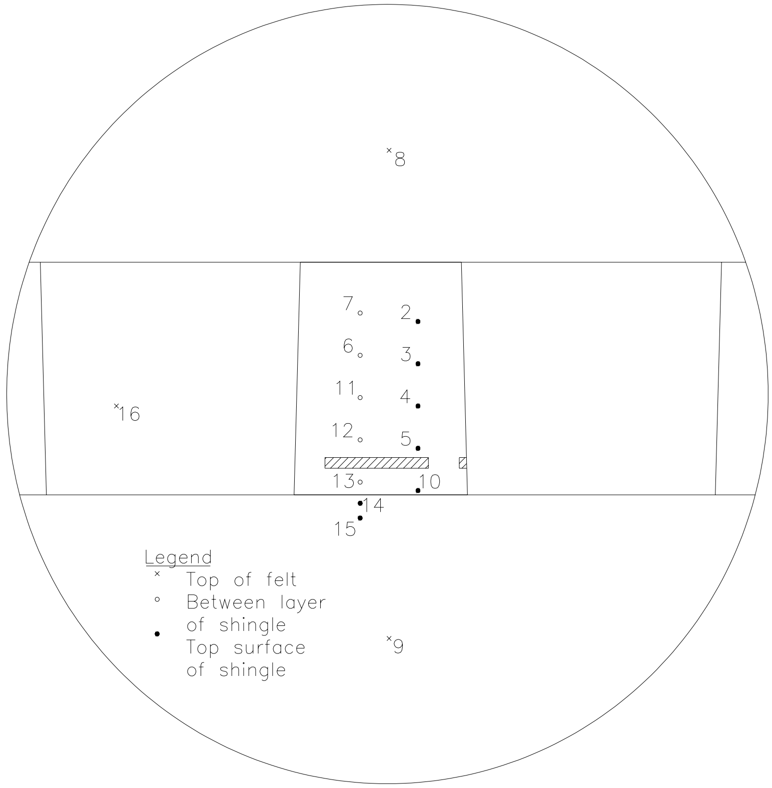


Figure 3. Sketch Showing Pressure Tap Layout on Architectural Shingle Specimen.

Figure 4. Photograph of Portion of Test Specimen with Pressure Taps.

Table 1. Mean Pressure Coefficients Determined for the Pressure Tap Locations on the Architectural Shingle Specimen at Two Wind Speeds.

Tap Number	Mean Pressure Coeff 70 mph Test	Mean Pressure Coeff 110 mph Test
2	0.20	0.19
3	0.16	0.15
4	0.13	0.12
5	-0.02	-0.01
6	0.18	0.16
7	0.18	0.17
8	0.14	0.13
9	0.06	0.04
10	-0.55	-0.53
11	0.18	0.17
12	0.18	0.16
13	0.55	0.54
14	0.48	0.47
15	0.41	0.40
16	0.15	0.13

The mean pressure coefficients measured across the top surface of the top shingle and across the top surface of the bottom shingle (between the shingles for most of the tap locations) are plotted in Figure 5 as a function of distance from the leading edge of the top shingle. Note that pressure coefficients for Taps 14 and 15, which are on the top surface of the bottom shingle but located upwind of the leading edge of the instrumented shingle, have been grouped with results for taps between the shingles. The relatively large positive pressures at these tap locations are consistent with the positive pressures measured under the shingle near the leading edge. The large positive pressures decrease rapidly for the major portion of the shingle that lies downwind of the adhesive strip and become roughly equal to the positive pressure exerted on the top surface of the shingle. The result is that the test only load the shingles in uplift over a distance of about two inches from the windward edge of the shingle. In these first couple of inches, the net mean loads on the shingles are the resultant of the negative pressure on the top surface of the shingle increased by the magnitude of the positive pressure between the shingles that tends to push the shingle edge upward.

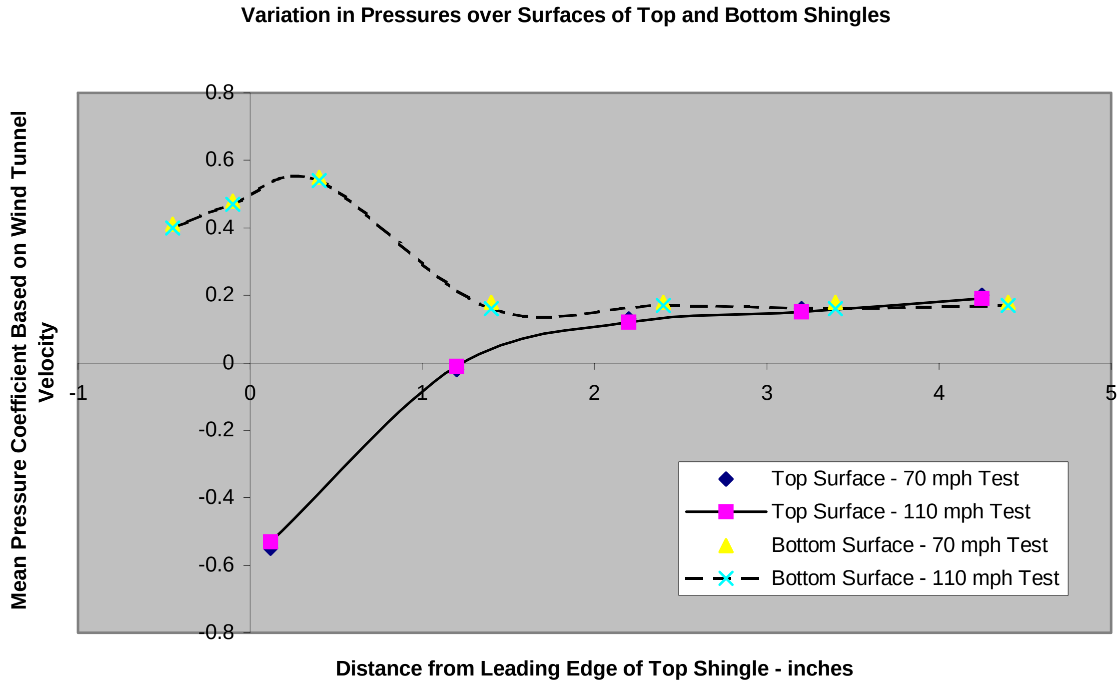


Figure 5. Plot of Pressure Coefficients on the Top and Bottom Surfaces of the Shingles as a Function of Distance from the Windward Edge of the Top Shingle for TAS 107 Tests of an Architectural Shingle.

With the honeycomb in place, the flow from the wind tunnel is very smooth. Consequently, pressure fluctuations were relatively small scale and not correlated over much of the shingles. There was some hint of a correlation between positive fluctuations in pressures between the shingle at tap location 13 and negative pressure fluctuations at tap location 10. However, more sensitive pressure transducers and a closer spacing of pressure taps is needed to further investigate this possibility.

With the smooth flow used in the TAS 107 tests, the mean pressure distributions measured in these tests tend to support the idea that a simple lift tab test should provide comparable test results to the TAS 107 tests. This is yet to be confirmed through side-by-side lift tab and TAS 107 tests for the same shingle products. Potential differences may center on the length of time that the load is applied (the TAS 107 test requires 2 hours of testing at 110 mph) and the potential visco-elastic or visco-plastic behavior of the adhesive strips. Nevertheless, the issue of the fundamental validity of either test still requires further investigation, including full-scale field measurements of fluctuating pressure distributions over the surfaces of the various layers, to determine whether these largely static loading conditions adequately reflect real wind loading conditions.

Since the field testing may require several years for successful completion, some hint of the potential dependence of loading on fluctuations in the wind may be possible by repeating these tests with more pressure taps, more sensitive pressure transducers and a more turbulent wind flow that can be generated by removing the honeycomb from the wind tunnel.

High Velocity Wind and Wind Driven Rain Testing (TAS 100)

During FY 03, modifications were made to the TAS 107 wind test facility to allow extension of the areas of inquiry to wind driven rain testing as well as the high velocity testing of the shingles. This was accomplished by constructing a stainless steel contraction and water spray section suitable for TAS 100 testing that could be attached to the drive section originally procured for the TAS 107 testing. Shake down testing of the facility have been completed and some preliminary wind driven rain testing has been carried out.

Wind velocity tests of the flow indicated that without honeycomb flow conditioning, the wind speeds varied by +10 and –12 percent of the mean velocity measured across the core of the wind tunnel jet. Results of these tests are presented in Table 2. The primary problem was reduced flow directly behind the hub of the fans as illustrated in Figure 6. This flow deficit was remedied by installing honeycomb flow conditioning between the fans and the contraction. The resulting flow with the honeycomb in place is more uniform with maximum deviations of +9 and –5 percent of the mean velocity measured across the core of the jet. In fact all but one measurement was within +/- 5 percent of the mean wind speed across the core of the jet. Results from the flow measurements are presented in Table 3 and the core flow is illustrated in Figure 7. The flow results obtained with the honeycomb in place are consistent with the requirements for flow uniformity in TAS 100.

Table 2. Velocity Measurements Across Central Core of Exit Jet from Wind and Wind Driven Rain Simulator without Honeycomb Flow Conditioning.

Measurement Position	Location X* - inches	Location Y* - inches	Velocity	Normalized Velocity
9	12	12	67.44	1.04
10	24	12	66.13	1.02
11	48	12	66.13	1.02
12	72	12	64.32	0.99
13	84	12	63.00	0.97
16	12	24	65.00	1.00
17	24	24	56.88	0.88
18	48	24	71.25	1.10
19	72	24	57.21	0.88
20	84	24	67.53	1.04
23	12	36	66.46	1.03
24	24	36	62.36	0.96
25	48	36	68.54	1.06
26	72	36	62.16	0.96
27	84	36	67.53	1.04
	Average	Velocity =	64.80	

*X and Y dimensions are measured from the lower left hand corner of the jet when facing the jet.

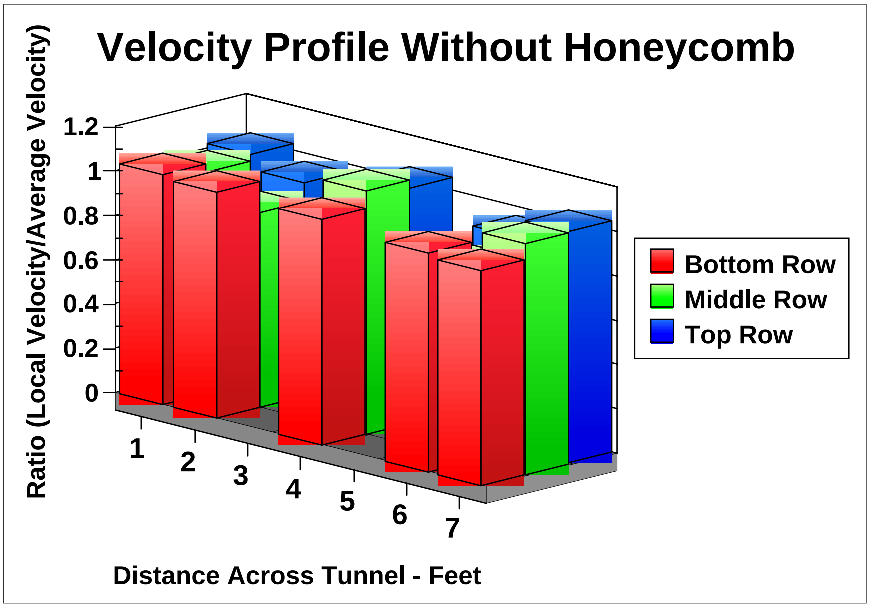


Figure 6. Graphic Illustration of Wind Flow Across the Core of Wind and Wind Driven Rain Wind Tunnel without Honeycomb (measured 2-feet downstream of outlet)

Table 3. Velocity Measurements Across Central Core of Exit Jet from Wind and Wind Driven Rain Simulator with Honeycomb Flow Conditioning.

Measurement Position	Location X* - inches	Location Y* - inches	Velocity mph	Normalized Velocity
9	12	12	68.26	1.03
10	24	12	64.13	0.96
11	48	12	62.90	0.95
12	72	12	63.30	0.95
13	84	12	68.54	1.03
16	12	24	69.12	1.04
17	24	24	62.95	0.95
18	48	24	70.11	1.05
19	72	24	63.15	0.95
20	84	24	72.55	1.09
23	12	36	68.45	1.03
24	24	36	66.23	1.00
25	48	36	64.08	0.96
26	72	36	64.18	0.96
27	84	36	70.20	1.05
	Average	Velocity =	66.54	

*X and Y dimensions are measured from the lower left hand corner of the jet when facing the jet.

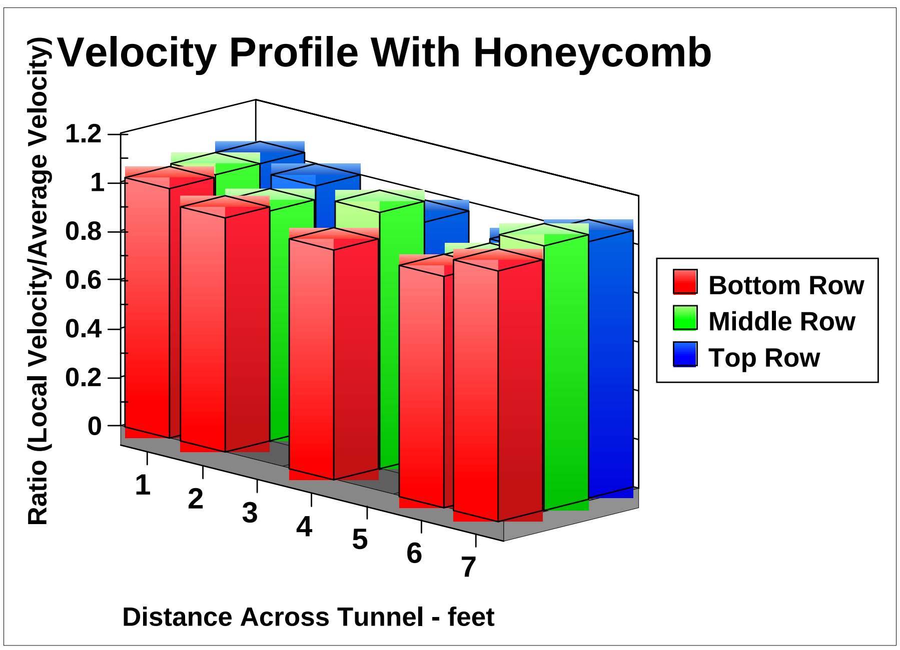


Figure 7. Graphic Illustration of Wind Flow Across the Core of Wind and Wind Driven Rain Wind Tunnel with Honeycomb in Place (measured 2-feet downstream of outlet)

The drive section originally developed for the TAS 107 facility does not have sufficient power to achieve the 110 mph wind speeds required for TAS 100 over the much larger jet cross-section. However, the facility is suitable for conducting the kind of scientific inquiry on flow conditions and pressure distributions that will help to define the true nature of the loadings and forcing functions achieved in the TAS 100 testing. Based on the wind speeds achieved with the 150 hp drive section for the TAS 107 tunnel (70 mph) it is estimated that about 650 hp is needed to achieve the 110 mph wind speeds needed for a fully operational TAS 100 facility. It is likely that the most economical means of obtaining this increased power is through the use of a couple of high performance V8 automotive engines coupled with airboat propellers.

The water supply for the wind driven rain simulation has been developed around a series of agricultural spray nozzles with the water being supplied by a large tank and a pump system that is capable of generating a wide range of water pressures. The spray nozzles can be rapidly changed and can be selected to produce various droplet sizes or a certain distribution of droplet sizes. Flow through the system is monitored by an in-line digital flow meter that tracks the flow rate and the total quantity of water sprayed. Results of preliminary tests with the spray nozzle system are given in Table 4. The uniformity of the water distribution is reasonably close to the +/- 5 percent requirements of TAS 100 for a first cut. The desired uniformity can be achieved through some minor tweaking of the nozzles.

Table 5. Distribution of Water Across Test Specimen Test Area.

Measurement Position	Center of Square X Direction - ft	Center of Square Y Direction - ft	Weight of Wet Specimen - lbs	Normalized Weight
1	2	1	0.70	1.04
2	4	1	0.48	0.71
3	6	1	0.70	1.04
4	2	3	0.76	1.12
5	4	3	0.60	0.89
6	6	3	0.76	1.12
7	2	5	0.74	1.09
8	4	5	0.68	1.01
9	6	5	0.72	1.07
10	2	7	0.66	0.98
11	4	7	0.66	0.98
12	6	7	0.72	1.07
13	2	9	0.64	0.95
14	4	9	0.62	0.92
15	6	9	0.70	1.04
		Average Weight =	0.676	

X and Y dimensions are measured from the lower left hand corner of the jet when facing the test specimen with your back to the fans.

References

1. Florida Building Code - 2001, TAS 107-95, "Test Procedure for Wind Resistance Testing of Non-Rigid, Discontinuous Roof System Assemblies."
2. Florida Building Code – 2001, TAS 100-95, "Test Procedure for Wind and Wind Driven Rain Resistance of Discontinuous Roof Systems."

3.1d INVESTIGATION OF INFLUENCE OF ARCHITECTURAL FEATURES ON WIND LOADS

Background and Objectives

The main objective of the work of the IHRC Team under the RCMP is to contribute to the development of effective methods and techniques to reduce the potential for damage to housing from the impact of hurricanes. In other words the RCMP funded research of the IHRC is about mitigation.

Building codes offer a venue for achieving mitigation over the long term through the design and construction of housing. However certain elements of house design and construction that could contribute to hurricane mitigation are not incorporated within current codes. The IHRC Team proposes to pursue a line of research that will increase our understanding of how various architectural features of house design, including the shape of the building or combinations of shapes, and other factors, may become performance modifiers for houses under the impact of hurricanes.

Building codes provide little guidance for estimating wind loads on buildings with complex shapes or a variety of architectural features. The latest editions of the ASCE 7 Standard do address simple rectangular gable, hip and monoslope roofs and they do include load coefficients for multispan gable roofs and sawtooth roofs. However, L shaped houses, houses with dormers, houses with dutch hip roofs, mansard roofs and a variety of common combinations of features are not handled well.

, There have been two schools of thought within the building code and wind engineering communities concerning the modifying effects of complex architectural features on wind loading. One school of thought suggests that all the complex features of modern homes and roofs work to break up the flow over the house and that this tends to reduce the action of coherent flow features that would tend to generate the highest wind loads. The second school of thought suggests that the flow separates from each of these features and that each feature potentially represents a local area where higher loads can occur on the building.

In an effort to gain some insight into these issues and to begin to determine which school of thought is correct, FIU undertook a series of tests of three reduced-scale models where a base simple building structure was made more complex through the addition of a number of typical architectural features. These models were outfitted with numerous pressure taps located at critical points over the entirety of the roof. Once tested, the maximum and minimum wind pressures at each tap location were recorded and incorporated in an overall pressure map. These pressure maps were then graphed on three-dimensional computer models for analysis and comparison. Tests of the simple models provided data which could be compared with pressure coefficients available in the building code and data that would serve as a basis for assessing the influence of the added architectural features on local wind loads on the buildings.

Model Tests

The Boundary Layer Wind Tunnel (BLWT) Model Studies that form the basis for this study were conducted at the Wind Load Test Facility (WLTF) at Clemson University. For this study, five 1:50 scale models were constructed by a team of students from the School of Architecture at Florida International University. Two of the models represented a basic building shape, one rectangular and one L shaped. The additional three models represented the base buildings with a variety of additional features including dormers, shed extensions, a two story block addition and a breezeway. Pressure data were collected during the testing using a Scanivalve pressure system. The following provides a description of the wind tunnel facilities, the methods used to collect the pressure data and the adjustments applied to convert the wind tunnel raw pressure data into coefficients that can be compared to pressure coefficients found in the ASCE 7 Standard.

The WLTF wind tunnel used for these tests is operated by the Clemson University Civil Engineering Department is a boundary layer wind tunnel with an open return design. Airflow within the tunnel is generated by twin 6-foot diameter fans powered by 100 Hp motors. The speed is regulated by a variable frequency drive that is used to control the speed of the fans. The flow of air generated by the fans flows through a rapid expansion with screens and a settling chamber, where it passes through a honeycomb grill and a series of screens that create a uniform flow of air. The airflow then enters a contraction section that reduces the cross sectional airflow area to that of the test and further improves the uniformity of the flow entering the test section. Once within the wind tunnel test section, the airflow encounters a series of spires, trip boards, and roughness elements placed along the tunnel floor before reaching the model. The wind tunnel test section extends a length of 53 feet from the end of the contraction section to the center of the turntable where the models are placed for testing. The nominal cross section of the test section is 10 feet wide by 6.5 feet high. The turntable has a diameter of 9 feet, and is used to vary the airflow angle with respect to the model.

The configuration of spires, trip boards, and roughness elements used in this study were developed by Monroe [1] and later refined by Chen [2]. This tunnel configuration was created to simulate flow over open country terrain. A detailed description of the flow simulation for this configuration can be found in Reference [2]. Studies conducted by Cope [3] compared results of model studies with field data obtained at Texas Tech University and showed that this flow simulation accurately reproduces full-scale wind pressures in open terrain flow conditions. A picture of the wind tunnel configuration used in the study is provided in Figure 1. Figure 2 is a sketch showing the plan view of the wind tunnel configuration.

Figure 1. Photograph of One of the IHRC Models in the BLWT at Clemson University.

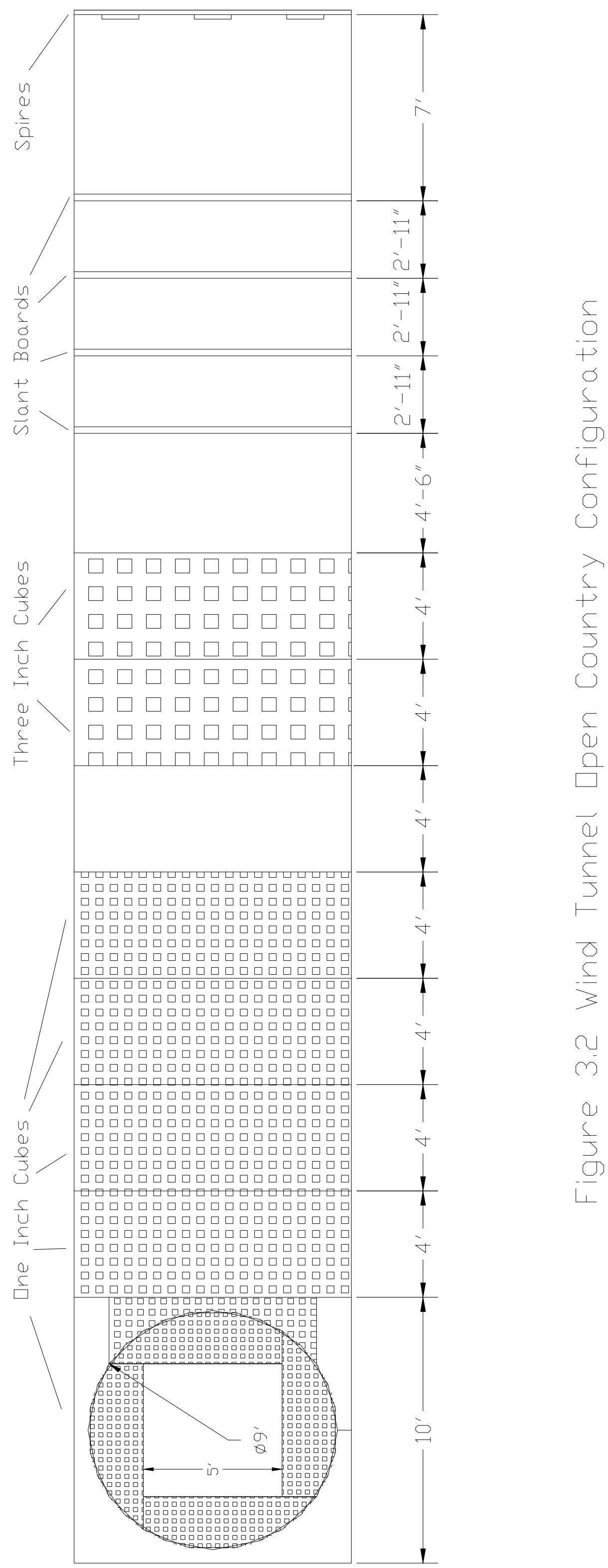


Figure 2. Layout of Roughness Elements Used to Create Open County Wind Flow

The instrumentation of each model consisted of several hundred pressure taps located at selected locations over the roof and on the soffits of the houses. The taps were installed by drilling 1/16-inch holes in the acrylic sheet comprising the model roofs. Steel tubing was placed in these holes and glued in place. The surface of the roof was then filed and sanded to remove the protruding steel tubing and provide a smooth surface.

Pressures at the various tap locations were sampled using a Scanivalve pressure system. This measurement system is comprised of eight Model 48JMG-48 port pressure switches in conjunction with eight Setra Model 239 differential pressure transducers. A reference pitot was positioned near the top of the wind tunnel test section to provide reference pressure for the system. Pressures from the model taps were transmitted through three-foot lengths of vinyl tubing to the Scanivalve transducers. The signals produced by these transducers were then conditioned using 1/3 octave graphic equalizers to compensate for the response characteristics of the tubing system and filtered at 200 Hertz. The signals from the Scanivalve system were sampled at 2000 Hertz using the program DATLOG, which provided mean, minimum, maximum and root-mean-square pressure coefficients based on the mean dynamic pressure from the reference pitot tube.

The pressure coefficient data obtained from the wind tunnel required two adjustments before they could be compared with ASCE 7 values. The pressure coefficients from the wind tunnel data acquisition program were based on the mean dynamic pressure from the reference pitot located near the top of the wind tunnel test section. ASCE 7 specifies pressure coefficients for low-rise buildings that are based on 3-second gust speeds at mean roof height. The first adjustment factor converts the wind tunnel measured pressure coefficients so that they are based on the mean wind speed at mean roof height. This adjustment factor uses the ratio of mean velocities at the mean roof height and the reference pitot height that was obtained using two hot film anemometers. The ratio of the dynamic pressures at the two elevations is equal to the ratios of the velocities squared. The resulting ratios of dynamic pressures, listed in Table 1, were used to convert the pressure coefficients to the respective mean roof height for each model.

Table 1 Hot Film Anemometer Measurements For Conversion of Coefficients to Mean Roof Height

	Velocity (mph)		Velocity	Pressure Coeff.
Position (in)	Ref. Pitot Velocity	Local Velocty	Ratio	Adjustment Factor
2.5	32.878	17.267	0.525	3.63
3.0	33.006	18.403	0.558	3.21
3.5	33.037	18.781	0.568	3.1
4.0	33.080	19.991	0.604	2.74
4.5	33.066	19.412	0.587	2.9
5.0	18.797	10.854	0.577	3
5.5	32.988	20.249	0.614	2.65
6.0	33.277	20.654	0.621	2.59

After adjusting the coefficients so that they were based on the mean wind speed at mean roof height, for comparison with ASCE 7-98 values, they required a second adjustment to values based on three-second gust wind speeds. This adjustment was accomplished by dividing the wind tunnel values by $(1.53)^2$ as suggested in the wind load commentary section of ASCE 7.

South Florida Single Family Residential Criteria

The models tested represented single-family homes of 1,700 square feet. This size was determined by an examination of median sale prices for homes in Florida. The median sales price for single-family existing homes in Florida was $ 149,600 (MLS sales levels from the Florida Realtor's boards and associations, see appendix 1). The Median single-family unit cost for new homes in 2002 through July 2002 was $135,870 (Building permit activity as recorded by the Florida Housing Business Association at www.fhba.com 11-13-02 see appendix 2). The average of these two figures is $142,500 per single family home. At an estimated construction value of $85.00 a square foot, the average size of a new home is approximately 1,676 square feet. The homes in test group one were one story in height while the 20-foot cubic addition model and the homes in test group two were two stories in height.

Pressure contours

All the data that is reviewed in this report concerns the reading of positive and negative pressure values on a roof surface. Negative roof pressures represent a pull or suction or uplift on the roof surface while positive roof pressures represent a push on the roof surface. After a review of the initial data from model test group one, a set of pressure contours was established to organize the different negative and positive pressure tap values. These pressure coefficients on roof surfaces are based on three-second gusts at mean roof height (see Dr. Timothy Reinhold's reports, appendices 3 thru 5). There are seven contour values:

1. +.60 to +1.00
2. +.20 to +.60
3. -.20 to +.20
4. -.60 to -.20
5. –1.00 to -.60
6. –1.40 to –1.00
7. less than –1.00

1 BASE MODEL- Unadorned Roof

Background

This house model represents a typical single-family Florida roof configuration. All the program of this house fits under the roof. The "L" form was determined to provide the house with roof ridge and valley conditions. The two ends of this home provide the two most typical roof configurations: that of a hip roof and that of a gable end. As roof overhangs are quite prevalent in Florida homes for shade and rain runoff, this house has 1-foot, 3-foot and 5-foot overhangs.,

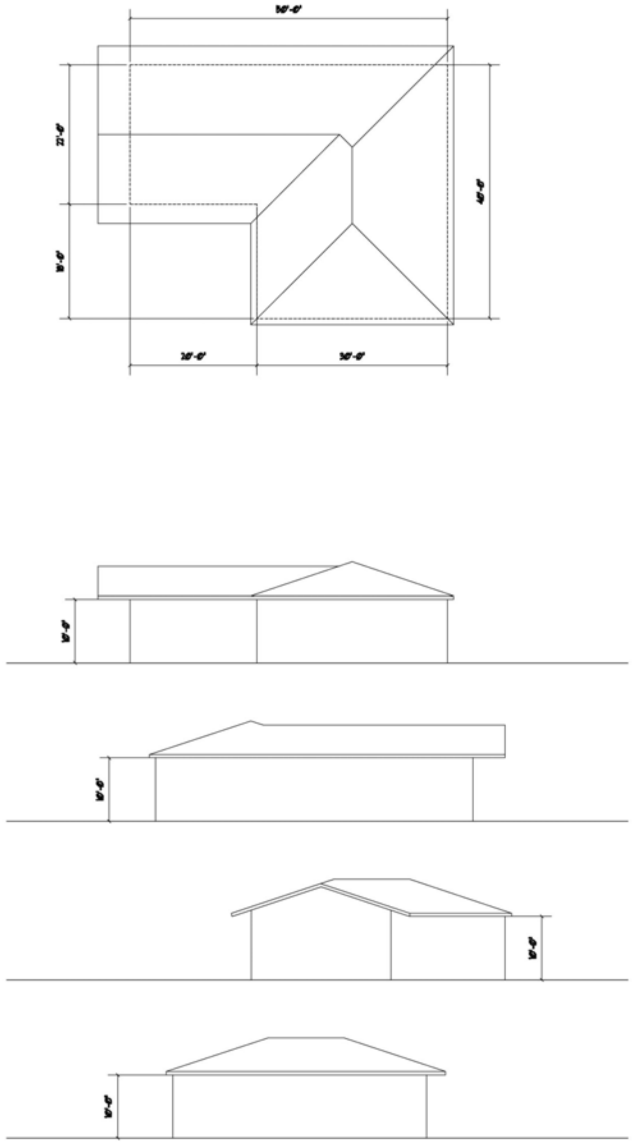
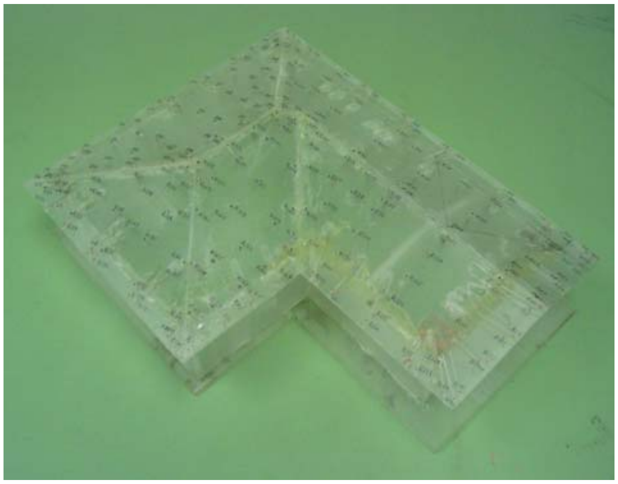
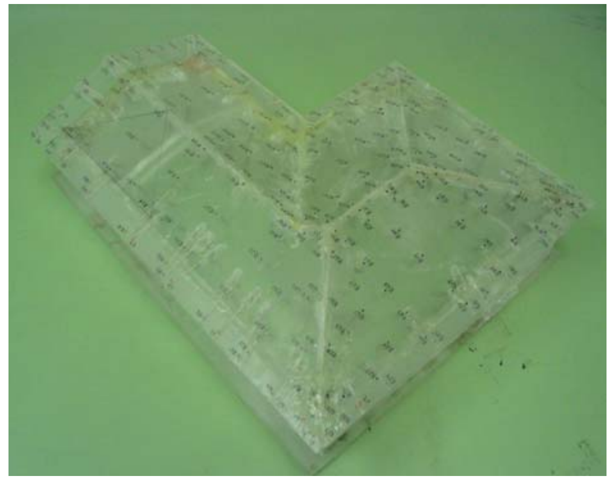


Figure 1a: Plan

Figures 1b,1b2: Model photo

Map Data

BASE 1 - **Positive** Pressure Maps

This map is based on maximum pressure coefficients from Dr. Timothy Reinhold's report: appendix 3, table of maximum and minimum Pressure Coefficients,

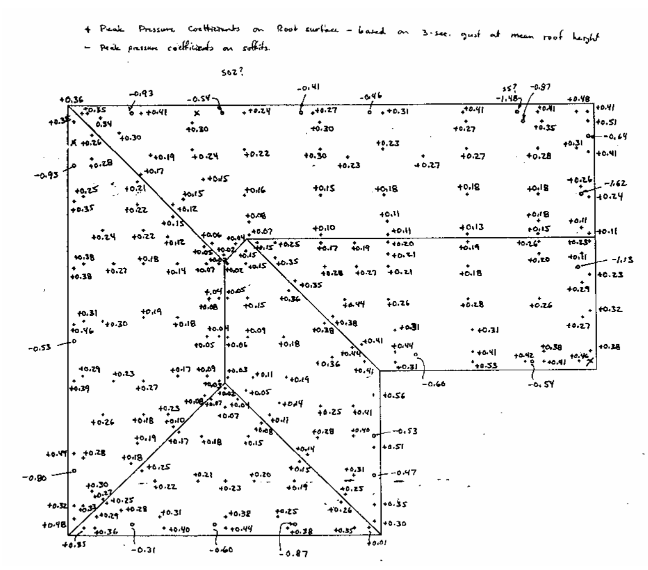
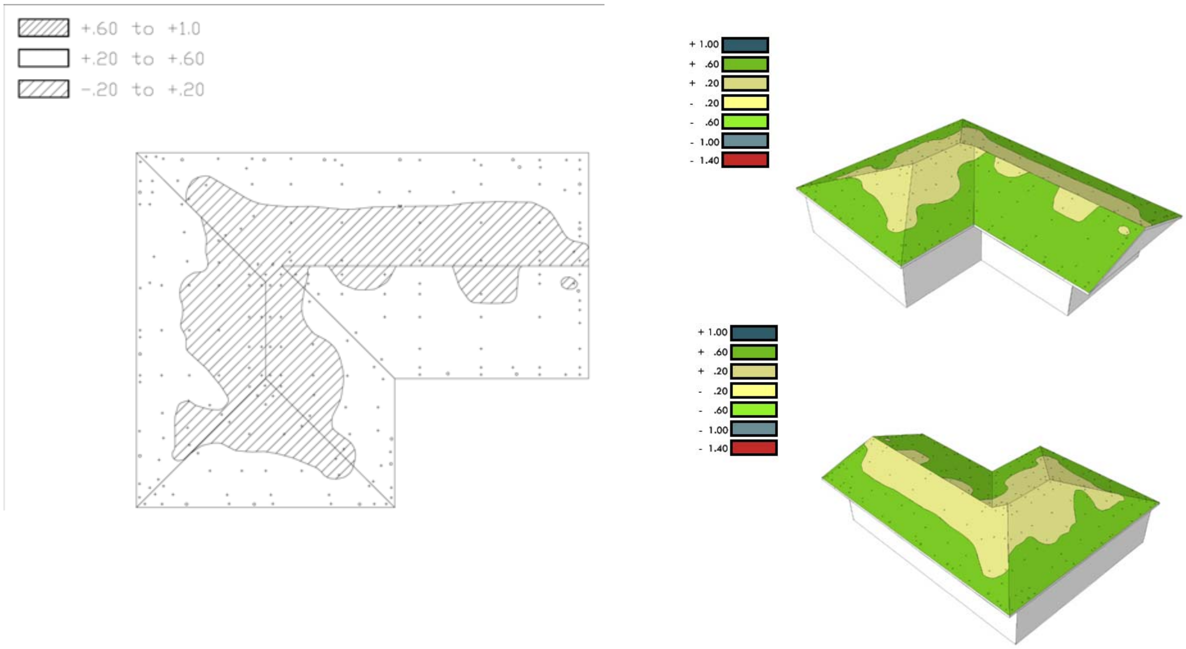


Figure 1c: Pressures Plan



Figures 1d and 1e: Roof Pressure Maps

This map is distinguished by essentially one pressure contour that separates positive pressure coefficients greater than +.20 and less than +.20. The greater pressures occur towards the overhang edges while the lower pressures occur towards the roof ridges. Within the contour of high pressures, the corners tend to have the greater positive pressures.

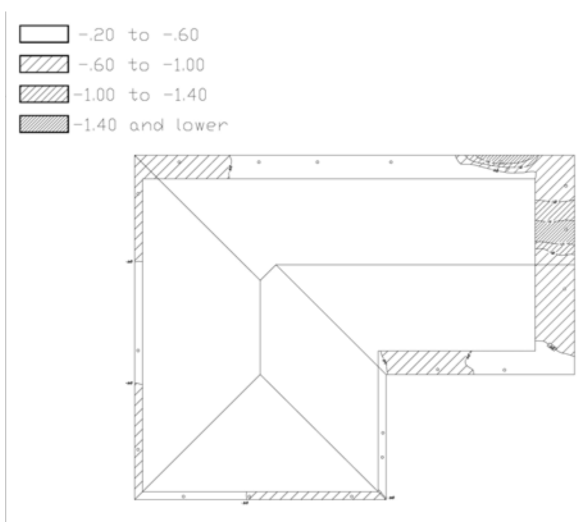


Figure 1f: Soffit Map

Figure 1f illustrates the minimum negative pressures under the soffits. The strongest negative pressures occur at the high point of the five-foot gable overhang and around the corner from this overhang.

Conclusions

There exist a straightforward variation in the positive pressure map without extreme conditions. As one moves from the ridge of the roof to the roof edge, the pressures increase. This consistency throughout the roof occurs at both ridges and valleys and at the varying roof overhangs. The greater pressures at the roof edges confirm our understanding that this is an area that requires special attention.

BASE 1 – **Negative** Pressure Map

This map is based on maximum pressure coefficients found in Appendix 3: table of maximum and minimum Pressure Coefficients.

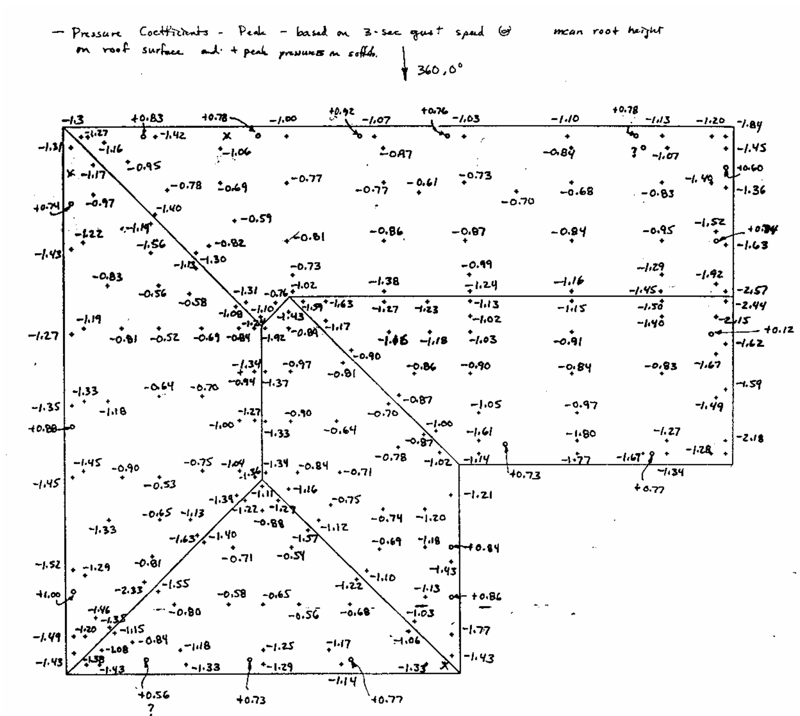
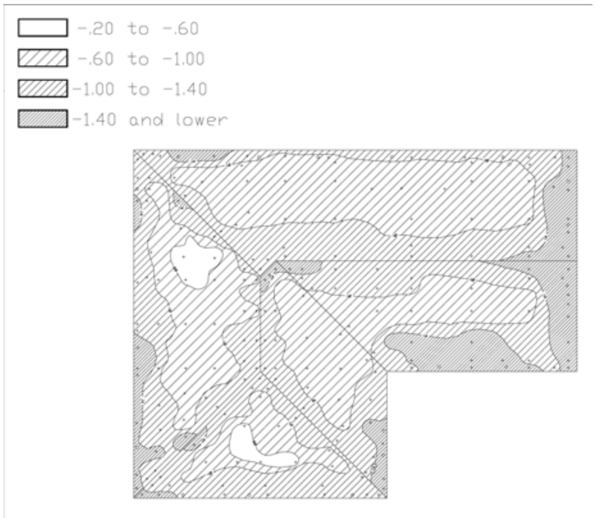
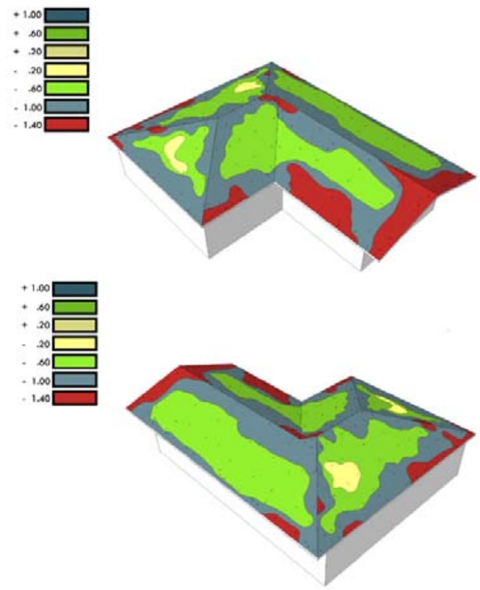


Figure 1g: Pressures Plan





Figures 1h and 1i: Roof Map

Four negative pressure contour areas distinguish this map. The strongest suction occurs at the gable end with the five-foot overhang. The most extreme suctions occur at the top of this gable. Other high suction areas occur at the edge of the roof overhangs close to the corners. A small grouping of high suctions occurs at the top of the valley at the ridge point of the roof. The smallest suctions occur at the middle of the roof planes.

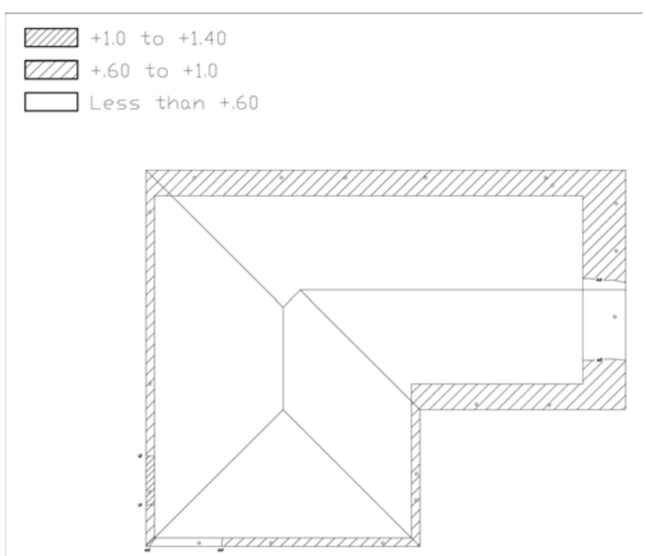


Figure 1j: Soffit Map

Figure 1j illustrates the maximum positive pressures under the soffits. The positive pressures under the soffit are quite uniform. The two significant variations occur; one at the top of the gable end with a comparatively small positive pressure and one higher pressure reading at a corner.

Conclusions

Generally there exists a straightforward variation in the negative pressure map. As one moves from the middle of the roof plane to the roof edge and ridges uplift increases. The extreme case of this occurs at the gable end. Significant jumps in pressure occur in a short distance making this a rather volatile area. It seems that drastic suctions occur at roof overhang edges and abrupt drops. This map and the positive pressure map confirm our understanding of the dynamics of wind on roof edges. Roof overhang edges remain of critical importance and should be protected accordingly.

2. BASE MODEL WITH FEATURES- Common Roof Elements

Background

This house model represents the typical Florida roof configuration represented in the first model with the addition of common roof elements. This model includes the follow roof elements:

1. A chimney
2. An extended eave carport or shed condition
3. A small gabled front porch
4. A gabled ridge vent
5. A dormer ridge vent
6. A side wall dormer
7. An eave dormer

These elements were distributed equally around the roof at allow for a certain degree of isolation for individual examination. As roof overhangs are quite prevalent in Florida homes, this house has 1-foot, 3-foot and 5-foot overhangs.

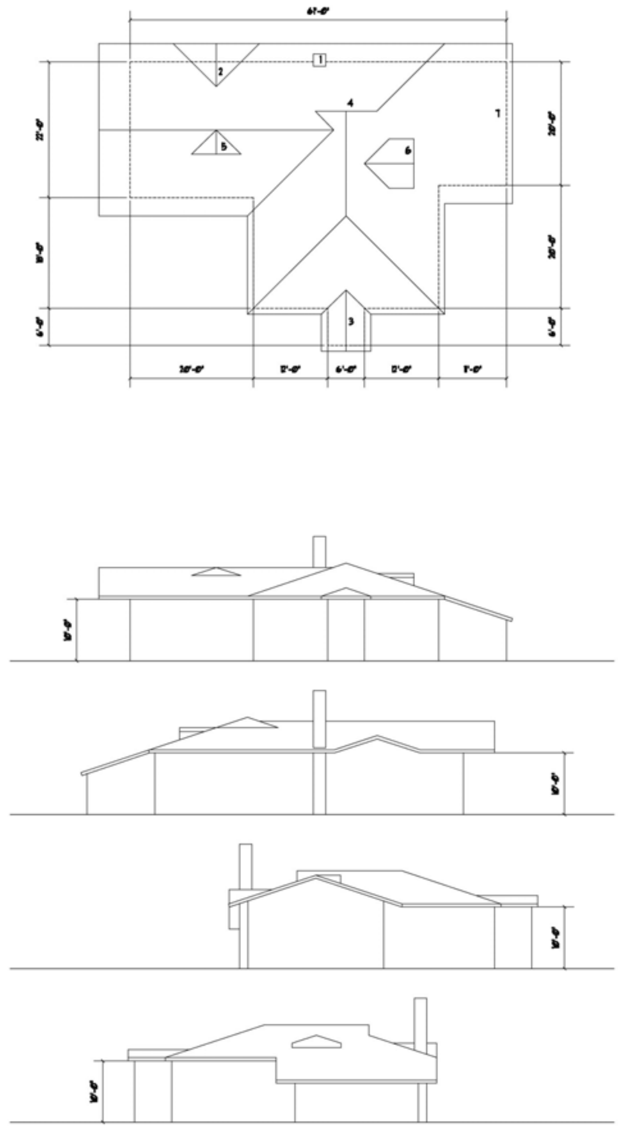
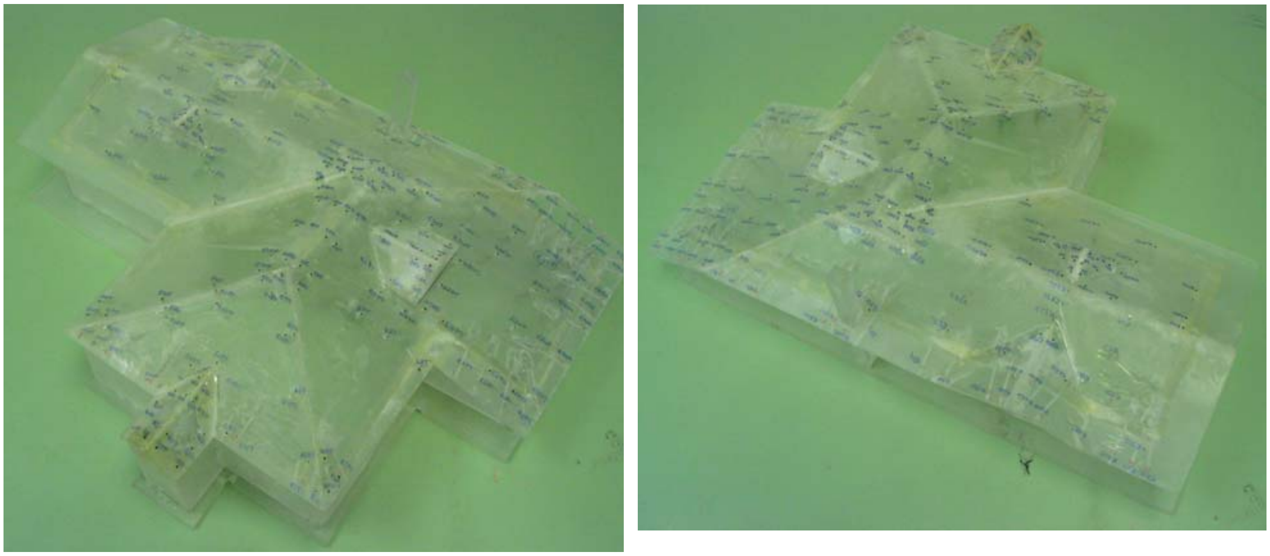


Figure 2a: Plan



Figures 2b,2b2: Model photo

Map Data

BASE BUILDING WITH FEATURES – **Positive** Pressure Map

This map is based on maximum pressure coefficients found in Appendix 4: table of maximum and minimum Pressure Coefficients,

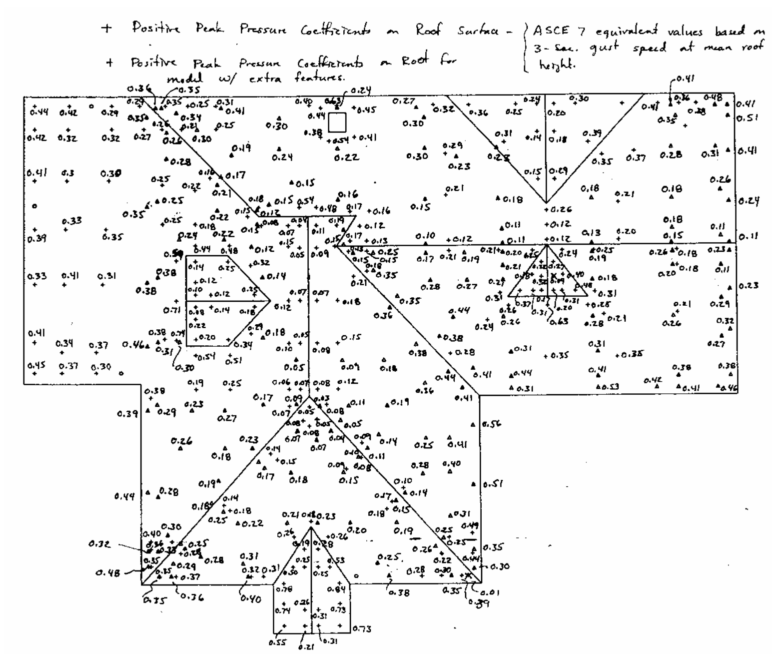
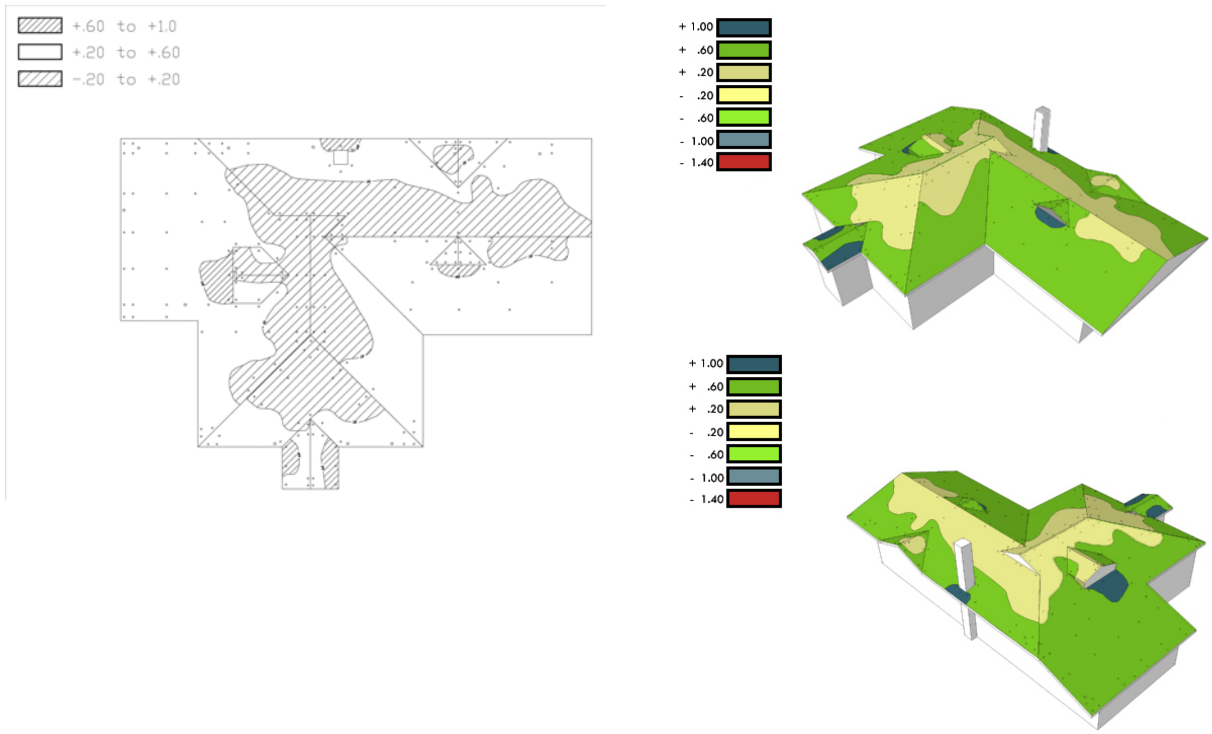


Figure 2c: Pressures Plan



Figures 2d and 2e: Roof Pressure maps

While the positive pressure map of the base building was distinguished by essentially one pressure contour that separated positive pressure coefficients greater than +.20 and less than +.20, here we see the same general layout of pressures with additional concentrated groupings of pressures greater that +.60. These higher pressures, which did not occur in the base model pressures map, tend to group in front of the vertical surfaces of the chimney and the dormer walls. These pressures also occurred at the edge of the small gabled front porch. Higher pressures also occurred in front of the gabled ridge vent but they did not exceed +.60.

Conclusions

The straightforward variations seen in the base model positive pressure map has been made more complex with the introduction of roof features. There still remains the consistent increase of pressures as one moves from the ridge of the roof to the roof overhang edge. This consistency is only interrupted when a roof feature exists. The introduction of these roof features created small interior corners that interrupted the smooth surface of the roof allowing additional resistance to the wind flow. As these areas need to resist stronger wind pressures care should be taken in their construction.

BASE BUILDING WITH FEATURES – **Negative** Pressure Map
This map is based on maximum pressure coefficients found in Appendix 4: table of maximum and minimum Pressure Coefficients.

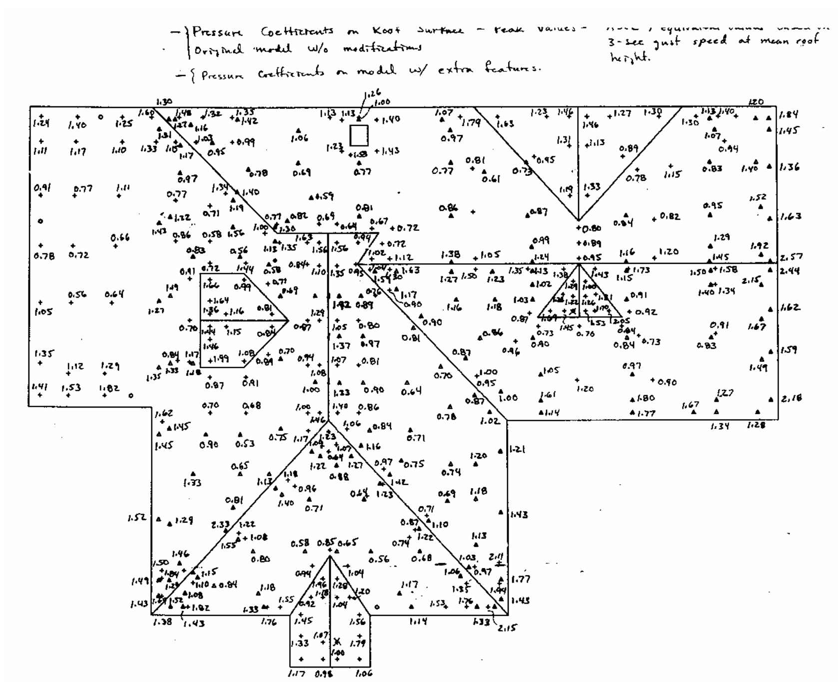
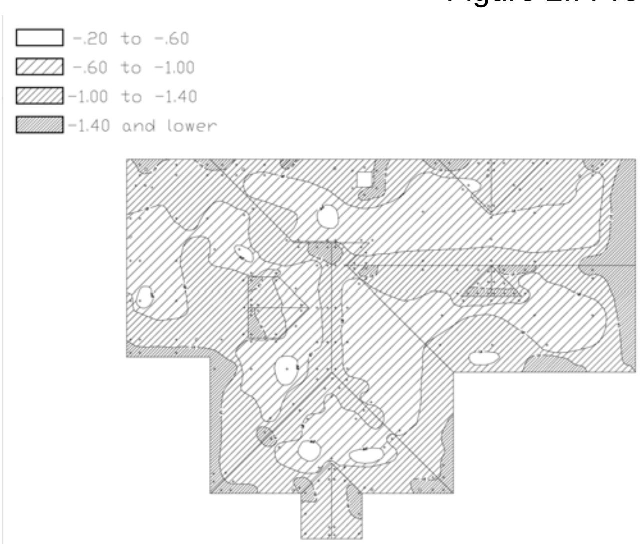
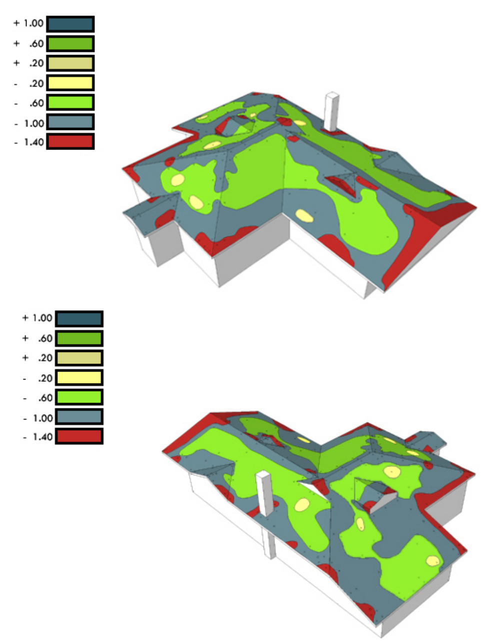


Figure 2f: Pressures Plan





Figures 2g and 2h: Roof Pressure Maps

As in the base model pressures map, four negative pressure contour areas distinguish this map. No suctions greater than those previously found at the top of the five-foot overhang occurred in this model. While the strongest suctions still occur at the gable end with the five-foot overhang the overall map is much more complex. In addition to roof overhang edges, the extreme suctions, less than –1.40, occur at the edges of the dormers, around the chimney, at top and edge of the roof vents and at the interior corners and tops of the dormers. The overall area of the smallest suctions, those greater than –1.0 has decreased.

Conclusions

The introduction of the roof features to the base model has not produced greater suctions than what was found originally in the base model. These features, while they produce a more complex pressure map and introduce high pressures in areas that they would not occur if they were not there, do not introduce higher pressures than that of the gable end with a five-foot overhang. This gable overhang produced pressures of -2.57 and –2.47. The dormer ridge vent (5), with a pressure of –2.05 produced the greatest negative pressure by a roof feature. The area of smaller suctions decreased but still maintained a significant presence on the roof. As a more dynamic pressure map, care should be taken to protect high uplift areas. The roof edges and gables ends remain of concern and should be protected accordingly. The introduction of the small roof features requires their localized protection. The remaining parts of the roof tend to maintain similar wind pressure as in the base model and do not seem to require additional protection.

General Base model and Base model with features Conclusions

The increase of complexity of the pressure map from the base model to the base model with features reveals that the addition of small roof features does not seem to enhance or dampen the impact of hurricane winds.

At these roof features, localized uplift and downward pressures pockets occur. Yet as one moves away from them, roof pressures tend to return to pressures found in the base model. While these pressures do not increase in a substantial manner from the base model care should be taken in their construction. As these features require more framing than an open area of roof, they will be stiffer and be able to resist higher wind pressures. They should be framed integrally to the structure of the roof and be properly flashed and protected by the chosen roofing system.

As stated before, the most volatile condition in this testing remains to be the five-foot gable overhang. It should remain as a primary condition for hurricane protection.

3. BASE MODEL WITH TWENTY-FOOT CUBIC ADDITION

<u>Background</u>

This house model represents the typical single-family home represented in the first model with a twenty-foot cubic addition. Often in residential architecture, additions are made to homes with little care given to integrating of them to the original house. This addition represents a common improvement to a single-family: a new master bedroom and bathroom upstairs with a new kitchen and family room downstairs. As the original house tends to take up much of the allowable buildable footprint of the property, additions are required to go upward. Like the roof features of the second model tested, this cubic addition is seen as a roof modifier. While much larger that the previous roof modifiers, this addition introduces an incongruity to the base model roof that may enhanced or dampened the impact of hurricane winds.

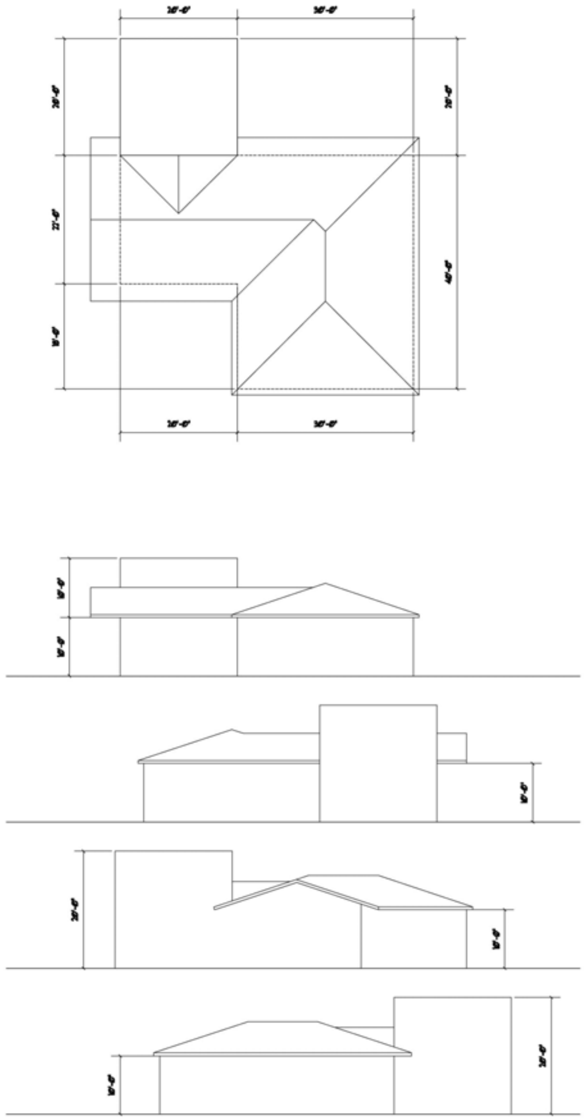
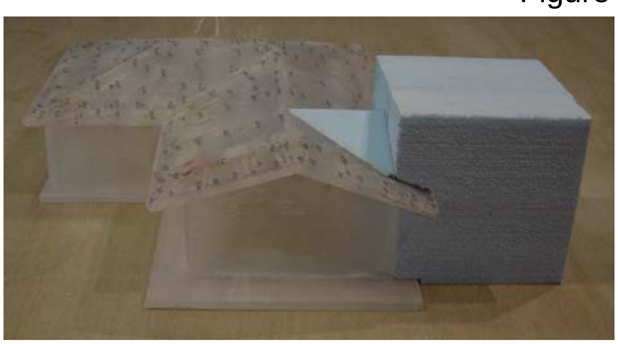


Figure 3a: Plan



Figures 3b,3b2: Model photos

Map Data

BASE BUILDING WITH 20-FOOT ADDITION - **Positive** Pressure Maps

This map is based on maximum pressure coefficients found in Appendix 5: table of maximum and minimum Pressure Coefficients.

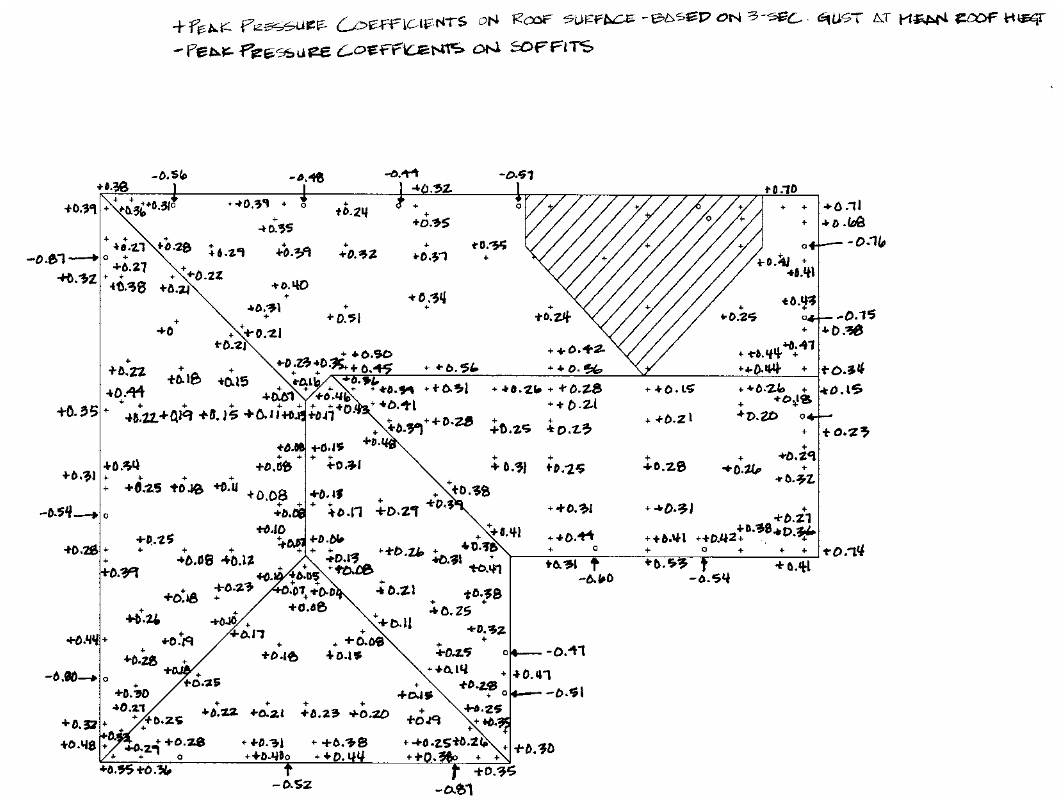
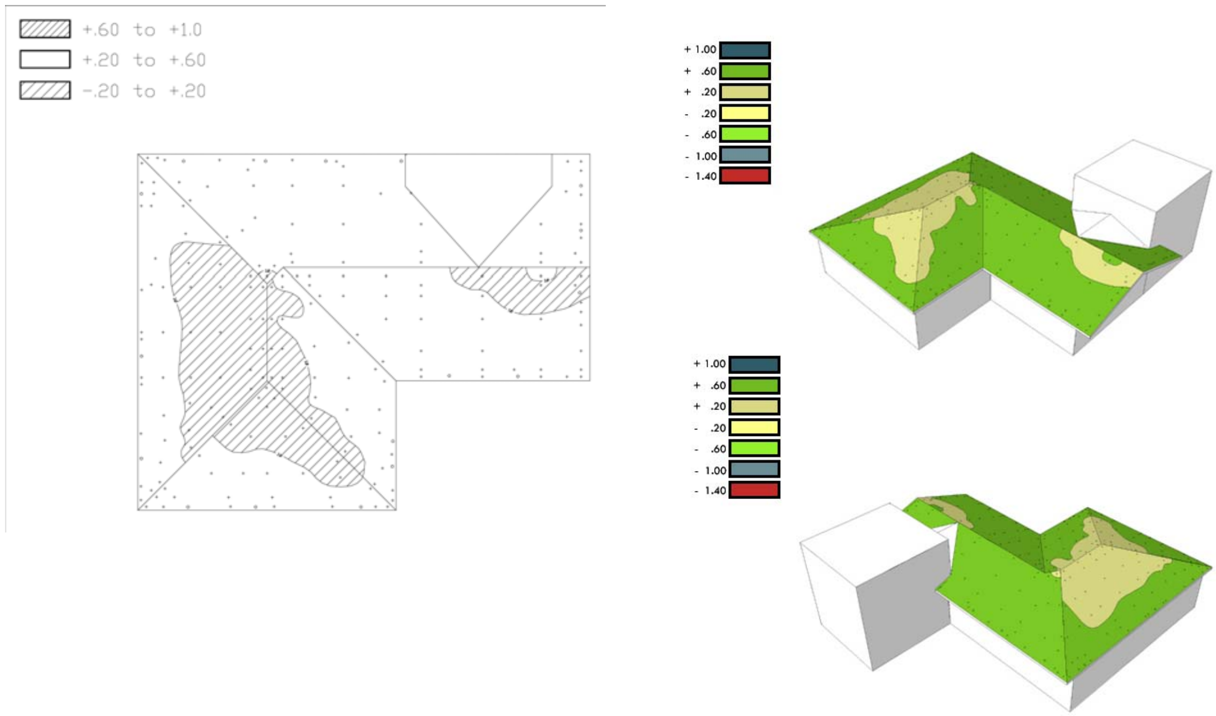


Figure 3c: Pressures Plan



Figures 3d and 3e: Roof Pressure Maps

As in the positive pressure map of the base building, this pressure map is distinguished by essentially one pressure contour that separated positive pressure coefficients greater than +.20 and less than +.20. What distinguishes this map from the original base map is at the roof plane where the addition attaches there is an absence of pressures with recordings less that +.20. At this roof plane all the pressures were above +.20 and less than +.60. Generally, the areas of pressures less than +.20 have decreased. There were no pressures of +.60 or greater recorded in this test. The greater pressures occur towards the overhang edges while the lower pressures occur towards the roof ridges.

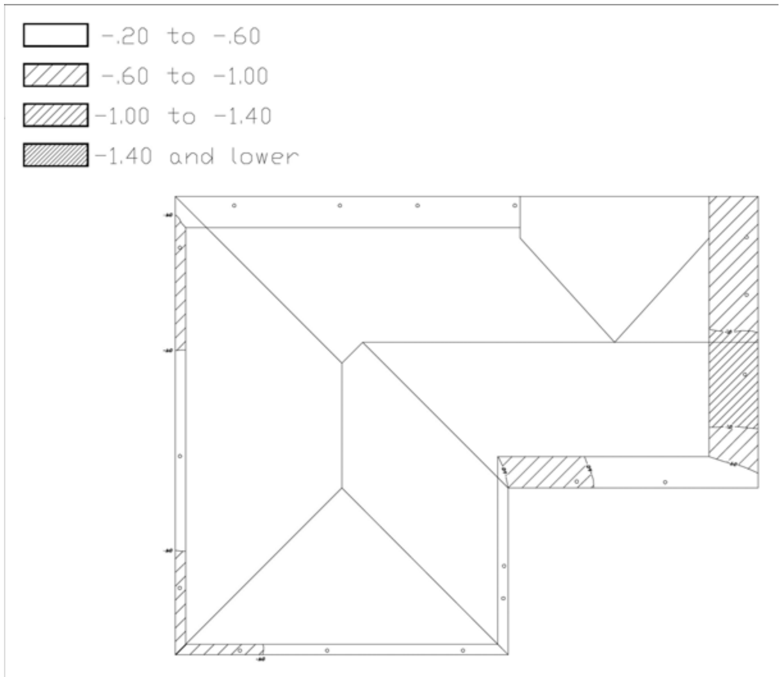


Figure 3f: Soffit Map

Figure 3f illustrates the minimum negative pressures under the soffits. Like the base model, the strongest negative pressures occur at the high point of the five-foot gable overhang. Yet these pressures are not as strong as the suction pressures as found in the base model. Here we do not see suctions less that –1.40.

<u>Conclusions</u>

It seems as though the cubic addition has done little to affect significant change in the pressures of the roof the original house. While lower positive pressures have diminished, there have been no additions of significantly higher pressures. In contrast, the soffit pressures seem to have been modified by the addition. The suctions in the five-foot overhang have decreased. It seems the extension of the wall under the overhang has diminished the exposure of the overhang. On one side, the wind can no longer wrap around the corner as it previously did creating strong suctions.

BASE BUILDING WITH 20-FOOT ADDITION – **Negative** Pressure Map
This map is based on maximum pressure coefficients found in Appendix 5: Table of maximum and minimum Pressure Coefficients.

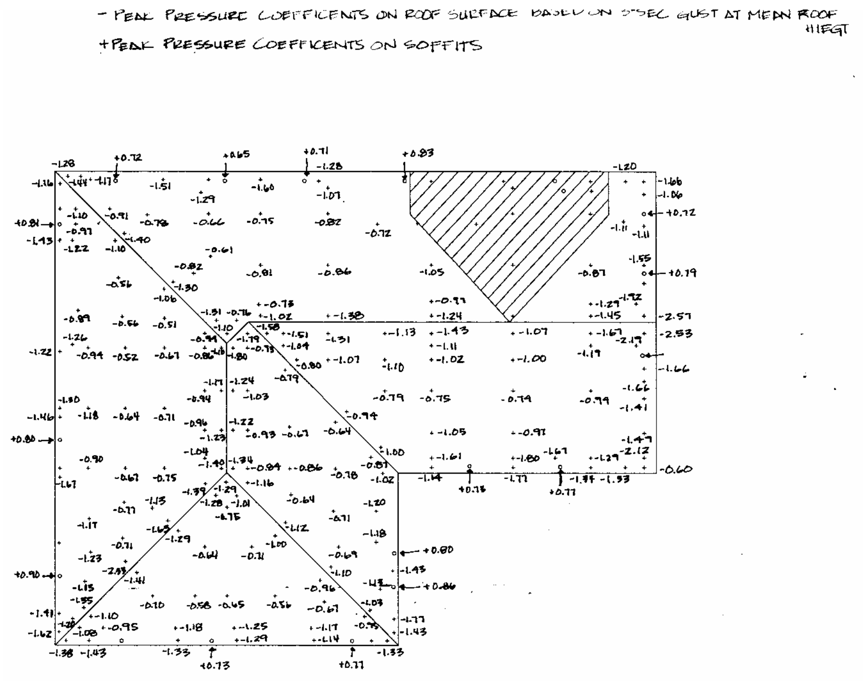
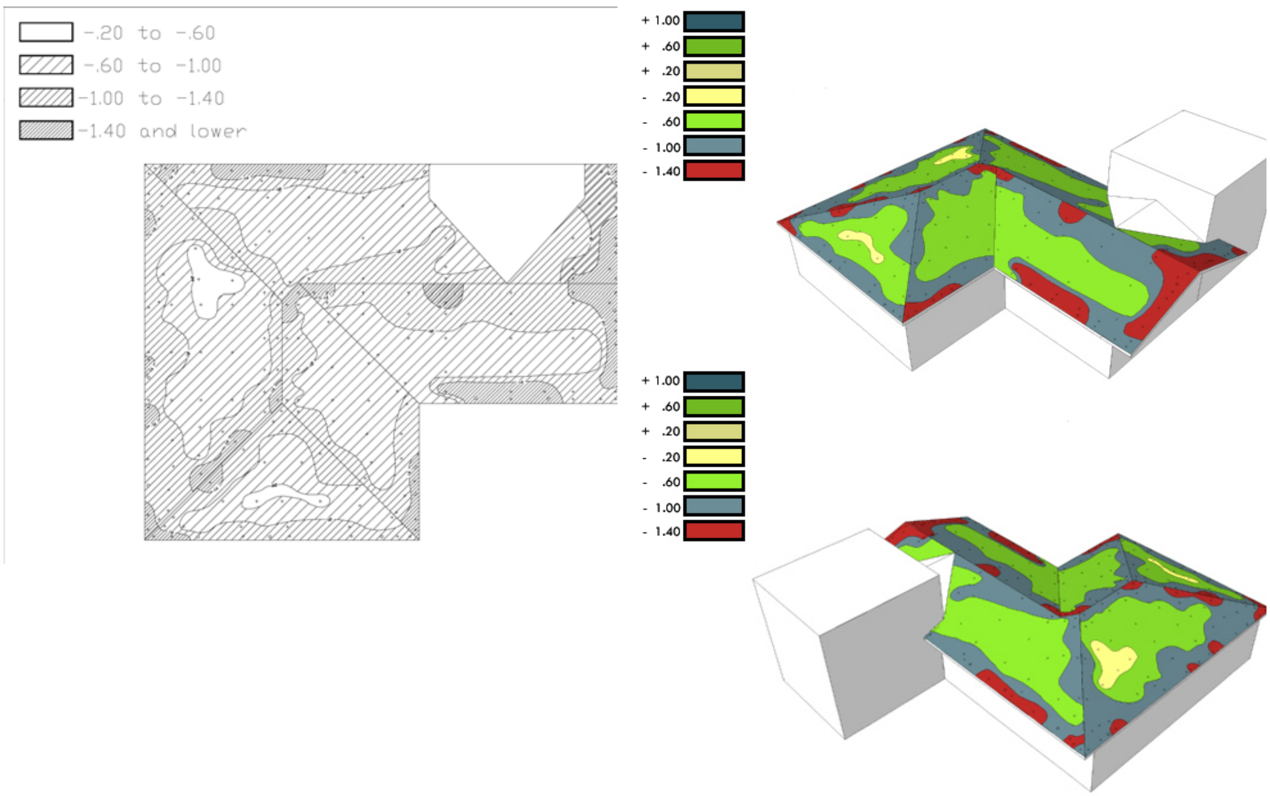


Figure 3g: Pressures Plan



Figures 3h and 3i: Roof Pressures Map

Four negative pressure contour areas distinguish this map. Again, the strongest suction occurs at the gable end with the five-foot overhang. The most extreme suctions occur at the top of this gable. This map is quite similar to the base building pressure map with one notable exception. At the top of the ridge just off the high point of the cricket of the cubic addition there is an uplift pressure contour of less than –1.40 (tap R106= -1.43). It seems that while the majority of the roof has remained similar to the base pressure map, the area where the cubic addition attaches has an increase of uplift pressures just off it. Like the base pressure map, other high suction areas occur at the edge of the roof overhangs close to the corners. A small grouping of high suctions occurs at the top of the valley at the ridge point of the roof. The smallest suctions occur at the middle of the roof planes.

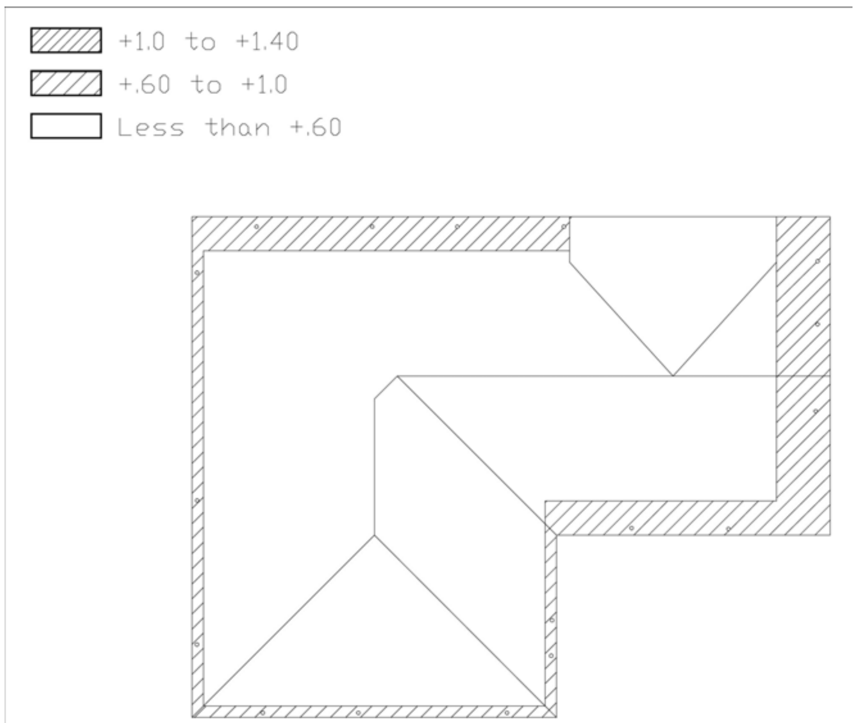


Figure 3j: Soffit Map,

Figure 3j illustrates the maximum positive pressures under the soffits. The positive pressures under the soffit are quite uniform. While there was some variation in the positive soffit pressures in the base model, here there is much more uniformity.

Conclusions

The area just off where the cubic addition attaches has seen an increase of uplift pressures. It seems the cubic addition wall facing the house has created a large pocket, which catches the wind causing uplift (not unlike those created at a smaller scale by the dormers and vents of the base model with features). While the positive soffit pressures found in this test are more uniform than the base model, little change has occurred here.

General Base model with twenty-foot addition Conclusions

It seems that the twenty-foot addition does little to enhance or dampen the impact of hurricane winds. As stated before, the most volatile condition in this testing remains to be the five-foot gable overhang. While the uplift pressures increase near to where the addition was attached to the house, these uplift pressures were significantly less substantial than the uplift pressures associated with the gabled end.

Additional Research

After an initial review of the data from the first three models (Base model, Base model with features and Base with 20’ cubic addition) it was observed that the extreme uplift pressures on the roofs occurred at the edges of roof peaks and overhangs. As these edge conditions seem to be the most volatile, these models were designed to examine such conditions. As the first models examined the affect of roof elements on roof uplifts, these following models examine the *interaction* of different roofs and how they may make act to enhanced or dampened the impact of hurricane winds. Two additional models should be developed to test this condition: the breezeway model and the sheds model.

The Breezway model will introduce an open covered breezeway and court condition. The edges of the roofs that line this space should produce significant uplift pressures. The space between the two separate enclosures represents the common condition of the separation of house and garage. This tunnel may cause additional uplift pressures. The Sheds model will represent the all too common condition of the protruding garage. What is of interest here is the “pinch” between overlapping roofs, the termination of a shed roof on a wall and the interaction of volume extensions below a main roof. The construction and testing of these types of models should be considered during THE 2003-2004 research period.

References

3. Monroe, J. S., “Wind Tunnel Modeling of Low Rise Structures in a Validated Open Country Simulation,” Masters of Science Thesis, Department of Civil Engineering, Clemson University, Clemson, SC, August 1996.
4. Chen, M., “ Characterization of Wind Pressure Fluctuations on a Gable Roof House,” Ph. D. Dissertation, Department of Civil Engineering, Clemson University, Clemson, SC, August 2000.
5. Cope, A. D., “Load Duration Effect on Peak Minimum Pressure Coefficients,” Masters of Science Thesis, Department of Civil Engineering, Clemson University, Clemson, SC, August 1997.

APPENDIX 1

FLORIDA SALES REPORT – YEAR END 2001

APPENDIX 2

BUILDING PERMIT ACTIVITY BY COUNTY

APPENDIX 3

FIU BASE BUILDING 1

APPENDIX 4

FIU BASE BUILDING 1 WITH EXTRA FEATURES

APPENDIX 5

FIU BASE BUILDING 1 WITH 20-FT CUBIC ADDITION

3.1e FIELD MEASUREMENTS OF WIND LOADS ON FLAT ROOFS

BACKGROUND AND OBJECTIVES

For the past 5 years, the State of Florida has supported the Florida Coastal Monitoring Program to instrument houses along the coast of Florida. Because of the design of the sensor package, that project has been limited to monitoring wind pressures on houses with sloped roofs. There is also a need for field measurements of wind pressures on commercial and light industrial buildings in hurricanes. Existing field data for these types of buildings has been limited to relatively low wind speeds (20 to 40 mph) in extra tropical storms.

The field measurement program initiated in FY 03 as part of the Hurricane Loss Mitigation Program seeks to develop the technology that will allow monitoring of wind loads on buildings with flat roofs. This has involved the re-design of the sensor packaging so that the sensor can be stably installed on a flat roof without creating penetrations in the roof surface, shown in Figure 1 [1]. The technical development of the sensor package was carried out in FY 02 under the sponsorship of a FIU International Hurricane Research Center HURRY (SP) Grant.

Figure 1. Pressure Sensor Packaging

INSTRUMENTATION AND DATA ACQUISITION

The instrumentation system, building off experiences of the Florida Coastal Monitoring Program, uses absolute pressure transducers to avoid having to run vinyl tubing over the roof in order to supply a reference pressure to each sensor. The technical development of this system is described in the MS Thesis by Michot [2]. The wiring of a sensor is accomplished with a single 4-conductor shielded cable. Wind speeds are monitored using a RM Young wind monitor with a hardened propeller and the speed range set at 0 to 200 mph. Data is collected using a National Instruments data acquisition board and a program developed using National Instrument's LabView object oriented software. The selected site for the FY 03 effort is the FIU Center for Engineering and Applied Science (CEAS) building located at 10555 W. Flagler Street in Miami. The sensor layout on the roof of the CEAS building is shown in Figure 2. A photograph of a sensor mounted on the roof is shown in Figure 3.

Figure 2. CEAS Building at Florida International University

Figure 3. Sensor Mounted on the Roof

Each of the sensors has been calibrated against a Setra Model 370 Digital Pressure Gage with an operating range of 800 to 1100 milli-bars. The obtained response is shown for one sensor in figure 4. The calibration functions for the 16 sensors are listed in Table 1 along with the R^2 value from the regression analysis.

Since the monitoring system is mounted on the FIU CEAS building (40' high building), a continuous monitoring of wind conditions and wind loads is possible. This will allow rapid debugging of the system before the heart of hurricane season is encountered.

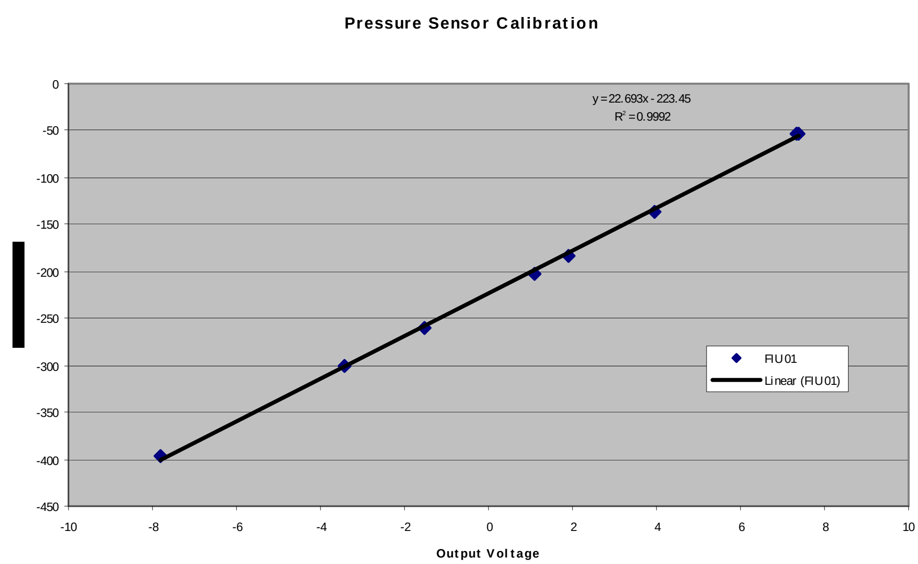


Figure 4. Pressure Sensor Calibration

Table 1. Calibration Equations for FIU Field Measurement Sensors			
Sensor Number	Slope of Calibration	Calibration Offset	Goodness of Fit – R^2
FIU 01	22.693	-223.5	0.9992
FIU 02	22.856	-200.1	0.9992
FIU 03	26.762	-277.3	0.9992
FIU 04	21.697	-182.3	0.9988
FIU 05	22.813	-208.6	0.999
FIU 06	26.774	-279.4	0.9993
FIU 07	21.732	-182.5	0.9988
FIU 08	21.588	-187.6	0.9988
FIU 09	26.816	-279.9	0.9991
FIU 10	22.8	-187.4	0.9992
FIU 11	26.952	-272.9	0.9985
FIU 12	26.809	-281.7	0.999
FIU 13	20.536	-206.7	0.9964
FIU 14	20.511	-212.1	0.9964
FIU 15	26.81	-282.3	0.9992
FIU 16	22.908	-196.6	0.9991

The data acquisition system is based on the National Instruments LabView, version 7.0. It was selected due to the versatility offered by this software-hardware system. Having installed the system opens new possibilities of utilization not only in this project, but also in general for collecting information and/or control in any other project. The data collection system structure is shown in Figure 5.

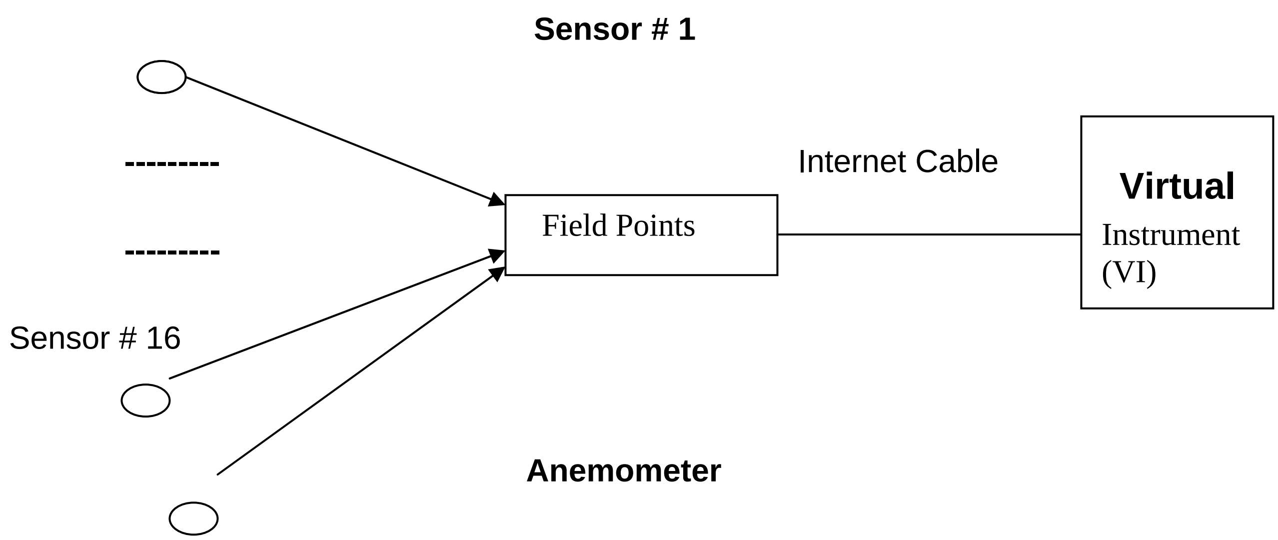


Figure 5. System Structure

As can be seen on figure 5, there are 16 pressure sensors and one anemometer connected, for a total of 18 lectures. Individual sensor location on the roof follows the scheme shown in figure 6. The installed system, shown in Figure 7, will permit among other results, to create a map of pressures on the roof under hurricane conditions.

The field points are shown in Figure 8. They are located also on the roof of the CEAS building, in a covered space known as the “penthouse”. The field points and the VI are connected to the source of energy through a UPS each in order to assure the necessary voltage to the system under any conditions.

Figure 9 shows the virtual instrument (VI) on the monitor screen. The data collection system is controlled by a National Instruments PXI, which an ideal computing device for this and similar tasks. The VI is saved in the file “Roof Instrumentation”. The information from the sensors is represented on the screen using two analog indicators. Each channel can be selected trough a pushbutton. The two variables from the anemometer are constantly indicated on the screen using two digital indicators. The sample rate can be modified through a pushbutton and is also indicated using a digital indicator.

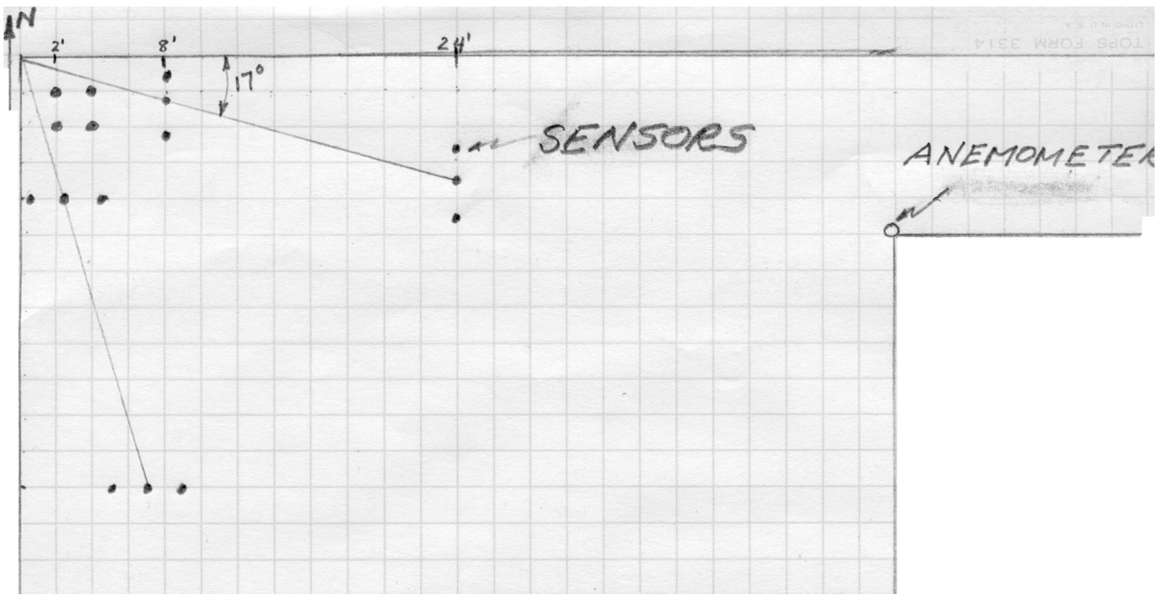


Figure 6. Lay Out of the 16 Sensors and the Anemometer

Figure 7. Pressure Sensors Installed on the Roof

Figure 8. The Field Points

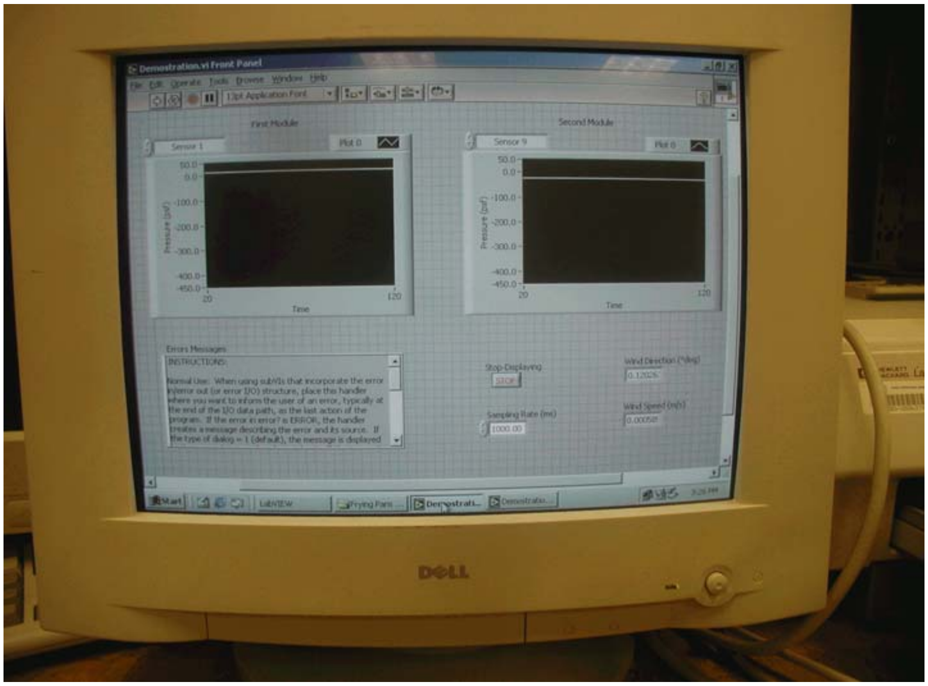


Figure 9. Virtual Instrument (VI)

Encountered difficulties:

The main encountered difficulty for the complete development of the work was the delay in installing the equipment on the roof of the CEAS building due to code regulations that was necessary to comply for getting the approval by the Department of Facility Management at FIU. This was communicated to us in June 2003, while the permit was submitted for approval on February 2003.

Conclusions and Recommendations

1. The data collection system is capable of sampling data from up to 24 sources at a sampling rate that can be fixed from a few milliseconds to several seconds. The data collection system has a precision better than 1%. The sensors and anemometer give the system precision, which is not better than 2%.
2. Several runs have been made showing the system working properly. One example of a run at a sampling rate of 1sample/second can be seen in file "Flat Roof Run 7-11-03". These runs have also given the idea of the necessary memory for a real experiment. For a sampling rate of 1 sample/second, the used memory in one hour is less than 0.5 MB. This result can lead to the conclusion of installing lower power computing units in future projects.
3. The electronic cards in the sensors have presented some reliability problems due to the extremely hard conditions of temperature and humidity they are forced to work with. It is recommended to realize a future work studying the following:
    - Improving the sensor packaging with respect to the heat absorption, the installation on the roof and simplifying the way the card is installed inside the device.
    - If the system will be installed in other buildings at FIU, coordinate with the Facility Management Department for the roof preparation.
    - Simplify the electronics used in the cards trying to improve the reliability through the use of few active components.

References

1. Caballero A., Mitrani J., Arencibia L*. Modification for the Sensors Field Measurement Applications.* Report presented to the IHC at Florida International University, June 2002.
2. Michot, B., *Full-Scale Wind Pressure Measurement Utilizing Unobtrusive Absolute Pressure Transducer Technology*, MS Thesis, Department of Civil Engineering, Clemson University, December, 1999.
3. National Instruments. LabView Version 7.0

3.1F GABLE END OVERHANGS

The portion of the gable roof that has been found to be a primary initiation point of failure during high wind events is the gable end overhang. Usually this overhang is constructed from a framing detail known as a "rake end overhang ladder detail." A sketch of this detail is shown in Figure 1. As shown in the figure, the wind passing over the bluff edge of the gable end of the structure tends to create uplift on the upper surface of the overhang, as well as on portions of the surface of the roof extending toward the interior of the roof. Simultaneously, wind action on the windward wall creates positive pressures that extend to the overhang above that wall. The negative upward pressure on the top surface of the overhang in conjunction with the positive upward pressure acting on the bottom surface of the overhang result in an overall increase in the upward force acting on the overhang. The combination of pressures acting above and below the overhang creates a moment at the point where the overhang attaches to the gable end truss or rafter. At the same time, a prying force is created at this same connection, between the roof sheathing and the last truss or rafter. The moment at this connection is resisted primarily by bending of the roof sheathing, while the uplift prying force is resisted by the weight of the overhang and by the fasteners that anchor the roof sheathing to the top of the gable end wall truss.

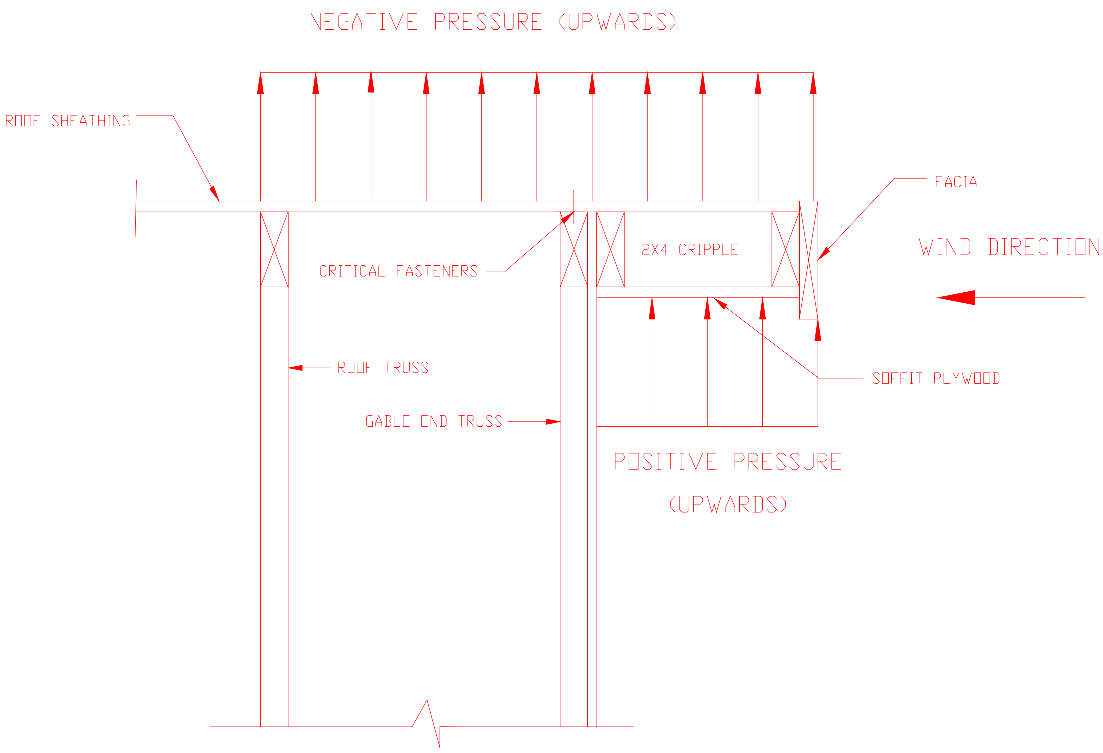


Figure 1. Rake Overhang Framing Detail

3.2a HLMP EVALUATION PROJECT: THE TARGETED SURVEY OF BUILDING PROFESSIONALS

Executive Summary

For the RCMP 2002-2003 research period the IHRC Team was tasked with assisting DCA in evaluating how effective the Hurricane Loss Mitigation Program (RCMP) has been in meetings its objectives. The approach used was to select one of the components of the RCMP to determine if its specific objectives were met during the year. The RCMP component selected was the program to educate building design and construction professionals across the state about the new, statewide, Florida Building Code. The method used was a targeted telephone survey of a representative sample of the building professionals.

The targeted survey of building professionals was conducted between mid April and early May of 2003. The target population was architects, professional engineers, and building related contractors. The primary purpose of the survey was to determine compliance with the educational requirement of the new statewide building code. The final sample size was 1361, which yields an overall margin of error of ±2.7 percentage points.

The major findings are as follows:

1. *On the whole, slightly more than 93% of building professionals are aware of the Core Curriculum course requirement established by the new statewide building code.*

2. *Overall nearly 66% of building professionals have taken the required course as of the time of the survey (between mid April and early May 2003). Architects (80.4%) were much more likely to have taken one of the new building code courses than are either contractors (68.6%) or engineers (57.5%).*

3. *Just at 69% of those who have not yet taken a course, intend to, but a sizable number indicate that they will not (20.4%) or are unsure (10.6%).*

4. *On the whole, a majority (52%) of those not intending on taking a training course consider that these courses are not mandatory.*

5. *By in large, the majority, 75.7%, of the building professionals that took one of the Core Curriculum courses were either satisfied or very satisfied with the course.*

6. *Nearly 68% of all building professionals, a clear majority, think that the adoption of the new statewide building code is a good thing. However, contractors (20.3%) are more likely to see the adoption of the statewide code as not good, when compared to engineers (13.1%) and architects (11.4%).*

7. *A majority of nearly 69% of building professionals thinks that the adoption of the new statewide building code will make Florida's homes safer from suffering hurricane damage.*

8. *Just at 53% of building professionals think that there has been more compliance with the new statewide building code and nearly 34% think compliance has remained the same. Only 5.4% think compliance has gotten worse.*

HLMP Evaluation Project:
The Targeted Survey of Building Professionals

The primary purpose of the Targeted Survey of Building Professionals (TSBP) was to determine compliance with the educational requirements of the new statewide building code. However, as part of the survey a variety of questions were asked of interviewees in order to obtain information on the following areas:

- Awareness of the new statewide building code's requirement that building and construction professionals must complete one of the "core" curriculum courses on the new building code.
- Compliance with the above requirement.
- The types of courses taken and when.
- How did they learn about the courses?
- If they have not taken the course:
    - Their intention to take a course.
    - If they don't intend to take the course, why is this the case?
- If they have taken a course:
    - Did the course increase their knowledge about the new code?
    - Their level of satisfaction with the course.
- Perceptions about the new statewide building code.
- Use of the Disaster Contractors' Network website.

METHODOLOGY:

Rather than having all building professionals licensed in the State of Florida as the target population, a decision was made to focus on building professionals most involved with issues of importance to Hurricane Loss Mitigation Program and related initiatives. Hence, the focus population of the targeted survey of building professionals was architects, contractors, and professional engineers. To carry out the survey a sample frame was developed from lists acquired from the State's licensing board's website. In total, the sample frame contained the names and addresses of 81,712 licensees. Table 1 displays the breakdown of the sample fame into architects, contractors and professional engineers. This listing was then sent to Survey Sampling Inc. who matched the names and addresses with telephone numbers and on the basis of this listing, a non-proportional stratified random sampling technique was utilized to derive the sample.

A non-proportional stratified sample was chosen to assure that adequate sub-sample sizes for each type of building professional would be obtained. The final sample[3] sizes for the total sample and each sub-sample, along with associated margins of error are also displayed in Table 1.

Table 1. Sample Frame, Sample and Subsample Sizes and Margins of Error

Licensed professional	Number in sample frame	Percentage of Frame	Sample Size	Margin of Errors
Architects	7,935	9.71	315	±5.5
Contractors	44,394	54.33	594	±4.0
Professional Engineers	29,383	35.96	454	±4.6
Totals	81,712	100.00	1363	±2.7

The advantage of a non-proportional sampling technique is that one can be assured of obtaining subsamples of sufficient size to establish reasonable margins of error, as is reflected in Table 1. Had such a procedure not been implemented, it is likely that the margin of error for the architect subsample would be much larger instead of the reasonable ±5.5 percentage points for this survey. However this technique also demands that the data be weighted in order to obtain valid estimates of the overall population -- in this case combined population of building professionals defined as architects, engineers, and building related contractors. Since there is no systemic information regarding the actual distributions of architects, building related contractors, and professional engineers in the population of all building professionals taken as a whole, the percentage of each group in the sample frame was used as our best estimate as to the actual percentages of each in the population.[4] These percentages were then used to determine appropriate weights when computing overall statistics for "building professionals" as a whole.

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[3] In total 1405 individuals were interviewed, however only 1363 identified themselves as architects, professional engineers, or contractors. The remaining individuals were dropped from the final sample utilized in this report. These individuals appeared in the sampling frame probably due to errors in the listings taken from the state licensing board, which may have for some reason included other building professionals in the listings of architects, engineers, or contractors.

[4] Since we encountered some errors in the listings acquired from the state licenceing board website, this assumption is certainly not without its problems. However, given the paucity of information, this assumption seems reasonably sound.

The survey was conducted between April 14th and May 8th 2003 by the Institute for Public Opinion Research (IPOR) at Florida International University at their telephone survey center located on the Biscayne Bay Campus.

The following section will highlight some of the findings. It will be followed with a more detailed discussion of particular questions included in the survey along with tables presenting the data from which these findings are drawn.

HIGHLIGHTS OF FINDINGS:

1. *On the whole, slightly more than 93% of building professionals are aware of the Core Curriculum course requirement established by the new statewide building code.*

2. *Overall nearly 66% of building professionals have taken the required course as of early May 2003.*

3. *In general, architects (80.4%) were much more likely to have taken one of the new building code courses than are either contractors (68.6%) or engineers (57.5%).*

4. *While nearly 33% of building professionals took courses before June of 2002, the majority of those that have taken a training course have done so since that time.*

5. *The majority (62.4%) of these building professionals took the basic core course, although sizable proportions have also taken the Structural (12.9%) and South Florida Building Code (12.8%) courses.*

6. *The vast majority of building professionals (85.4%) took an actual course rather than a virtual course on the web. Engineers (34%) were significantly more likely to take a web based training course than were either architects (10.5%) or contractors (4.9%).*

7. *The majority (58%) of those taking a training course learned of the course through a direct mailing.*

8. *Just at 69% of those who have not yet taken a course, intend to, but a sizable number indicate that they will not (20.4%) or are unsure (10.6%). Architects and*

engineers, particularly engineers, are much more likely to indicated that they either do not plan to take a course or are not sure.

9. *On the whole, a majority (52%) of those not intending on taking a training course are under the mistaken perception that these courses are not mandatory. Engineers and architects, when compared to contractors, are more likely to consider these courses as non-mandatory.*

10. *In general, most building professionals (60.5%) that took the training courses indicated that they were only somewhat familiar (44.4%) or not familiar at all (16.1%) with building code changes under the new statewide building code.*

11. *The vast majority, 78.6%, of the building professionals that took one of the Core Curriculum courses felt that it increased their knowledge of the new statewide building code.*

12. *By in large, the majority, 75.7%, of the building professionals that took one of the Core Curriculum courses were either satisfied or very satisfied with the course.*

13. *A majority of nearly 68% of all building professionals thinks that the adoption of the new statewide building code is a good thing. However, contractors (20.3%) are more likely to see the adoption of the statewide code as not good, when compared to engineers (13.1%) and architects (11.4%).*

14. *A majority of nearly 69% of building professionals thinks that the adoption of the new statewide building code will make Florida's homes safer from suffering hurricane damage. However, a significant percentage of contractors (23.9%) are more likely to think that the new code will not make Florida's homes safer and sizable percentages of both contractors (12.4%) and engineers (14.6%) are simply not sure of the new code's consequences for hurricane safety.*

15. *Just at 53% of building professionals think that there has been more compliance with the new statewide building code and nearly 34% think compliance has remained the same. Only 5.4% think compliance has gotten worse.*

16. *Just slightly less than half (49.1%) of the building professionals interviewed have purchased or acquired a copy of the new statewide building code. Architects, at nearly 69%, when compared to other building professionals, are much more likely to have a copy of the new statewide building code.*

17. *Very few if any building professionals, only 2.7%, have visited the Disaster Contractors Network website.*

DETAILED FINDINGS:

In the following sections the results for specific questions will be presented. Each section will begin with a listing of the specific question asked on the survey. This will be generally be followed by two subsections. First the findings for the building professionals as a whole will be presented and second, the results for each type of professional (architects, professional engineers and contractors) will be presented. It in each case, the statistics for the building professionals as a whole reflect estimates computed on the appropriately weighted data. The statistics for the individual subsamples – usually presented in the form of cross-tabulations -- are produced employing data weighted differently than the general statistics, which will yield the best possible estimates for each subsample. Chi-squared test are also presented for each cross-tabulation to help interpret whether the variations among the three groupings are potentially significant. In each case the chi-squared table always immediately follows the cross-tabulation to which it refers. In only a few cases, in which the data are too cumbersome and show little, will the results for comparing groups not be presented.

1. Are you aware that as part of Florida's New Statewide Building Code, construction professionals must complete a four-hour Core Curriculum course on the new code to maintain their license?

a. Building professionals as a whole: On the whole, slightly more than 93% of building professionals are aware of the Core Curriculum course requirement.

Aware of core curriculum course requirement

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	1269	93.1	93.2	93.2
	NO	93	6.8	6.8	100.0
	Total	1362	99.9	100.0	
Missing	DON'T KNOW/NO RESPONSE	1	.1		
Total		1363	100.0		

b. Comparisons among professionals: While there are some minor differences among these professionals, they are not statistically significant.

Aware of core curriculum course requirement * Type of building professional Crosstabulation

			Type of building professional		
			Engineers	Architects	Contractors
Aware of core curriculum course requirement	YES	Count	414	294	560
		% within Type of building professional	91.2%	93.9%	94.3%
	NO	Count	40	19	34
		% within Type of building professional	8.8%	6.1%	5.7%
Total		Count	454	313	594
		% within Type of building professional	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.223[a]	2	.121
Continuity Correction			
Likelihood Ratio	4.078	2	.130
Linear-by-Linear Association	3.680	1	.055
N of Valid Cases	1361		

a. **0 cells (.0%) have expected count less than 5. The minimum expected count is 21.39.**

2. Have you taken one of the four-hour Core Curriculum Courses on the new Statewide Building Code?

a. Building professionals as a whole: Overall nearly 66% have taken the required course as of the timing of the survey between mid April and early May 2003.

Has taken core curriculum course

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES, I HAVE	893	65.5	65.7	65.7
	NO, I HAVEN'T	466	34.2	34.3	100.0
	Total	1359	99.7	100.0	
Missing	DON'T KNOW/NO RESPONSE	4	.3		
Total		1363	100.0		

b. Comparison among building professionals: There are significant variations among professionals. In general, architects (80.4%) were much more likely to have taken one of the new building code courses than are either contractors (68.6%) or engineers (57.5%).

Has taken core curriculum course * Type of building professional Crosstabulation

			Type of building professional		
			Engineers	Architects	Contractors
Has taken core curriculum course	YES, I HAVE	Count	261	251	406
		% within Type of building professional	57.5%	80.4%	68.6%
	NO, I HAVEN'T	Count	193	61	186
		% within Type of building professional	42.5%	19.6%	31.4%
Total		Count	454	312	592
		% within Type of building professional	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	44.968[a]	2	.000
Continuity Correction			
Likelihood Ratio	46.259	2	.000
Linear-by-Linear Association	11.823	1	.001
N of Valid Cases	1358		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 101.09.

3 When did you take your new code-training course?

a. Building professionals as a whole: While just over 32% of professionals took courses before June of 2002, the majority of those that have taken a training course have done so since last June. Just over 75% had taken a course by the end of December 2002. While there were some variations among professionals, overall the results were quite similar, hence the cross-tabulation is not presented.

When code course was taken

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BEFORE JUNE 2002	272	20.0	32.1	32.1
	JUNE 2002	54	4.0	6.4	38.4
	JULY 2002	88	6.4	10.3	48.7
	AUGUST 2002	81	5.9	9.5	58.3
	SEPTEMBER 2002	28	2.1	3.4	61.6
	OCTOBER 2002	35	2.6	4.1	65.7
	NOVEMBER 2002	55	4.1	6.5	72.2
	DECEMBER 2002	43	3.1	5.1	77.3
	JANUARY 2003	49	3.6	5.8	83.0
	FEBRUARY 2003	55	4.0	6.5	89.5
	MARCH 2003	31	2.3	3.7	93.2
	APRIL/MAY 2003	58	4.3	6.8	100.0
	Total	850	62.3	100.0	
Missing	DON'T KNOW/NO RESPONSE	44	3.2		
	System	470	34.5		
	Total	513	37.7		
Total		1363	100.0		

4. Which type of new building code course did you take?

a. Building professionals as a whole: The majority (62.4%) of these building professionals took the basic core course, although sizable proportions have also taken the Structural (12.9%) and South Florida Building Code (12.8%) courses.

Type of code course taken

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BASIC CORE	534	39.2	62.4	62.4
	BUILDING STRUCTURAL	110	8.1	12.9	75.3
	BUILDING FIRE	18	1.3	2.1	77.4
	PLUMBING/GAS	2	.1	.2	77.6
	MECHANICAL/ENERGY	16	1.2	1.9	79.5
	SOUTH FLORIDA BUILDING CODES	110	8.0	12.8	92.3
	NOT SURE	30	2.2	3.5	95.8
	OTHER, SPECIFY	36	2.6	4.2	100.0
	Total	855	62.8	100.0	
Missing	DON'T KNOW/NO RESPONSE	38	2.8		
	System	470	34.5		
	Total	508	37.2		
Total		1363	100.0		

b. Comparison among building professionals: As one might well expect, there are significant variations in the courses taken by these professionals. Engineers were least likely to take the basic core course, while contractors were most likely to take that course.

Type of code course taken * Type of building professional Crosstabulation

			Type of building professional		
			Engineers	Architects	Contractors
Type of code course taken	BASIC CORE	Count	133	149	263
		% within Type of building professional	52.4%	61.1%	68.7%
	BUILDING STRUCTURAL	Count	42	26	43
		% within Type of building professional	16.5%	10.7%	11.2%
	BUILDING FIRE	Count	7	17	3
		% within Type of building professional	2.8%	7.0%	.8%
	PLUMBING/GAS	Count	1	1	
		% within Type of building professional	.4%	.4%	
	MECHANICAL/ENERG`	Count	13		1
		% within Type of building professional	5.1%		.3%
	SOUTH FLORIDA BUILDING CODES	Count	33	38	46
		% within Type of building professional	13.0%	15.6%	12.0%
	NOT SURE	Count	7	2	18
		% within Type of building professional	2.8%	.8%	4.7%
	OTHER, SPECIFY	Count	18	11	9
		% within Type of building professional	7.1%	4.5%	2.3%
Total		Count	254	244	383
		% within Type of building professional	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	76.162[a]	14	.000
Continuity Correction			
Likelihood Ratio	76.200	14	.000
Linear-by-Linear Association	9.365	1	.002
N of Valid Cases	881		

a. 5 cells (20.8%) have expected count less than 5. The minimum expected count is .55.

5. Did you take the course on the Web or Internet, or through an actual training course?

a. Building professionals as a whole: The vast majority (85.4%) of building professionals took an actual course rather than a virtual course on the web.

Web or actual training course

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	ON WEB	130	9.5	14.6	14.6
	ACTUAL TRAINING COURSE	756	55.5	85.4	100.0
	Total	885	65.0	100.0	
Missing	DON'T KNOW/NO RESPONSE	8	.6		
	System	470	34.5		
	Total	478	35.0		
Total		1363	100.0		

b. Comparison among building professionals: Engineers (34%) were significantly more likely to take a web based training course than were either architects (10.5%) or contractors (4.9%).

Web or actual training course * Type of building professional Crosstabulation

			Type of building professional		
			Engineers	Architects	Contractors
Web or actual training course	ON WEB	Count	87	26	20
		% within Type of building professional	34.0%	10.5%	4.9%
	ACTUAL TRAINING COURSE	Count	169	221	385
		% within Type of building professional	66.0%	89.5%	95.1%
Total		Count	256	247	405
		% within Type of building professional	100.0%	100.0%	100.0%

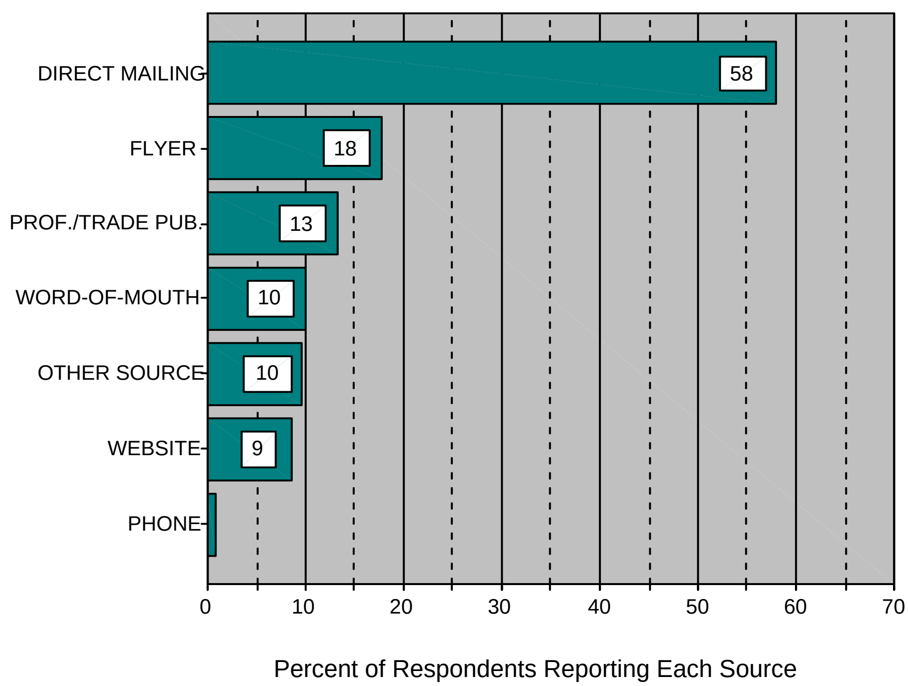
Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	110.459[a]	2	.000
Continuity Correction			
Likelihood Ratio	102.741	2	.000
Linear-by-Linear Association	99.032	1	.000
N of Valid Cases	908		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 36.18.

6. How did you learn about where you could take courses? (Check all that apply)

a. Building professionals as a whole: The majority (58%) of those taking a training course mentioned that one of the ways learned of the course through a direct mailing.



b. Comparison among building professionals: There were a number of significant differences among building professionals in terms of the sources from which they learned about where to take courses on the new building code. In general, it must be remembered that across the board, direct mailing was the major source, however there were some variations on the proportions within each group that mentioned direct mailing, which bordered on significant. Specifically, slightly fewer engineers reporting direct mailing as a source. However, engineers (16.1%) were more likely to report the web as a source than architects (8%) and contractor (4.7%). In addition both engineers (16.1%) and architects (21.2%) were more likely to report learning about these courses from professional or trade publications than contractors (9.9%). Contractors (21.7%), on the other hand, were more likely to report learning of these courses from a flyer than engineers (12.3%) or architects (12.7%). Each comparison is presented below.

From Website?

			Type of building professional		
			Engineers	Architects	Contractors
WEBSITE	not this source	Count	219	231	387
		% within Type of building professional	83.9%	92.0%	95.3%
	Yes, this source	Count	42	20	19
		% within Type of building professional	16.1%	8.0%	4.7%
Total		Count	261	251	406
		% within Type of building professional	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	26.033[a]	2	.000
Continuity Correction			
Likelihood Ratio	24.626	2	.000
Linear-by-Linear Association	24.699	1	.000
N of Valid Cases	918		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 22.15.

From Flyer?

			Type of building professional		
			Engineers	Architects	Contractors
FLYER	not this source	Count	228	220	318
		% within Type of building professional	87.7%	87.3%	78.3%
	Yes, this source	Count	32	32	88
		% within Type of building professional	12.3%	12.7%	21.7%
Total		Count	260	252	406
		% within Type of building professional	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	13.811[a]	2	.001
Continuity Correction			
Likelihood Ratio	13.726	2	.001
Linear-by-Linear Association	11.393	1	.001
N of Valid Cases	918		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 41.73.

From Direct Mailing?

			Type of building professional		
			Engineers	Architects	Contractors
DIRECT MAILING	not this source	Count	123	109	157
		% within Type of building professional	47.1%	43.4%	38.7%
	Yes, this source	Count	138	142	249
		% within Type of building professional	52.9%	56.6%	61.3%
Total		Count	261	251	406
		% within Type of building professional	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.876[a]	2	.237
Continuity Correction			
Likelihood Ratio	2.560	2	.278
Linear-by-Linear Association	1.977	1	.160
N of Valid Cases	918		

a. 3 cells (50.0%) have expected count less than 5. The minimum expected count is 1.91.

Word of Mouth?

			Type of building professional		
			Engineers	Architects	Contractors
WORD-OF-MOUTH	not this source	Count	235	233	363
		% within Type of building professional	90.0%	92.5%	89.4%
	Yes, this source	Count	26	19	43
		% within Type of building professional	10.0%	7.5%	10.6%
Total		Count	261	252	406
		% within Type of building professional	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.735[a]	2	.420
Continuity Correction			
Likelihood Ratio	1.806	2	.405
Linear-by-Linear Association	.174	1	.677
N of Valid Cases	919		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 24.13.

Professional or Trade Publication?

			Type of building professional		
			Engineers	Architects	Contractors
PROFESSIONAL OR TRADE PUBLICATION	not this source	Count	219	198	366
		% within Type of building professional	83.9%	78.9%	90.1%
	Yes, this source	Count	42	53	40
		% within Type of building professional	16.1%	21.1%	9.9%
Total		Count	261	251	406
		% within Type of building professional	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	16.246[a]	2	.000
Continuity Correction			
Likelihood Ratio	16.269	2	.000
Linear-by-Linear Association	6.726	1	.010
N of Valid Cases	918		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 36.91.

Other Source?

			Type of building professional		
			Engineers	Architects	Contractors
OTHER SOURCE	not this source	Count	233	228	369
		% within Type of building professional	89.3%	90.8%	90.9%
	Yes, this source	Count	28	23	37
		% within Type of building professional	10.7%	9.2%	9.1%
Total		Count	261	251	406
		% within Type of building professional	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.549[a]	2	.760
Continuity Correction			
Likelihood Ratio	.538	2	.764
Linear-by-Linear Association	.430	1	.512
N of Valid Cases	918		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 24.06.

7. Do you intend to take a training course on the new building code?

a. Building professionals as a whole: This question was, of course, only asked of those that have not taken a course by the time of the interview. Just at 69% of those who have not yet taken a course, intend to, but a sizable number indicate that they will not (20.4%) or are unsure (10.6%).

Intends to take code course

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	324	23.8	69.0	69.0
	NO	96	7.0	20.4	89.4
	NOT SURE	50	3.6	10.6	100.0
	Total	470	34.5	100.0	
Missing	System	893	65.5		
Total		1363	100.0		

b. Comparison among building professionals: Among those who have not taken a course, architects and engineers, particularly engineers, are much more like to indicated that they either do not plan on taking the required course or are not sure as to whether or not they will. Just over 51% of the engineers who have not taken a course say that they will not or are not sure if they will take the course.

Intends to take code course * Type of building professional Crosstabulation

			Type of building professional		
			Engineers	Architects	Contractors
Intends to take code course	YES	Count	94	47	163
		% within Type of building professional	48.7%	73.4%	86.7%
	NO	Count	72	9	11
		% within Type of building professional	37.3%	14.1%	5.9%
	NOT SURE	Count	27	8	14
		% within Type of building professional	14.0%	12.5%	7.4%
Total		Count	193	64	188
		% within Type of building professional	100.0%	100.0%	100.0%

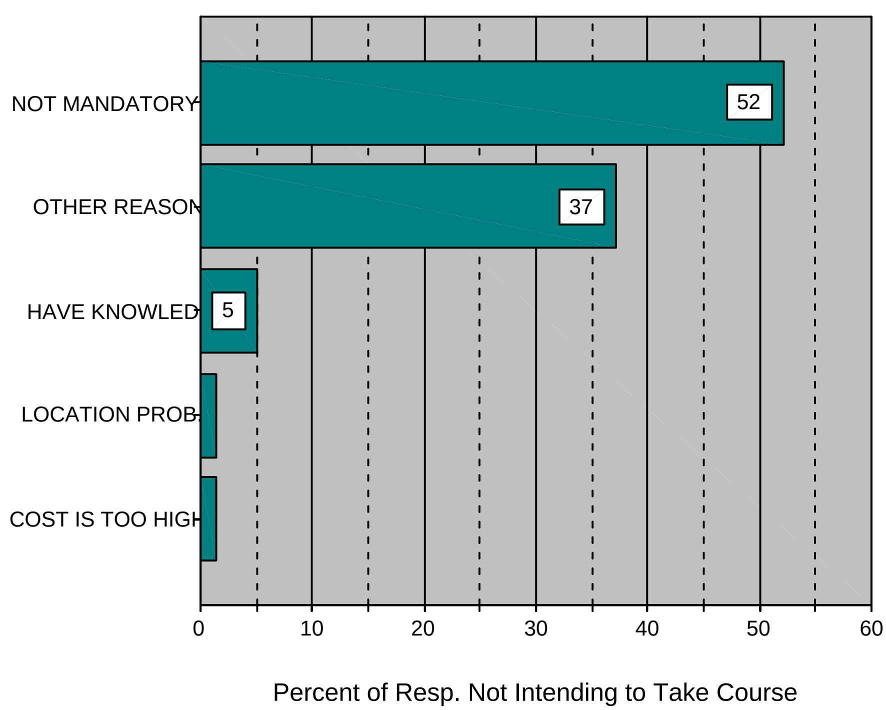
Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	71.423[a]	4	.000
Continuity Correction			
Likelihood Ratio	75.188	4	.000
Linear-by-Linear Association	40.576	1	.000
N of Valid Cases	445		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 7.05.

8. Why don't you plan to take the training? (Check all that apply).

a. Building professionals as a whole: This question was only asked of those (less than 100) not intending to take the training. On the whole, the majority (52%) of those not intending to take the training course are under the mistaken perception that these courses are not mandatory. A sizable percentage (37%) also has other reasons ranging from retirement, shifts in business interests or activities, etc.



b. Comparison among building professionals: While there are some variations among building professions regarding reasons for not having taken a course, the only variation that is significant concerned the perception that these courses are not mandatory. Of those not intending to take one of the courses, engineers (58.9%) and architects (55.6%) are more likely to indicate that they will not be taking a course because they feel that the course is not mandatory for them.

Feel that the Course is Not Mandatory by type of Building Professional

			Type of building professional		
			Engineers	Architects	Contractors
IT ISN'T MANDATORY	not a reason	Count	30	4	10
		% within Type of building professional	41.1%	44.4%	83.3%
	Yes, a reason	Count	43	5	2
		% within Type of building professional	58.9%	55.6%	16.7%
Total		Count	73	9	12
		% within Type of building professional	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.407[a]	2	.025
Continuity Correction			
Likelihood Ratio	7.878	2	.019
Linear-by-Linear Association	6.401	1	.011
N of Valid Cases	94		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is 4.21.

9. Prior to taking the course, how familiar with the new Florida Building code changes were you? Would you say you were very familiar, familiar, somewhat familiar, or not familiar at all?

a. Building professionals as a whole: In general, most building professionals (60.5%) that took the training courses indicated that they were only somewhat familiar (44.4%) or not familiar at all (16.1%) with building code changes under the new statewide building code.

How familiar with code changes before course

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	VERY FAMILIAR	201	14.7	22.5	22.5
	FAMILIAR	151	11.1	17.0	39.5
	SOMEWHAT FAMILIAR	396	29.0	44.4	83.9
	NOT FAMILIAR	143	10.5	16.1	100.0
	Total	891	65.4	100.0	
Missing	DON'T KNOW/NO RESPONSE	2	.1		
	System	470	34.5		
	Total	472	34.6		
Total		1363	100.0		

b. Comparison among building professionals: There were some significant variations among the professions, with engineers being slightly more inclined to indicate they were unfamiliar with the code changes, followed by architects and then contractors.

How familiar with code changes before course * Type of building professional Crosstabulation

			Type of building professional		
			Engineers	Architects	Contractors
How familiar with code changes before course	VERY FAMILIAR	Count	45	64	101
		% within Type of building professional	17.4%	25.5%	24.9%
	FAMILIAR	Count	54	48	59
		% within Type of building professional	20.8%	19.1%	14.5%
	SOMEWHAT FAMILIAR	Count	102	97	196
		% within Type of building professional	39.4%	38.6%	48.3%
	NOT FAMILIAR	Count	58	42	50
		% within Type of building professional	22.4%	16.7%	12.3%
Total		Count	259	251	406
		% within Type of building professional	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	23.284[a]	6	.001
Continuity Correction			
Likelihood Ratio	23.362	6	.001
Linear-by-Linear Association	4.690	1	.030
N of Valid Cases	916		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 41.10.

10. In general, did the course increase your knowledge of the new building code?

a. Building professionals as a whole: The vast majority, 78.6%, of the building professionals that took one of the Core Curriculum courses felt that it increased their knowledge of the new statewide building code.

Course increased knowledge of code

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	697	51.1	78.6	78.6
	NO	190	13.9	21.4	100.0
	Total	887	65.1	100.0	
Missing	DON'T KNOW/NO RESPONSE	6	.5		
	System	470	34.5		
	Total	476	34.9		
Total		1363	100.0		

b. Comparison among building professionals: There were significant variations among the professions with respect to their assessments of whether or not the courses increased their knowledge. While again the clear majority of professionals, across the board, thought the courses increased their knowledge, contractors in particular, were more likely to feel that the courses did not increase their knowledge of code changes.

Course increased knowledge of code * Type of building professional Crosstabulation

			Type of building professional		
			Engineers	Architects	Contractors
Course increased knowledge of code	YES	Count	211	213	305
		% within Type of building professional	82.1%	84.9%	75.3%
	NO	Count	46	38	100
		% within Type of building professional	17.9%	15.1%	24.7%
Total		Count	257	251	405
		% within Type of building professional	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.916[a]	2	.007
Continuity Correction			
Likelihood Ratio	9.962	2	.007
Linear-by-Linear Association	5.685	1	.017
N of Valid Cases	913		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 50.58.

11. How would you rate your overall satisfaction with the course? Were you very satisfied, satisfied, somewhat satisfied, or not satisfied?

a. Building professionals as a whole: By in large, a clear majority, 75.7%, of the building professionals that took one of the Core Curriculum courses were either satisfied or very satisfied with the course.

Overall satisfaction with course

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	VERY SATISIFIED	245	17.9	27.5	27.5
	SATISIFIED	428	31.4	48.2	75.7
	SOMEWHAT SATISIFIED	144	10.6	16.2	91.9
	NOT SATISIFIED	72	5.3	8.1	100.0
	Total	889	65.2	100.0	
Missing	DON'T KNOW/NO RESPONSE	5	.3		
	System	470	34.5		
	Total	474	34.8		
Total		1363	100.0		

b. Comparison among building professionals: While in general all building professionals were at least satisfied with the courses, contractors were somewhat more likely to indicate dissatisfaction with the courses, and this variation was approaching significance when comparing across building professionals.

Overall satisfaction with course * Type of building professional Crosstabulation

			Type of building professional		
			Engineers	Architects	Contractors
Overall satisfaction with course	VERY SATISIFIED	Count	72	70	110
		% within Type of building professional	27.8%	28.1%	27.2%
	SATISIFIED	Count	131	113	192
		% within Type of building professional	50.6%	45.4%	47.4%
	SOMEWHAT SATISIFIED	Count	45	49	60
		% within Type of building professional	17.4%	19.7%	14.8%
	NOT SATISIFIED	Count	11	17	43
		% within Type of building professional	4.2%	6.8%	10.6%
Total		Count	259	249	405
		% within Type of building professional	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	11.650[a]	6	.070
Continuity Correction			
Likelihood Ratio	12.034	6	.061
Linear-by-Linear Association	2.387	1	.122
N of Valid Cases	913		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 19.36.

12. Would you recommend taking a course from that provider to a friend or associate?

a. Building professionals as a whole: An overwhelming percentage of 85.8% would recommend taking the course from the same provider to a friend or associate.

Would recommend course

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	746	54.7	85.8	85.8
	NO	123	9.0	14.2	100.0
	Total	869	63.7	100.0	
Missing	DON'T KNOW/NO RESPONSE	25	1.8		
	System	470	34.5		
	Total	494	36.3		
Total		1363	100.0		

b. Comparison among building professionals: The same pattern held across building professionals. There were no significant variations.

Would recommend course * Type of building professional Crosstabulation

			Type of building professional		
			Engineers	Architects	Contractors
Would recommend course	YES	Count	219	210	337
		% within Type of building professional	87.3%	87.5%	84.7%
	NO	Count	32	30	61
		% within Type of building professional	12.7%	12.5%	15.3%
Total		Count	251	240	398
		% within Type of building professional	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.350[a]	2	.509
Continuity Correction			
Likelihood Ratio	1.345	2	.511
Linear-by-Linear Association	1.006	1	.316
N of Valid Cases	889		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 33.21.

13. In general, do you think the adoption of this statewide code was a good thing?

a. Building professionals as a whole: A majority of nearly 68% of all building professionals thinks that the adoption of the new statewide building code is a good thing.

Adoption of new code a good thing

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	898	65.9	67.9	67.9
	NO	223	16.4	16.9	84.8
	NOT SURE	201	14.8	15.2	100.0
	Total	1322	97.0	100.0	
Missing	DON'T KNOW/NO RESPONSE	41	3.0		
Total		1363	100.0		

b. Comparison among building professionals: While a clear majority of all building professionals think that the adoption of the new statewide building code is a good thing, there are some significant variations. Specifically, contractors (20.3%) are more likely to see the adoption of the statewide code as not good, when compared to engineers (13.1%) and architects (11.4%).

Adoption of new code a good thing * Type of building professional Crosstabulation

			Type of building professional		
			Engineers	Architects	Contractors
Adoption of new code a good thing	YES	Count	316	218	373
		% within Type of building professional	72.6%	71.2%	64.2%
	NO	Count	57	35	118
		% within Type of building professional	13.1%	11.4%	20.3%
	NOT SURE	Count	62	53	90
		% within Type of building professional	14.3%	17.3%	15.5%
Total		Count	435	306	581
		% within Type of building professional	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	17.167[a]	4	.002
Continuity Correction			
Likelihood Ratio	17.135	4	.002
Linear-by-Linear Association	4.209	1	.040
N of Valid Cases	1322		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 47.45.

14. Do you think the new code will make Florida's homes safer from hurricane damage?

a. Building professionals as a whole: Nearly 69% of building professionals think that the adoption of the new statewide building code will make Florida's homes safer from suffering hurricane damage. And yet, a sizable percentage of just over 31% indicate that it will not, or they are unsure.

New code will make homes safer from hurricanes

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	908	66.6	68.7	68.7
	NO	247	18.1	18.7	87.3
	NOT SURE	167	12.3	12.7	100.0
	Total	1322	97.0	100.0	
Missing	DON'T KNOW/NO RESPONSE	41	3.0		
Total		1363	100.0		

b. Comparison among building professionals: While a majority of all building professionals think that the adoption of the new statewide building code will make Florida's homes more hurricane safe, there are significant variations. Specifically, contractors (23.9%) are more likely to think that the new code will not make Florida's homes more hurricane safe and sizable percentages of both contractors (12.4%) and engineers (14.6%) are simply not sure of the new code's consequences for hurricane safety.

New code will make homes safer from hurricanes * Type of building professional Crosstabulation

			Type of building professional		
			Engineers	Architects	Contractors
New code will make homes safer from hurricanes	YES	Count	318	242	371
		% within Type of building professional	73.8%	77.8%	63.7%
	NO	Count	50	47	139
		% within Type of building professional	11.6%	15.1%	23.9%
	NOT SURE	Count	63	22	72
		% within Type of building professional	14.6%	7.1%	12.4%
Total		Count	431	311	582
		% within Type of building professional	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	38.329[a]	4	.000
Continuity Correction			
Likelihood Ratio	39.418	4	.000
Linear-by-Linear Association	4.098	1	.043
N of Valid Cases	1324		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 36.88.

15. Do you think that with the new statewide building code, we will see more compliance by the building community, or will compliance be worse, or stay the same?

a. Building professionals as a whole: Just at 53% of building professionals think that there has been more compliance with the new statewide building code and nearly 34% think compliance has remained the same. Only 5.4% think compliance has gotten worse.

Compliance has improved since new code adoption

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	MORE COMPLIANCE	693	50.9	53.0	53.0
	WORSE COMPLIANCE	71	5.2	5.4	58.4
	STAY THE SAME	440	32.3	33.6	92.0
	NOT SURE	105	7.7	8.0	100.0
	Total	1309	96.0	100.0	
Missing	DON'T KNOW/NO RESPONSE	54	4.0		
Total		1363	100.0		

b. Comparison among building professionals: There are some significant variations among building professionals in terms of compliance although on the whole the patterns are more or less consistent. In general terms contractors remaining somewhat more pessimistic about compliance.

Compliance has improved since new code adoption * Type of building professional Crosstabulation

			Type of building professional		
			Engineers	Architects	Contractors
Compliance has improved since new code adoption	MORE COMPLIANCE	Count	239	179	289
		% within Type of building professional	55.5%	58.1%	50.4%
	WORSE COMPLIANCE	Count	19	7	38
		% within Type of building professional	4.4%	2.3%	6.6%
	STAY THE SAME	Count	139	91	202
		% within Type of building professional	32.3%	29.5%	35.3%
	NOT SURE	Count	34	31	44
		% within Type of building professional	7.9%	10.1%	7.7%
Total		Count	431	308	573
		% within Type of building professional	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	14.158[a]	6	.028
Continuity Correction			
Likelihood Ratio	14.820	6	.022
Linear-by-Linear Association	1.294	1	.255
N of Valid Cases	1312		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 15.02.

16. Have you purchased or acquired a copy of the new building code?

a. Building professionals as a whole: Just slightly less than half of the building professionals interviewed have purchased or acquired a copy of the new statewide building code.

Has copy of the new building code

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	665	48.8	49.1	49.1
	NO	691	50.7	50.9	100.0
	Total	1356	99.5	100.0	
Missing	DON'T KNOW/NO RESPONSE	7	.5		
Total		1363	100.0		

***b. Comparison among building professionals**:* Architects, at nearly 69%, when compared to other building professionals are much more likely to have a copy of the new statewide building code.

*Has copy of the new building code * Type of building professional Crosstabulation*

			Type of building professional			Total
			Engineers	Architects	Contractors	
Has copy of the new building code	YES	Count	212	214	278	704
		% within Type of building professional	46.8%	68.6%	47.1%	52.0%
	NO	Count	241	98	312	651
		% within Type of building professional	53.2%	31.4%	52.9%	48.0%
Total		Count	453	312	590	1355
		% within Type of building professional	100.0%	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	44.940[a]	2	.000
Continuity Correction			
Likelihood Ratio	45.926	2	.000
Linear-by-Linear Association	.104	1	.747
N of Valid Cases	1355		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 149.90.

17. And lastly, have you visited the Disaster Contractors Network website?

a. Building professionals as a whole: Very few if any building professionals, only 2.7%, have ever visited the Disaster Contractors Network website.

Has visited Disaster Contractors Network Website

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	YES	37	2.7	2.7	2.7
	NO	1314	96.4	97.3	100.0
	Total	1351	99.1	100.0	
Missing	DON'T KNOW/NO RESPONSE	12	.9		
Total		1363	100.0		

b. Comparison among building professionals: This same patter holds across professions; essentially few, in any, building professionals are making use of the Disaster Contractor's Network website at this time.

Has visited Disaster Contractors Network Website * Type of building professional Crosstabulation

			Type of building professional		
			Engineers	Architects	Contractors
Has visited DCNONLINE	YES	Count	12	7	17
		% within Type of building professional	2.7%	2.3%	2.9%
	NO	Count	437	303	574
		% within Type of building professional	97.3%	97.7%	97.1%
Total		Count	449	310	591
		% within Type of building professional	100.0%	100.0%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.300[a]	2	.861
Continuity Correction			
Likelihood Ratio	.308	2	.857
Linear-by-Linear Association	.055	1	.814
N of Valid Cases	1350		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.27.

SUMMARY:

In summary, while the vast majority of building professional interviewed knew of the educational requirement of the building code, it is somewhat surprising that only two-thirds have complied with the requirement, particularly given that the TSBP was undertaken just prior to the deadline for most of these professionals. A rather substantial number not haven taken the course are under the impression that it is not mandatory. Nevertheless, the majority of those not haven taken a course, do plan to in the future. The vast majority that has taken a course, found the course to be at least satisfactory and it increase their knowledge of the new building code.

The vast majority of building professionals think that the adoption of the statewide building code is a good thing for Florida and it will make Florida's homes safer from hurricane damage.

3.2b HLMP EVALUATION PROJECT: THE HURRICANE LOSS MITIGATION BASELINE SURVEY

I. INTRODUCTION

The International Hurricane Research Center (IHRC) at Florida International University (FIU) has, from its inception, sought to assist the Florida Department of Community Affairs (DCA) in its goal of strengthening Florida's communities through a variety of research endeavors. DCA has, through what were its divisions of Housing and Community Development and Emergency Management developed a number of innovative programs seeking to lessen the State's vulnerability hurricanes. Over the years since Hurricane Andrew, these programs have included the Residential Construction Mitigation Program (RCMP), the Long-term Recovery Program, the Local Mitigation Strategy, etc. More recently DCA has integrated the RCMP and other programs, utilizing CAT funding, into the Hurricane Loss Mitigation Program although most everyone continues to refer to it as RCMP.

A critical target of DCA's programs, has been homeowners of single-family residences. When compared to renters or even condominium owners, the owners of single-family detached housing have the greatest freedom and potential to undertake modifications to their homes that can mitigate the potential for hurricane damage. Unfortunately, policy development has been hampered by lack of significant information on the mitigation status of Florida's single-family housing in the first place. For example, answering the simple question of how extensively are Florida's homeowners making use of even obvious hurricane mitigation technologies, such as shutters can be important for targeting programs to particular regions of the state or even particular segments of the state's population who are particularly at risk. Furthermore, little is known about perceptions of hurricane risk or opinions regarding the importance of mitigation nor is there information about the degree to which homeowners know of various mitigation techniques that they might employ to make their homes safer. To guide planners in the development of effective programs and policies, there is a need to better understand what factors tend to motivate or inhibit mitigation, and how attitudes vary according to geographic location, as well as consequences of prior hurricane experience. Such information will assist DCA and other government agencies to better understand their clientele, enabling the design and delivery of more effective targeted programs.

To assist DCA to better understand the nature, characteristics, and perceptions of one of its primary target populations and to gain information concerning the level of awareness throughout the State regarding DCA's hurricane loss mitigation programs, the IHRC has conducted the Hurricane Loss Mitigation Program Baseline survey. The target population of this survey is households residing in single-family owner occupied detached homes. The ultimate goals are to provide critical information regarding this populations perceptions of hurricane risk, use and awareness of hurricane mitigation technologies, such as shutters, perceptions of state programs to promote hurricane safety, and potential responsiveness to various incentive programs promoting hurricane mitigation. This report presents the specific findings regarding these issues utilizing information gathered as a part of this survey and analyzed herein. However, it should also be pointed out that the long-term data collection goal should be to repeat the Hurricane Loss Mitigation Survey on a bi-annual basis to facilitate the tracking of changes in the hurricane mitigation status of Florida's homes and to better assess the effectiveness of RCMP programs.

Specifically this report presents findings drawn from the Hurricane Loss Mitigation Program Survey related to:

- Household characteristics of Florida's single family homeowners
- Housing characteristics, including the use of hurricane shutters and envelope coverage
- Relative importance of various sources of mitigation information, along with assessments of trust and effectiveness.
- Homeowners' experience with hurricanes
- Homeowners' perceptions of hurricane and other natural hazard risk
- Homeowners' knowledge and opinions of various mitigation incentive programs
- Homeowners' knowledge of various hurricane mitigation technologies beyond window protection.
- Regional variations with respect to all of the above

Before discussing the findings, it is critical to understand the nature of the sample and data collection procedures and to understand that the findings are limited to households residing in owner occupied single-family detached housing.

II. METHODOLOGY

1. The Survey

The statewide Hurricane Loss Mitigation Baseline (HLMB) Survey was conducted between February 26th and March 20th 2003 by the Institute for Public Opinion Research (IPOR) at Florida International University using telephone interviewing techniques. The instrument, while based, in part, upon previous survey instruments employed in surveys conducted throughout Florida developed by researchers affiliated with the Laboratory for Social and Behavioral Research at the IHRC and IPOR, was modified through the addition of questions regarding hurricane mitigation technologies and various state programs[5]. In addition, just prior to the start of the survey itself, the IHRC Team was requested to incorporate questions from the Florida Alliance for Safe Homes (FLASH) survey of "likely voters" conducted in October of 1999 (www.flash.org/News/MasonDixon/MasonDisonPoll.html). Some of these suggested questions were not included, because similar questions were already being asked[6] and the format of the questions that were included was modified to better fit within the existing instrument's format and to reduce potential response bias[7]. On the whole, the survey instrument was designed to acquire information from a key household informant, usually the male or female head of household, on household and home characteristics and a variety of perceptions and opinions. A copy of the complete interview schedule can be found in Appendix A.

2. The Sample

As mentioned above, the Hurricane Loss Mitigation Baseline (HLMB) Survey was undertaken to provide data on households residing in owner-occupied single-family detached residences throughout the entire state of Florida. Together, these households represent the major contributors to the State's hurricane catastrophic insurance fund and are a primary target for many statewide hurricane mitigation initiatives.

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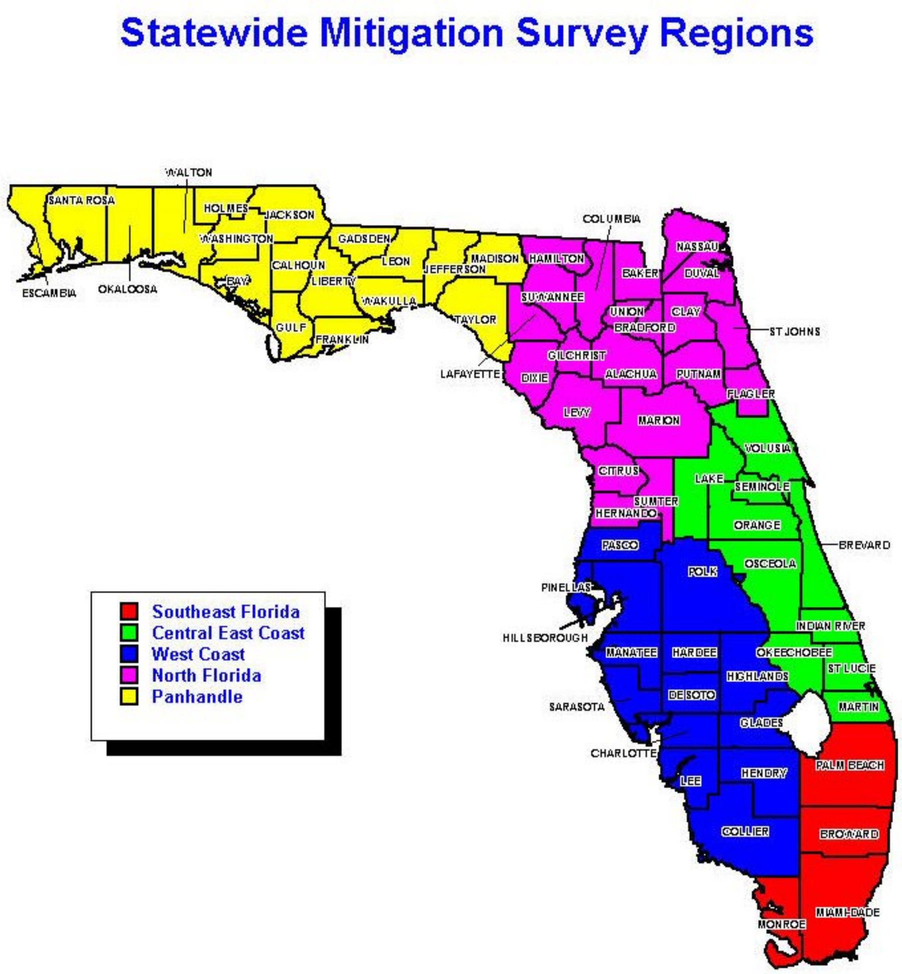
[5] In addition to the author other researchers that have contributed and/or commented on the instrument include Hugh Gladwin, Ricardo Alvarez, Carolyn Anderson, Mike Lindell, and Betty Morrow. Jim Rivers deserves special thanks for his comments and participation in development of the instrument.
[6] Questions on incentives and experience were already a part of the original instrument.
[7] Hugh Gladwin deserves special thanks for helping rework, reformat and cobble together the restructured instrument with all of its last minute changes. Unfortunately newly added and modified questions could not be adequately pretested due to the time constrains imposed by their late addition.

A plan was developed to obtain a random sample of approximately 1200 home owning households residing in single-family detached housing[8]. A major problem of conducting such a survey is that not every one reached to participate in the survey will be a part of the target population. According 2000 US Census just over 70% of households are located in owner occupied housing, which is up slightly from the 1990 census figure of 67.2%. This percentage is high relative to the population of interest, since it includes home ownership of everything from single-family detached housing, through condominiums and attached dwellings to mobile homes. Again, according to the 2000 census, the homeownership rate for single-family detached housing is only 49% percent for the State of Florida, a figure that is also up from 1990 when it was approximately 46%. Thus, when considering the development of our sampling methodology, our target population represented only 49% of all households in the State.

The telephone survey was conducted employing an equal probability randomly digit dialed sample that was drawn by Survey Sampling, Inc. At the beginning of each call a series of screening questions was asked to determine if the contacted person was an adult decision maker in a household residing in an owner-occupied single-family detached residence and was a Florida resident. If these criteria were met, an interview was conducted. Since the proportion of households actually residing in owner occupied single family detached housing was 49% in the state, a large number of phone calls were required until appropriate households were located. The final sample size was 1260 households residing in single family owner occupied detached homes which should yield a margin of error of approximately ± 2.8 percentage points, assuming one is interested in establishing 95% confidence intervals. This margin of error is, of course, approximate, because the actual margin of error for each question will depend upon its level of measurement and the dispersion of cases within the measure.

[8] Homeowners of attached housing, such as condominiums and townhouses are subject to many more constraints in terms of modifying their structures to make them more hurricane safe, hence they are not included.

Figure 1.



In order to help DCA target initiatives to the varying needs of homeowners located in different areas of the state, in addition to statewide findings, results will often be presented and discussed by regions as illustrated in Figure 1. These regions are Southeast Florida (red), the West Coast (blue), the Central East Coast (green), North Florida (purple), and the Panhandle (yellow). In addition, at times findings with respect to coastal versus inland counties will also be discussed. Sample breakdowns by regions are presented in Table 1 and by coastal location in Table 2 (see below).

Table 1. Hurricane Loss Mitigation Baseline Survey Regions

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Southeast Florida	399	31.7	31.7	31.7
	Central East Coast	248	19.7	19.7	51.3
	West Coast	340	27.0	27.0	78.3
	North Florida	181	14.4	14.4	92.7
	Panhandle	92	7.3	7.3	100.0
	Total	1260	100.0	100.0	

The majority of households are located in either the Southeast (31.7%) or the West Coast (27.0%) regions, combining to make up nearly 59% of the total sample. Since the sample was designed to be representative of population distributions, these breakdowns also reflect the distribution of owner occupied households throughout the state. As seen in Table 2, the vast majority of owner occupied single-family residences, 78%, are located in coastal counties. With the exception of the Panhandle, most coastal counties have at least part of their areas included in the State's wind-borne debris region which, under the new statewide building code requiring shutters or impact resistant glass.

Table 2. Coastal and Inland Counties

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Inland County	277	22.0	22.0	22.0
	Coastal County	983	78.0	78.0	100.0
	Total	1260	100.0	100.0	

III. HIGHLIGHTS OF FINDINGS AND SUMMARIES

The following section offers highlights of the survey's findings. These findings are broken down into the following sections: 1) Household demographic characteristics; 2) Housing characteristic and hurricane mitigation status; 3) How much has been spent, is necessary to spend, and likely to be spent to better protect family and home; 4) The importance of hurricane safety features when purchasing a home; 5) Hurricane season preparation; 6) Hurricane experience; 7) Hurricane and other natural hazard risk perception; *8)* Knowledge about hurricane risk, damage, and mitigation; 9) Sources, methods, and trust in public information about hurricanes; 10) Awareness of State Government programs and organizations active in promoting hurricane safety; and 11) Incentives to shutter. Each section will list highlights from the data analyses presented later in this report and conclude with a summary that will often discuss the policy implications of the findings and suggestions for the future course of policy.

1. Household Demographic Characteristics:

1.1. As noted above, the majority of households residing in single family owner occupied detached housing are located in either the Southeast (31.7%) or the West Coast (27.0%) regions, combining to make up nearly 59% of the total sample. The breakdowns for other regions are 19.7% in the Central East Coast region, 14.4% in North Florida, and 7.3% in the Panhandle. As with the population of Florida in general, the vast majority of these households are located in coastal counties.

1.2. Households residing in single-family owner occupied detached residences are relatively affluent. The average reported value of their homes is slightly more than $169,000, 57% report household incomes in excess of $50,000 and 55% of these households have at least one household member with a college, professional or graduate degree. There are however regional variations, for example homes in Southeast Florida have significantly higher reported values than other regions of the state. Despite the affluence, one-fifth of these households also report household incomes less than $30,000 and 23% have no members with higher than a high school diploma.

1.3. Just over 12% of households residing in single-family owner occupied detached homes are occupied by households in which all members are 65 or older. Some regions have relatively high concentration of elder households. For example, 17.7% of single family home owning households in the Central East Coast, 16.3% in the

Panhandle, 13.4% in the West Coast region, and 12.7% in North Florida are composed of members that are all 65 years or older.

1.4 Florida's single-family homeowner households are diverse: While nearly 72% are non-Hispanic White, nearly 9% are non-Hispanic Black and 16% are Hispanic. Black households are concentrated in Southeast Florida and Hispanic households are as well, with a sizable percentage of Hispanic households also located in the West Coast Region. Nearly 10% of Florida's households principally speak Spanish or another language other than English in their homes. Many minority households in this population, particularly non-Hispanic Black and Hispanic households, have significantly fewer economic resources.

1.5. While respondents report being residents of Florida for an average of 25 years, most of Florida's single-family homeowner households have been in their current home less than 10 years and substantial percentage, 36.1%, has been in their home for 5 years or less.

Summary of Household Demographic Characteristics: While diversity exists among Florida's households, there is also a degree of similarity. On the whole, these homeowners are non-Hispanic White, have relatively good incomes, live in homes of considerable value, have good education levels, almost all have insurance, and they have resided in their homes for approximately 13 years on average, and the majority are located in coastal counties. The differences among these home-owning households may be equally important however, in developing effective mitigation programs. For example, there is considerable ethnic and racial diversity, particularly in the Southeast and increasingly in the West Coast and Central East Coast regions. Furthermore these variations are also related to levels of income, home value and education with minority households having significantly fewer of these assets. Substantial percentages of these households also predominately speak Spanish or some other language in their homes. Hence, to effectively reach and promote mitigation throughout Florida, programs must be designed to reach all constituents in terms of language and should be mindful of potentially vulnerable minority populations that do not have the economic and social capital to effectively mitigate against potentially dramatic hurricane impacts.

2. Housing Characteristic and Hurricane Mitigation Status

2.1. A substantial portion of the housing stock of single-family owner occupied homes is relatively new with over 8% built since 2000 and an additional 30% built since 1990. However, the average home statewide is almost 25 years old with a median age of

22. The housing with the oldest average age is in Southeast Florida followed by housing in the Panhandle.

2.2. Nearly 48% of Florida's owner occupied single-family homes have no window protection at all. On the other hand, 40.9% has complete window protection – 14.3% with 100% window coverage using some form of shutter protection and 26.6% with 100% coverage using building code approved protection materials. These figures are a substantial improvement over the 1999 figures.

2.3. The regional picture is not as good. While 33.3% of this housing in Southeast Florida has at best incomplete to nonexistent window protection, the figures for other regions are dramatically worse: over 72% of East Coast households, nearly 70% of West Coast households, 69% of North Florida households, and nearly 77% of Panhandle households have at best limited coverage and most with no coverage. In addition, less than 20% of homes in each of the region outside Southeast Florida have 100% window protection employing materials likely to meet code. While a concern, these numbers too are much better than they were in 1999.

2.4. Coastal county homeowners in these regions have only a slightly higher rates of home protection in some regions and even worse in others. With the exception of Southeast Florida which is at 47%, the percentages with total protection using code approved materials in other regions are: 21% in the Central East Coast, 18% in the West Coast, and only 15% in North Florida and the Panhandle. Unfortunately, just over 33% of Southeast homes have limited or no window protection followed by 61.7% along the Central East Coast, 70.5% on the West Coast, 72% in North Florida coastal counties, and 76.9% in the Panhandle. This picture is quite sobering, particularly since we are dealing with only coastal counties in these regions.

2.5. Younger homes are more likely to have total coverage with code compliant window protection (39%), however, with the exception of homes built prior to 1940, younger homes are also more likely to have no window protection at all.

2.6 Of those with shutters, just over 64% installed some or all of their window protection after buying their homes and nearly 72% of those with 100% coverage had all or some of their window coverage installed after they purchased their homes.

2.7. Just over 50% of homes with sliding glass doors have either no or only partial protection and just over 40% of homes with garages do not have hurricane resistant or reinforced garage doors.

2.8. While 15% of the households surveyed have absolutely no envelope protection, only 18% have complete envelope coverage. On the whole, the weight of the population falls toward the positive end of the distribution, meaning better envelope coverage. Unfortunately, this is due, almost exclusively to homes in Southeast Florida who have significantly higher quality envelope coverage than homes in any other region of the State. Focusing exclusively on coastal counties in these regions does not improve the picture with regard to envelope coverage.

2.9 Statewide, just over 47% of those without window protection indicated that the reason they had no protection, was because they did not need it. However, a sizable percentage, nearly 29%, also indicated that expense was the primary reason they had no window protection. When considering only coastal counties, substantial percentages mentioned that cost was the primary factor for not having shutters. Specifically, among coastal county respondents without protection, 45% in the Southeast, 36% in the Central East Coast, 31% in the West Coast region, and even 26% in the Panhandle mentioned cost as the primary reason for not having window protection.

Summary of Housing Characteristics and Hurricane Mitigation Status and Policy Implications*:* The evidence suggests that the situation among owner occupied single family detached housing had improved considerably since Hurricane Floyd threatened the entire Atlantic coast of Florida in 1999. However, the picture is far from pretty. Significant percentages of this housing, particularly in coastal counties, are still lacking in window protection and total envelope coverage must significantly improve. Younger housing is more likely to have code compliant protection, but it is also likely to have no protection as well. The new statewide building code will have a positive impact for areas included in the new wind-borne debris regions. However, some areas that many would feel needed to be included in the wind-borne debris region, particularly in the panhandle, will not benefit from this at all. The age of housing, particularly in the Southeast and the Panhandle, does suggest that as windows are replaced and re-roofing is undertaken there will be opportunities to improve the mitigation status of homes. However this will not happen in areas not part of the wind-borne debris region and even in areas where the new code is likely to improve the mitigation status of homes as repairs and maintenance is being undertaken, home owners need to know what to look and ask for from their contractor. As a consequence these are significant opportunities to help inform and educate the pubic that must be address. Furthermore, the building profession must also be encouraged to provide the public with the options to significantly up-grade the hurricane safety of their homes, beyond code requirements should they choose. Roofers, for example, often do not want to change normal ways of doing business, by offering to add additional nails or screws. Once the new roof is down, however, the opportunity is lost for many years.

The data clearly suggest that cost is increasingly mentioned as a major impediment to improving the mitigation status of homes. Programs and policies that help bring down, offset or subsidize, in some fashion, the cost associated with improving a home's hurricane safety must continue to be explored. This is particularly so for low income and some minority households.

3. How Much has Been Spent, Is Necessary To Spend, and Likely to Spent to Better Protect Family and Home.

3.1 Statewide, households estimate that they have spent on average of $3,477 to make their home safe from hurricanes since it was purchase. Furthermore, they estimate that they will need to spend, on average, an additional $2,800. Unfortunately, the great majority of households will, at best, only be able to spend a small part of that amount in the near future.

Summary of spent/spending findings: On the whole these data at least suggest that in areas that do have somewhat better mitigation status significantly more has been spent than in areas with significantly lower mitigation status. Furthermore, the average amount spent in the Southeast is not insignificant in and of itself for many of these households. However, the fact that the estimated amounts that need to be spent are essentially equivalent across regions suggests that households may not have an accurate idea of what it might take to fully address the hurricane safety of their homes. In this context programs such as a hurricane safety audit program, similar to FPL's energy audit program, that will inspect homes and make recommendations on how to effectively improve the mitigation status of ones home may well help households better understand their mitigation options and possibilities. These types of programs are addressed further below.

4. Hurricane Safety Features When Purchasing a Home.

4.1. The majority, 54%, of current homeowners in Florida indicated that hurricane safety features were important when purchasing their homes. This finding is consistent when comparing across regions and even when comparing only coastal counties across regions. Hence, hurricane safety features are indeed being considered as important in home purchases statewide

4.2 Over the last twenty years there has been a clear trend toward increasing importance of hurricane safety features when purchasing a home. Nearly 65% of homeowners that purchased their homes during the last 5 years considered hurricane safety features as somewhat or very important in their decision.

4.3. The types of hurricane safety features mentioned as important include building materials (CBS construction) (47%), window protection (39%), and roof materials or bracing (32%).

Summary of the importance of hurricane safety features when purchasing ones home. Clearly there has been a clear shift in the importance of how a home's hurricane safety features are evaluated when purchasing a home over the last 20 years, particularly since Hurricane Andrew. Even more important is the fact the percent considering such features as very important in their decision-making is rising. This represents a golden opportunity to shape the market demand for these features, if effective educational materials can be provided to potential home buyers when they are making their purchasing decisions. The State should look into mechanisms to help educate the consumer even further about what to look for and how to evaluate a home's hurricane safety features. Hurricane safety features should be part of any home inspection guide, and professional home inspectors should be trained to discuss such matters with prospective buyers who hire them to inspect homes. Hurricane safety features should be part of the standard home inspection checklist and should also be included on the standard real estate tax portfolio information that real estate professionals and buyers often consult. Furthermore, since this finding is consistent across the state, home build industry would do well to accentuate a homes hurricane safety features when marketing property and the real estate industry as well should also discuss and highlight hurricane safety features to prospective clients.

The responses to questions about why their household did not have window protection suggest yet another consideration regarding the purchase of a new home. A number of respondents noted that they had just purchased their homes and hoped to shutter them later, because they did not have sufficient money to do so at this time. If there were incentives to motivate prospective homebuyers to increase their mortgages slightly so they might finance major hurricane mitigation expenditures, such as shuttering at the time of purchase, then perhaps they would do so. Mortgage companies would also have to be open to and perhaps even encourage such an arrangement as well. Over the life of a mortgage, financing $5,000 dollars of shutters would add little to a monthly mortgage payment, yet would significantly enhance the hurricane safety of the home.

The state and county might reduce fees and taxes when homebuyers undertake the option to improve the mitigation status of their new home as an incentive.

5. Hurricane Season Preparation

5.1. Just over 74% of households statewide and 77% in coastal counties engage in routine preparatory activities prior to hurricane season. The vast majority gather supplies, check shutters, and check on or purchase battery powered radios. Not surprisingly, households in Southeastern Florida are significantly more likely to engage in these activities and less likely to do nothing than households in all other regions, with the exception of households in the Panhandle. These observations hold even when comparing only households residing in coastal counties in each region.

Summary of Hurricane Season Preparation: The fact that so many households, regardless of region engage in some degree of hurricane preparation is, to a limited extent, a success. It certainly suggests that households are not only cognizant of hurricane season, but that they are also responsive to preparation messages. It is time, particularly with the new wind borne debris regions adopted as part of the statewide building code, to enhance lessons about how to significantly improve the hurricane safety of existing homes. Part of any hurricane preparation guide, should be assistance in locating their home with respect to surge and wind potentials. Literature should help the public pinpoint their location not only vis-à-vis the wind borne debris region, but perhaps even wind probability maps, such as the ASCE-7-98 peak gusts contours, or even the TAOS wind return time contours developed as part of the statewide LMS, so that households they can better assess the wind damage potential for their home's location and what they might do to improve the structural integrity of their homes. Households need to better understand their hurricane hazard risk as part of their preparation.

6. Hurricane Experience

6.1. More than three-quarters of Florida Single family homeowner households include someone with hurricane experience.

6.2. When experience is defined as damage however a substantially lower 28.3% report having an adult member that has actually lived in a home damaged by a hurricane and 20% of these individuals report that the damage was major.

Summary of Hurricane Experience Section: The difference between reporting "hurricane experience" and "damage experience" is quite interesting. There are clearly substantial numbers of households that consider themselves experienced when it comes to hurricanes and yet have not suffered any damage from them. These variations are likely to have important consequences for how people anticipate and prepare for hurricanes; indeed research has clearly shown that "experience" does have consequences for mitigation. It is often reported that many more people have experienced a hurricane miss than a hit and this can be part of the problem. A point of potential concern is the substantial proportions of Florida's homeowners that have experience a miss, and hence "successfully survived another hurricane" even when they were not properly prepared. This "experience" promotes thinking that households do not need hurricane mitigation technologies such as shutters, because they survived the last hurricane. One has to only think about the many near misses along the Panhandle since hurricane Andrew and the type of findings mentioned above about not needing shutters to perhaps consider that it may be important to undertake a public education program about how yesterday's near miss or safe "hurricane experience," may not provide an accurate picture of ones actual hurricane risk nor the likelihood of the next hurricane hitting their area.

7. Hurricane and Other Natural Hazard Risk Perception:

7.1. Over 51% of respondents indicated that, of the many potential natural hazards they might be exposed to, they were most concerned about Hurricanes. An additional 31% also expressed concern about tornados. There were some regional variations where in general, hurricanes were more of a concern to residents in Southeastern Florida, tornadoes were a bit more of a concern to Panhandle residents, and wildfires were a bit more of a concern to the residents of the Central East Coast and North Florida.

7.2. Southeast Florida homeowners tend to be much more worried about hurricanes than homeowners in other regions, although a substantial proportion in all other regions, around 40%, express some worry about hurricane impacting their communities.

7.3. Nearly 58% of respondents think it is very likely that a hurricane will disrupt their daily routines this hurricane season. Significantly higher proportions are found in both Southeast Florida, 70.2%, and in the Panhandle, 61%.

7.4. A substantial proportion of just over 43% of Florida's single family homeowners believe it is very or somewhat likely that a Category 3 or higher hurricane will impact their home this year. There are however considerable regional variations with over 56% in the Southeast compared to only 30% in North Florida considering such an event as very or somewhat likely. These differences, while still significant, do diminish somewhat if only coastal counties in each region are compared.

Summary of Hurricane and Other Natural Hazard Risk Perception: The scientific literature has clearly shown that risk perception is a potentially important contributor to motivating households and individuals to mitigate and households with higher hurricane risk perceptions are much more likely to make their homes more hurricane safe in Florida. The recent debates over the new wind borne debris regions – how expansive they are, who is exempt and why, etc. – only adds to the potential confusion about the nature of hurricane risk and what it should mean for household preparation and mitigation. Much more needs to be done to help households better understand their potential risks and how to translate that risk into action. With the confusion, mis-statements, and contradictions, inaction is often the preferred course of action. To get people to act, they must understand more clearly why they should act and they must hear a consistent factual message. Continued education on hurricane, and other hazard risk for the entire State of Florida is a must.

8. Knowledge About Hurricane Risk, Damage, and Mitigation

8.1. Most respondents, report that their households are highly knowledgeable about hurricane risk, 56%, the damage caused by hurricanes 56%, and how to prevent hurricane damage 60%. These findings were consistent across regions with only exception having to do with knowledge about how to prevent hurricane damage. A higher percentage of respondents in Southeast Florida felt their households were more knowledgeable about preventing hurricane damage than did respondents in other areas.

8.2. Despite perceived high levels of knowledge about hurricanes and hurricane mitigation, with the exception of safe rooms, far fewer of Florida's single family homeowners have heard of additional mitigation techniques such as: extra gable end bracing (44%), adding additional nails or screws to ones roof when reproofing (39%), or adding adhesive to joint between truss and roof (20.7%) than might have been anticipated.

Summary of Knowledge about Hurricane Risk, Damage, and Mitigation*:* Despite the very high percent of respondents that considered their households as highly knowledgeable about hurricanes in general and hurricane mitigation in particular, the results on hearing about specific hurricane mitigation technologies strongly suggest that much more needs to be done to educate homeowners about what they can do to effectively make their homes more hurricane safe.

9. Sources, Methods, and Trust in Public Information About Hurricanes

9.1. Just less than half, 49.5%, of the sample reported recently receiving or seeing information on making their homes more hurricane safe. Statewide, the residents of North Florida (38.7%) and the Panhandle (45.7%) were less likely than homeowners elsewhere to report receiving such information.

9.2. Television (46%) was the most important way respondents got information about making their homes hurricane safe, followed by newspapers (34%), the mail (24%), and brochures and flyers (17%).

9.3. Television stations (47%) and newspapers (30%) are perceived most often as the principal provider of hurricane safety information. The next highest source was a government agency (11%) of some form.

9.4. Most respondents reported that the most effective way to communicate hurricane safety information to their household was the television (58.7%), followed by newspapers (15.8%) and direct mailings (12.4%).

9.5. For most respondents (46%) television was the most trusted source for information to help make their homes and family safer from hurricanes. Television was followed by non-profit organizations at 28% (like the Red Cross) and governmental agencies at 26%.

Summary of Sources, Methods, and Trust in Public Information about Hurricane Safety: Television is the clear winner here. The National Hurricane Center has done a wonderful job of working with local television stations to get the message out on hurricane situations when areas are threatened. But the groundwork for that is laid far ahead of time by working with the media, providing short courses and training, and assisting local channels when producing their own programs on hurricane preparedness. Perhaps the State should take a lesson and begin working with regional media outlets, assisting them in producing hurricane preparation programs that included information on making homes safer, assessing hurricane risk and acting on that risk. The considerable resources assembled, for example, when promoting the LMS, such as the mapping and GIS tools could also be provided to local television stations, helping them pinpoint vulnerable areas and zones where their attention should be in the case of a natural hazard. The point is to begin developing that relationship so that, much like with the NHC, DCA can be more influential and hence better assured that consistent, on message, information is getting to the public about how to effectively prepare their homes for hurricanes.

10. Awareness of State Government Programs and Other Organizations Active in Promoting Hurricane Safety.

10.1. On the whole less than 20% of Florida's single-family homeowners are aware of organizations and State programs that have been initiated to help promote hurricane safety. Just at 16% have heard of Florida's Showcase Community program, however less than 10% report having heard of programs such as LMS, RCMP, or HLMP.

Summary of Awareness of State Government Programs and Other Organizations Active in Promoting Hurricane Safety*:* While name recognition should not be a goal of State programs or departments, it is unfortunate that such a small percentage of this population – the owners of single-family detached residences, a population that is often the target of such programs and efforts – is aware of these important state programs or of the specific state agencies in charge of the. This is partially a result of State agencies often channeling these programs through private non-profit organizations and through local county governments and agencies.. Furthermore, these programs, much less the state agencies behind them, are not highlighted as the funding mechanisms or sponsors, making it all but impossible for the public to potentially recognize these programs in the first place. Nevertheless, there may well be advantages to increasing recognition; at least of the programs seeking to promote hurricane mitigation in part because it lends weight to its importance for all of Florida's households and citizens. In other words, the more individuals sees State agencies and programs out in front, or at least walking hand in hand, with local government the private sector to promote hurricane safety, the more seriously homeowners are likely to practice hurricane mitigation.

11. Incentives to Shutter

11.1. Nearly 22% of the single-family homeowners are receiving some form of insurance discount for their home's hurricane safety features. Unfortunately nearly 46% of homeowners have no idea if their insurance carrier offers any form of mitigation incentives.

11.2. Property tax reduction (67%) and lower insurance premiums (66%) are the two incentives that garner the most favorable response from homeowners without window protection. The reductions suggested by respondents are considerable. On average respondents would like to see a property tax reduction of 28% and insurance premium reduction of 29%.

11.3 More than 46% of Southeastern single-family homeowners without shutters would be very likely or somewhat likely to be motivated or enabled to employ mitigation technologies by a low-interest loan whereas the percent in other regions is consistently below 30%.

11.4 More than 65% of Southeastern single-family homeowners without shutters would be very likely or somewhat likely to be motivated to employ mitigation technologies by a five year forgivable loan. Rather substantial percentages of between 50% to almost 60%, of households in other regions also responded as being very likely to somewhat likely to be motivated by a forgivable loan.

11.5. The most consistent positive responses across all regions were for lower insurance premiums or lower property taxes. More than 60% of household in owner occupied single family detached housing indicated that reductions in property taxes or insurance premiums would be very or somewhat likely to motivate or enable, them to undertake hurricane mitigation improvement to their homes. The major variation among regions, is that significantly higher percentages of homeowners in Southeast Florida indicated that they would be "very likely" to be motivated by reductions in these two areas.

11.6. Nearly 68% of homeowners without window protection indicated they would very (26.2%) or somewhat (41.3%) interested in a hurricane mitigation audit program similar to FPL's energy audit program.

Summary of incentive programs*:* On the whole, Southeastern homeowners, who lack protection, are much more likely to respond favorably to all four types of incentives than are similar homeowners in other areas. However, substantial percentages of homeowners in other areas also respond quite favorably, particularly to reductions in property taxes and insurance premiums as incentives to help motivate or perhaps enable them to undertake hurricane protection measures. Given the size of the reductions suggested by respondents, it is however a major point of speculation as to whether any of these incentive programs are likely to significantly impact decisions, because programs with those levels of reductions are simply not feasible. Nevertheless a combination of incentives is more likely to impact decision-making than a single small incentive program. Since some insurance companies are already offering incentives, perhaps even a minor reduction in property taxes will help draw attention to the importance of homeowners to begin the process of implementing hurricane protection options. However, insurance companies must also do a better job of making their incentive more readily available and must publicize the possibility to the homeowners they are underwriting. In addition, some form of a hurricane mitigation audit program might also be considered to help insure that effective mitigation technologies are implemented. Such a program would probably be more effective if operated by a non-governmental organization such as a non-profit.

IV. DETAILED FINDINGS AND DISCUSSIONS

The following presents a more detailed examination of the survey data that informed each of the findings above. It is also divided into eleven sections covering the topics introduced above. They are again: 1) Household demographic characteristics; 2) Housing characteristic and hurricane mitigation status; 3) How much has been spent, is necessary to spend, and likely to spent to better protect family and home; 4) Hurricane safety features when purchasing a home; 5) Hurricane season preparation; 6) hurricane experience; 7) Hurricane and other natural hazard risk perception; *8) Knowledge about hurricane risk, damage, and mitigation;* 9) Sources, methods, and trust in public information about hurricanes; 10) Awareness of State Government programs and organizations active in promoting hurricane safety; and 11) Incentives to shutter. Each section lists the findings presented above, followed by a detailed discussion and data analysis. And finally, each section ends with a summary statement.

1. Household Demographic Characteristics

Throughout this report it will be important to remember that these data are representative of households residing in owner occupied single-family detached residences, not all households in Florida. To reinforce this point, we begin by examining the characteristics of these households.

1.1. Households residing in single-family owner occupied detached residences are relatively affluent. The average reported value of their homes is slightly more than $169,000, 57% report household incomes in excess of $50,000 and 55% of these households have at least one household member with a college, professional or graduate degree. There are however regional variations, for example homes in Southeast Florida have significantly higher reported values than other regions of the state. Despite the affluence, one-fifth of these households also report household incomes less than $30,000 and 23% have no members with higher than a high school diploma.

As might be expected households that have the ability to own there homes are relatively affluent. Table 3 displays reported total household annual income. The results indicate that slightly more than 57% (see valid percentages) report incomes in excess of $50,000. The largest group, about 22%, report incomes between $50 and $75,000. There are some minor regional variations, with the Southeastern region, which includes the ‘gold coast,’ appearing more affluent with slightly more than 23% reporting incomes in excess of $100,000. However, there are also substantial numbers of Southeastern households reporting lower incomes as well. Hence, there are few significant regional variations in reported total household income.

Table 3. Annual Household Income

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	UNDER $5,000	8	.6	1.0	1.0
	$5,000 - $10,000	18	1.4	2.2	3.2
	$10,000 - $20,000	48	3.8	6.0	9.2
	$20,000 - $30,000	99	7.9	12.3	21.5
	$30,000 - $50,000	169	13.4	21.0	42.5
	$50,000 - $ 75,000	175	13.9	21.7	64.2
	$75,000 - $100,000	138	11.0	17.1	81.4
	OVER $100,000	150	11.9	18.6	100.0
	Total	805	63.9	100.0	
Missing	DON'T KNOW/NO RESPONSE	455	36.1		
Total		1260	100.0		

Of course, one of the most important economic assets of many households is the home itself. Table 4 presents the reported home values for the sample. Slightly less than one quarter of the sample report home values of $100,000 or less; conversely, over 50% of the sample report home values in excess of $150,000. The average home value, estimated from these data, is slightly more than $169,000. There are significant variations across state regions. The highest average home value is found in the Southeast ($196,019) followed by the West Coast ($163,677), Central East Coast ($161,319), North Florida ($146,576), and the Panhandle (132,364). The average home value for the Southeast is significantly greater than home values in all other regions of the state. Nearly 98% of these households report having homeowners insurance.

Table 4. Reported Market of Home

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	50,000 or less	31	2.5	3.0	3.0
	50,001 to 75,000	75	6.0	7.2	10.1
	75,001 to 100,000	149	11.8	14.2	24.4
	100,001 to 150,000	246	19.5	23.5	47.9
	150,001 to 175,000	117	9.3	11.2	59.1
	175,001 to 225,000	152	12.1	14.5	73.6
	225,001 to 300,000	142	11.3	13.6	87.2
	Over 300,000	134	10.6	12.8	100.0
	Total	1046	83.0	100.0	
Missing	DK/NR	214	17.0		
Total		1260	100.0		

The affluence of households residing in owner occupied households is also reflected in their educational status. Table 5 presents the highest educational attainment for a member of the household. From these data it can be seen that over 33% of these households have a member who is a college graduate and nearly 22% have members who have graduate or professional degrees. On the other hand, 23.2% of these households report that a high school degree or less is the highest educational status for a household member.

Table 5. Highest grade completed by an adult member of Household

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	GRADE SCHOOL	8	.6	.6	.6
	SOME HIGH SCHOOL	36	2.9	2.9	3.5
	HIGH SCHOOL GRAD	244	19.4	19.6	23.2
	SOME COLLEGE	265	21.0	21.3	44.5
	COLLEGE GRADUAT	421	33.4	33.9	78.4
	GRADUATE DEGREE	268	21.3	21.6	100.0
	Total	1242	98.6	100.0	
Missing	DON'T KNOW/NO RESPONSE	18	1.4		
Total		1260	100.0		

1.2. Just over 12% of households residing in single-family owner occupied detached homes are occupied by households in which all members are 65 or older. Some regions have relatively high concentration of elder households. For example, 17.7% of single family home owning households in the Central East

Coast, 16.3% in the Panhandle, 13.4% in the West Coast region, and 12.7% in North Florida are composed of members that are all 65 years or older.

On average Florida's home-owning households are composed of 2.9 individuals with a median of 2 individuals. The vast majority of respondents, nearly 72%, report that they are married, with an additional 9% reporting that they are widowed. Approximately 27% have at least one household member who is 65 years or older and just over 12% are composed of individuals all 65 years or older. There are some regional variations. First, nearly 30% of households with all members over 65 are located in the West Coast region, with an additional 28% located in the Central east coast. Furthermore, 17.7% of single family home owning households in the Central East coast, 16.3% in the Panhandle, 13.4% in the West Coast region, and 12.7% in North Florida have households members that are all 65 or older.

1.3 Florida's single-family homeowner households are diverse: While nearly 72% are non-Hispanic White, nearly 9% are non-Hispanic Black and 16% are Hispanic. Black households are concentrated in Southeast Florida and Hispanic households are as well, with a sizable percentage of Hispanic households also located in the West Coast Region. Nearly 10% of Florida's households principally speak Spanish or another language other than English in their homes. Many minority households in this population, particularly non-Hispanic Black households, but also Hispanic households, have significantly fewer economic resources.

There is considerable ethnic and racial variation among these households, although homeowners are not as diverse as Florida's population as a whole. Overall 71.8% are non-Hispanic Whites or Anglos, 8.5% are non-Hispanic Blacks, 16.4% are Hispanic, and 3.3% identify themselves as some other group such as Native American or Asian. Not surprisingly, there are regional variations as can be seen in Figure 2. Hispanics are, of course, concentrated in Southeast (71.8%) and in the West Coast (16.3%) and as a consequence make up substantial proportions of the population in those regions. Specifically Hispanics make up just over 37% of the Southeast sample, and 10% in Central East Coast region. While just over 12% of the homeowners in Southeast Florida are non-Hispanic Blacks, that region has the highest concentration of Non-Hispanic Black homeowners. Just over 45% of all non-Hispanic Black single-family homeowners are located in Southeastern Florida.

In addition, just over 87% of the respondents statewide report English as the language spoken most often in the home, however nearly 8% report Spanish as the language spoken in the home and an additional 1.8% report some other language. Nearly 81% of the households reporting Spanish as the household language, reside in Southeast Florida.

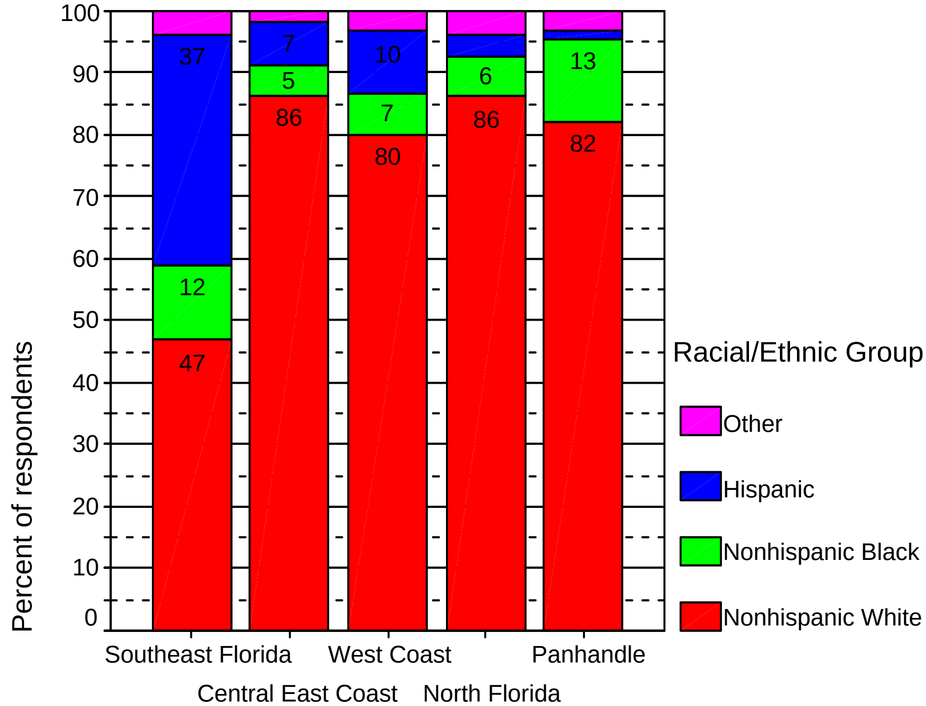


Figure 2. Ethnic Groups Across Regions

The economic affluence discussed above is not found proportionally among all ethnic groups. In particular, non-Hispanic White households have higher levels of household income when compared to both Hispanic and non-Hispanic Black households. The reported value of non-Hispanic Black households is significantly lower then either Hispanic or non-Hispanic White households. Furthermore, non-Hispanic White, Hispanic, and other households are much more likely to have households members with college degrees as well as households members with graduate/professional degrees. On the whole then non-Hispanic Black in particular, and Hispanic households to a certain extent, will potentially have significantly fewer economic and human capital assets to draw upon when it comes to adding costly hurricane safety features, should such features need to be added after purchasing a home.

1.4. While respondents report being residents of Florida for an average of 25 years, most of Florida's single-family homeowner households have been in their current home less than 10 years and substantial percentage, 36.1%, has been in their home for 5 years or less.

It is generally understood that the population of the United States is highly mobile and one of the important reasons Florida continues to grow is due to migration from both within and outside the United States. Mobility can have consequences for mitigation initiatives in terms of a household's knowledge and experience related to hurricanes, in addition, the fewer number of years a households has resided in their home, the fewer the number of years they may have invested in mitigating their home. Respondents reported being a resident of Florida for a mean average of 25.4 years, with the median of 23 years. Given the skewed nature of these data, median may be more useful in terms of capturing the typical household. While the number average and median years a resident of Florida is fairly high, the households as a whole have been living in their current residence for a mean of 12.7 years, with a median of 9 years.

Summary statistics, such as averages, however can often obscure considerable variation. As can be seen in Table 6, for example, over 36% of the sample has resided in their home for 5 or fewer years, with another 21.4% having been there between 6 to 10 years. Together then, about 58% of all households have been in their current homes for less than 10 years.

These data certainly suggest that these households should have gained a good deal of experience from what to expect in Florida because they have, in general, been residents of Florida for a good deal of time. Whether or not they have had time to translate that experience into preparing their homes for potential hurricane hazards, however is another question, since so many have been residing in their homes for 5 years of less, they may not have had the financial ability to add hurricane protection features if the home was not already equipped.

Table 6. Years in current residence

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5 years or less	455	36.1	36.1	36.1
	6 to 10 years	270	21.4	21.4	57.5
	11 to 15 years	155	12.3	12.3	69.8
	16 to 20 years	111	8.8	8.8	78.7
	21 to 25 years	85	6.7	6.7	85.4
	26 to 30 years	72	5.7	5.7	91.1
	31 to 35 years	38	3.0	3.0	94.1
	36 to 40 years	28	2.2	2.2	96.3
	Over 40 years	46	3.7	3.7	100.0
	Total	1260	100.0	100.0	

Summary of Household Demographic Characteristics**:** While diversity exists among Florida's households, there is also a degree of similarity. On the whole, these homeowners are non-Hispanic White, have relatively good incomes, live in homes of considerable value, have good education levels, almost all have insurance, and they have resided in their homes for approximately 13 years on average. The differences among these home-owning households may be equally important however, in developing effective mitigation programs. For example, there is considerable ethnic and racial diversity, particularly in the Southeast and increasingly along the West Coast and Central East Coast regions. Furthermore these variations are also related to levels of income, home value and education with minority households having significantly fewer of these assets. Substantial percentages of these households also predominately speak Spanish or some other language in their homes. Hence, to effectively reach and promote mitigation throughout Florida, programs must be designed to reach all constituents in terms of language and should be mindful of potentially vulnerable minority populations that do not have the economic and social capital to effectively mitigate against potentially dramatic hurricane impacts.

2. Housing Characteristic and it Hurricane Mitigation Status

2.1. A substantial portion of the housing stock of single-family owner occupied homes is relatively new with over 8% built since 2000 and an additional 30% built since 1990. However, the average home statewide is almost 25 years old with a median age of 22. The housing with the oldest average age is in Southeast Florida followed by housing in the Panhandle.

In general, single-family detached homes in Florida are relatively new. As shown in Table 6, approximately 8% have been built since 2000, 22% were built in the 1990s and an additional 22% were been built in the 1980s. Thus, slightly more than 52% of the owner-occupied single-family detached houses in Florida were built in the last 23 years. It should be pointed out that studies of damage resulting from Hurricane Andrew suggested that housing built during the 1980's was particularly susceptible to damage. The average age for these homes is 24.7 years, with a median age of 22 years. However, there are important regional variations as revealed in Table 7.

Table 7. Decade home built

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2000-2003	100	7.9	8.3	8.3
	1990-1999	266	21.1	22.1	30.4
	1980-1989	266	21.1	22.1	52.4
	1970-1979	237	18.8	19.7	72.1
	1960-1969	145	11.5	12.0	84.1
	1950-1959	129	10.2	10.7	94.9
	1940-1949	37	2.9	3.1	97.9
	1939 or earlier	25	2.0	2.1	100.0
	Total	1205	95.6	100.0	
Missing	System	55	4.4		
Total		1260	100.0		

Table 8. Descriptive Statistics on Age of Home

Estimate age of home

State Regions	Mean	Median	Std. Deviation	N
Southeast Florida	28.5871	28.0000	16.80217	373
Central East Coast	22.1975	18.0000	16.71918	243
West Coast	23.2991	20.0000	17.52396	331
North Florida	21.7633	18.0000	17.42544	169
Panhandle	25.8202	18.0000	19.51431	89
Total	24.6846	22.0000	17.48056	1205

The oldest homes are found in Southeast Florida where they average 28.6 years old (median of 28 years), followed by the Panhandle at 25.8 years (median of 18 years), West Coast homes at 23.3 years (median 20 years), Central East Coast at 22.2 years (median of 18 years) and lastly North Florida at 21.8 years (median of 18 years). Given the relatively skewed nature of most of these data, the medians might be more reflective of the typical, in which case Southeast homes are clearly some of the oldest homes in the state where the typical home, as indicated by the median, is 8 to 10 years older than homes in other regions.

Housing Mitigation

Respondents were asked a variety of questions regarding mitigation measures, such as whether or not they have shutters for their windows and sliding glass doors or whether their windows and sliding glass doors were made of new impact resistant glass. In addition they were asked about the type of shutters, who installed them, whether all of the windows were covered, and whether the garage door was reinforced or was a new hurricane-resistant door

2.2. Nearly 48% of Florida's owner occupied single-family homes have no window protection at all. On the other hand, 40.9% has complete window protection – 14.3% with 100% coverage using some form of shutter protection and 26.6% with 100% coverage using building code approved protection materials. These figures are a substantial improvement over the 1999 figures.

Window coverings or shutters will be examined first. When assessing the shuttering of a home's windows, it is important to consider, not only the type of material employed, but how completely the home's windows are covered. Having top of the line commercially installed shutters on only a couple of windows, leaving the remainder exposed to potential flying debris, can be of little protection. If unprotected windows fail, the home's envelope is breached and the potential for roof failure is greatly increased.

Given the importance of complete coverage and the material used, respondents were asked if they had shutters or impact resistant windows, they were then asked about how whether they had coverings (or impact resistant glass) for all, most, some, or none of their windows and then they were asked about the nature of the shutters. Table 9 displays rather detailed information on the type of windows or material used to shutter the home's windows and the completeness of window coverage.

Table 9. Detailed Categories on Window Coverage and Type

		Freq.	%	Valid %	Cum. %
Valid	No window protection	593	47.1	47.5	47.5
	Partial protection with something	48	3.8	3.8	51.3
	Most protected by plywood, awnings or combination	49	3.9	3.9	55.2
	Most protected by impact, panels, or shutters	48	3.8	3.8	59.1
	Total protection with plywood or awnings	150	11.9	12.0	71.1
	Total with plywood, awnings and some impact, panels or shutters	29	2.3	2.3	73.4
	Total with panels	145	11.5	11.6	85.0
	Total with panels and some impact or shutters	14	1.1	1.1	86.1
	Total with impact glass or shutters	173	13.7	13.9	100.0
	Total	1249	99.1	100.0	
Missing	Not classified	11	.9		
Total		1260	100.0		

On the whole, nearly 48% of these homes have no protection at all and an additional 11.5% have only partial coverage or at best most of their windows protected. On the other hand as we move up in levels of coverage and quality, 12% have total protection with awnings, Bahamian shutters, or plywood and an additional 2.3% have some combination of materials including plywood and awnings but also impact resistant glass, hurricane panels, or shutters providing them with total coverage. Almost 13% have 100% of their windows protected with hurricane panels or some combination including panels, and finally nearly 14% have 100% protection utilizing impact resistant glass or shutters (roll down or accordion). In general, these numbers reflect some improvement since 1999, when at least one survey found that approximately 62% of single-family owner occupied housing had absolutely no protection (see Peacock 2003).

While this more detailed presentation give a good idea of the varieties of materials used and coverage obtained, it is useful to also simplify this information into fewer categories that also reflect, to some degree, building code requirements. Hence, based on the data homes were reclassified into one of 5 categories reflecting: 1) 100% window coverage by materials meeting the building code such as impact resistant glass, accordion or pull down shutter systems or by hurricane panels; 2) 100% window coverage by materials such as plywood, awnings, Bahaman shutters, or some combination of materials that would not meet building code requirements; 3) most windows are covered by any type of material; 4) only partial coverage by any type of material or combination; and 5) no window coverage at all. This reclassification is displayed in Table 10.

Table 10. Window Coverage and Type

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No window protection	593	47.1	47.5	47.5
	Partial protection with something	48	3.8	3.8	51.3
	Most protected with something	97	7.7	7.8	59.1
	100% with something	179	14.2	14.3	73.4
	100% with building code approved materials	332	26.3	26.6	100.0
	Total	1249	99.1	100.0	
Missing	System	11	.9		
Total		1260	100.0		

Again, the sizable percentage (47.5%) has no window protection or coverage at all. In addition we see that nearly 27% of all households have 100% window protection with materials recommended by the statewide building code and 14.3% have 100% coverage with some form of protection that might not meet building code standards, yet provide some form of protection. Overall then, nearly 41% of surveyed households have 100% coverage with some form of protection. An additional 11.6% have most or only partial protection. These percentages improve slightly when considering only coastal counties in each region where we find that 42.6% have no protection, 12.2% have only partial or most of their windows protected, 15.5% have 100% protected by something and 29.7% have total protection by materials consistent with the building codes.

These figures are substantial improvements over figures for 1999, approximately 3.5 year prior to this survey. At that time 62% of single-family owner occupied housing lacked any form of window protection. Conversely and only 11.5 % had coverage with building code approved materials with an additional 15.3% with 100% coverage using some form of window protection. Overall that means we have seen a 15-point drop in non-protected homes and a 25.5 percentage point increase in homes with 100% of their windows protected. While these data certainly speak of improvements in coverage, the fact that over 59% of all households statewide, and nearly 55% or coastal homes have either no or only limited protection is still of concern. Unfortunately the regional data is even more sobering.

2.3. The regional picture is not as good. While 33.3% in Southeast Florida has at best incomplete to nonexistent window protection, the figures for other regions are dramatically worse: over 72% of East Coast households, nearly 70% of West Coast households, 69% of North Florida households, and nearly 77% of Panhandle households have at best limited coverage. In addition, less than 20% of homes in each of the region outside Southeast Florida have 100% window protection employing materials likely to meet code. Nevertheless, these numbers too are much better than they were in 1999.

Figure 3 below presents the wind coverage and type of protection findings for surveyed homes by region. While 20% of Southeast Florida homes are without any protection, 60% of East Coast homes, 57% of West Coast homes, 62% of north Florida homes and over 69% of Panhandle homes have none. Furthermore, if homes reporting incomplete coverage are added to these, the percentages are even more dramatic and sobering. Slightly more than 33.3% in Southeast Florida, nearly over 72% of East Coast households, nearly 70% of West Coast households, 69% of North Florida households, and nearly 77% of Panhandle households have at best incomplete to nonexistent window protection. Clearly, these numbers suggest that the vast majority of Florida homes outside the Southeast Florida will be at major risk when facing the consequences of a major hurricane. For the most part, less than 20% of the homes outside the Southeast have 100% of their windows protected with materials likely to meet code.

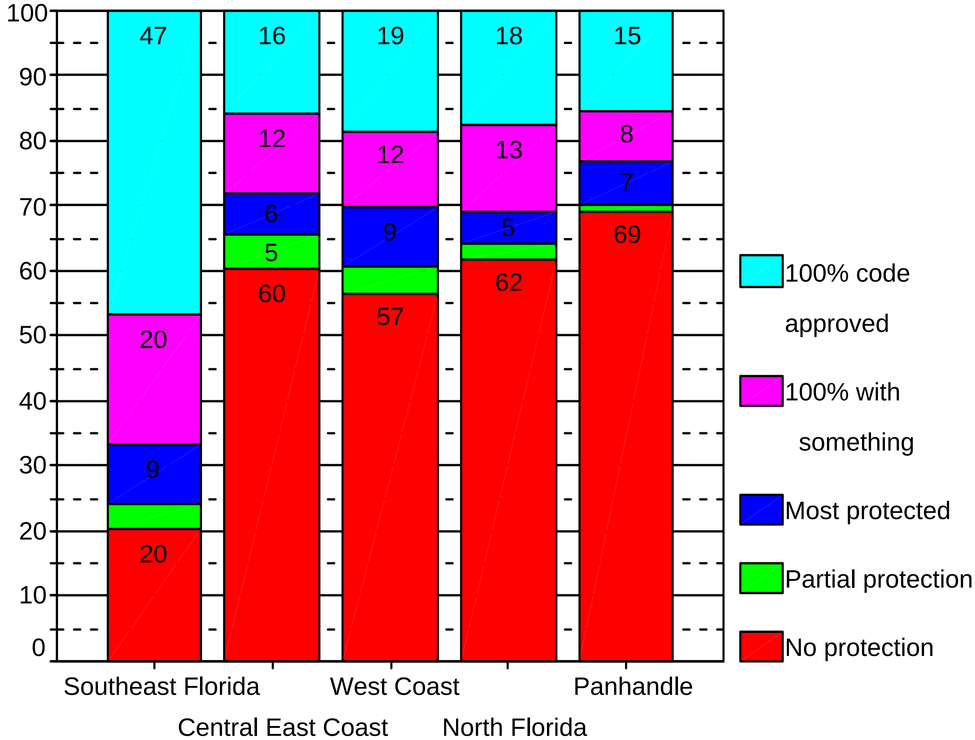


Figure 3. Window Coverage and Type

Despite these very sobering figures, they to suggest improvement over the situation in 1999. Figure 4 presents a graph similar to figure 3, but using data from 1999. Across the board, in every region of the state, there has been a reduction in the percentage of single-family owner occupied detached housing without window protection of any type. Furthermore we have seen rather substantial improvements in the percentage protected by materials that will meet building code specifications.[9] These gains are particularly noticeable in Southeast Florida, however in terms of percent improvement, some of the other regions show even greater gains.

[9] This does not, of course mean that they would meet building code specifications, because the materials may not be installed correctly, and often they may have been installed without permits.

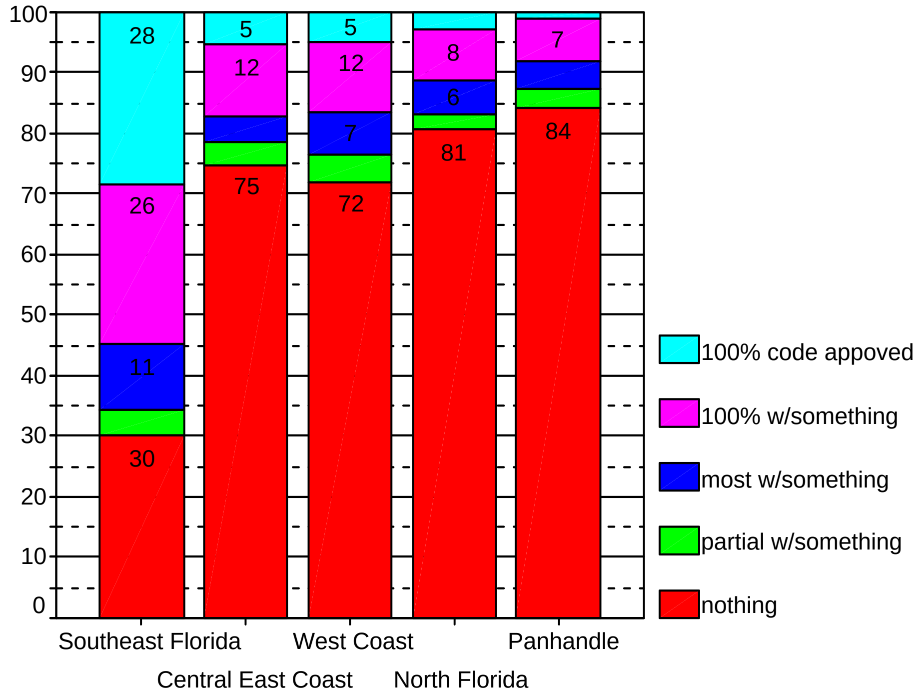


Figure 4. Window Coverage and Type, 1999

Another sobering factor concerns who does and does not have quality window protection. While in some regions, with comparatively limited coverage in the first place, such variations are dwarfed by the greater need across the all segments of the population. However, if the distributional aspects of window protection is examined in Southeast Florida, the region with the greatest coverage there are clear differences in coverage depending upon household income. Specifically, lower income households are much less likely to have window protection that will meet code. On conversely, households with higher income are much more likely to have 100% coverage with code approved materials. In Miami Dade county with assistance from DCA has sought to address this issue to a limited extent as part of its LMS process. In that county there exist a special programs set up to facilitate low-income households, particularly elderly households, to acquire code approved window protection. There perhaps needs to be greater emphasis placed on such programs in the future.

2.4. Coastal county homeowners in these regions have only a slightly higher rates of home protection in some regions but even worse levels in others. With the exception of Southeast Florida which is at 47%, the percentages with total protection using code approved materials in other are: 21% in the Central East Coast, 18% in the West Coast, and only 15% in North Florida and the Panhandle. Unfortunately, just over 33% of Southeast homes have limited or no window

protection followed by 61.7% along the Central East Coast, 70.5% on the West Coast, 72% in North Florida coastal counties, and 76.9% in the Panhandle. This picture is quite sobering, particularly since we are dealing with only coastal counties in these regions.

The 2003 picture improves only slightly if we consider only households located in coastal counties within each region (see Figure 5 compared to Figure 3). The numbers do not change for Southeast Florida, since all counties in this area are coastal, where we again find that 67% have total window protection and 47% are utilizing code approved materials and just over 33% with no or only limited protection. On the other hand, only 39% along the Central East Coast have total coverage, with only 21% using code-approved materials. The respective percentages for coastal counties in other regions are even lower, with the lowest being found in the Panhandle, an area that unfortunately has been largely exempt from the new wind bore debris coverage requirement. In the panhandle only 23 % of owner occupied single-family detached homes have total window coverage, with only 15% utilizing code-approved materials. But again, the most disconcerting figures are the percentages of coastal county owner occupied single-family residents -- the residential structures most likely to have hurricane protection measures in the first place -- that in fact have little or no window protection. While the 33% of these homes in Southeast Florida are a point of concern, that percentage pales by comparison with the rather substantial percentages in other regions which range between a low of 62% along the Central East Coast to a high of nearly 77% in the Panhandle.

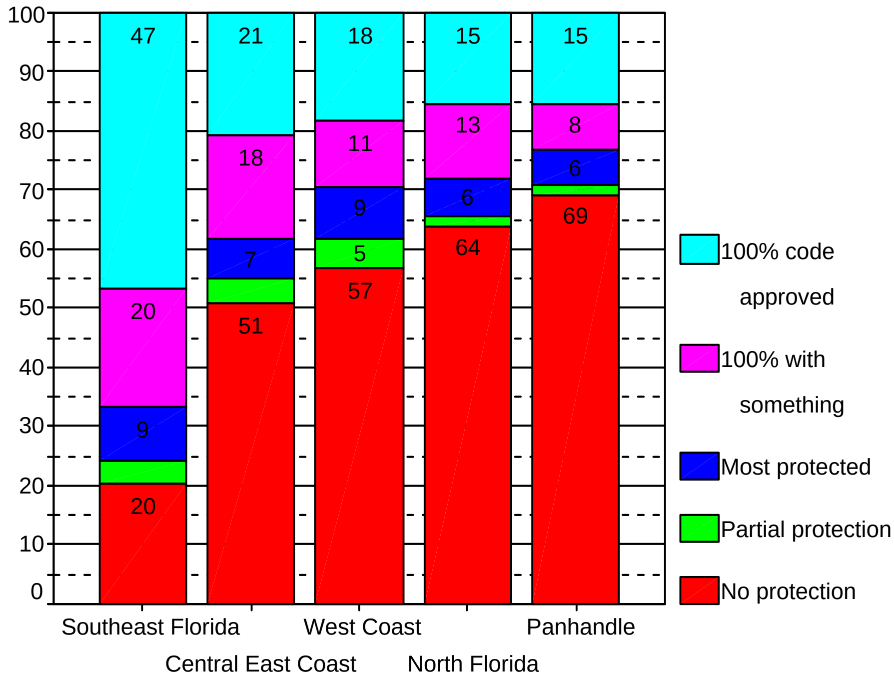


Figure 5. Window Coverage & Type: Coastal Counties

2.5. Younger homes are more likely to have total coverage with code compliant window protection (39%), however, with the exception of homes built prior to 1940, younger homes are also more likely to have no window protection at all.

Since Hurricane Andrew there has been ever improving building codes in Southeastern Florida where the South Florida building code not only improved, but also increased window protection requirements and these requirement have spread into counties through the region. In addition, the statewide building code, which went into effect March 1, 2002, also demanded greater window protection, particularly in most coastal counties, again with the exception of the Panhandle. These many changes suggest that homes build more recently should display better window protection than older homes. Figure 5 presents window protection data by the decades in which the home was built.

The data in Figure 6, presents a somewhat contradictory set of picture in effect telling three different but related stories. If one focuses on 100% coverage with code approved materials, then the general trend suggests that newer homes are much more likely to have potentially code compliant window protection. However, add into the mix, 100% coverage with anything and 100% with code compliant materials, and the trend is curvilinear in that homes built during the 50s and 60s -- a period of high hurricane activity -- display coverage level comparable with the 90s and 2000s, followed by older homes with much more limited compliance. So the curve is a bit "S" shaped. Similarly, if one focuses on percentages of homes with no coverage, the trend suggest that homes build more recently are more likely to have no protection, while those built in the 50s and 60s have relatively lower levels of no protection (or better levels of protection). This period is again, however, is followed by relatively high level of homes with no protection. On the whole then, home build in more recent decades do indeed appear to have much greater percentages with total window protection utilizing materials with consistent with code requirements. However, homes build in more recent decades also have higher percentages of homes with no window protection as well. Thus, the glass is both half full and half empty, with a few holes in it as well.

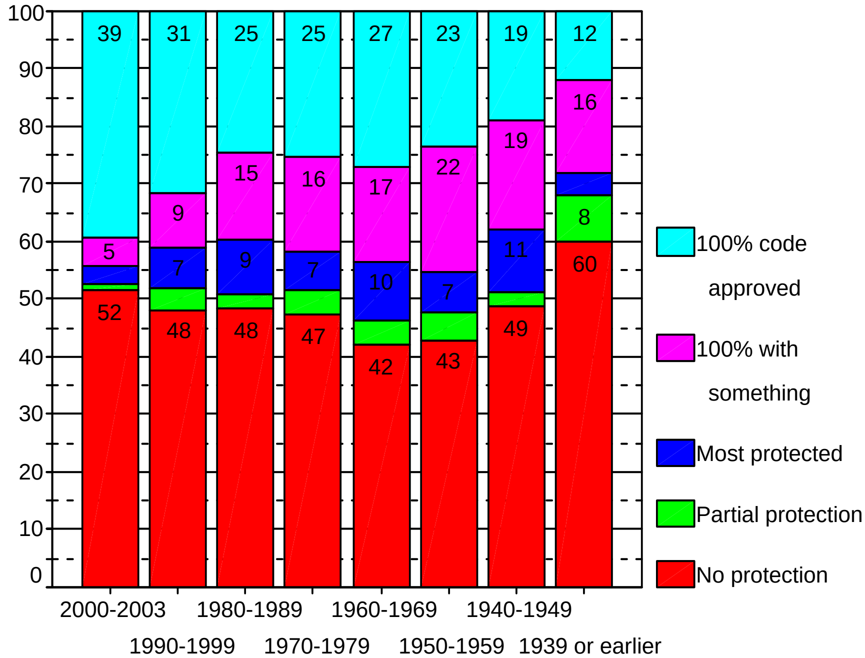


Figure 6. Window Protection by Decades

2.6 Of those with shutters, just over 64% installed some or all of their window protection after buying their homes and nearly 72% of those with 100% coverage had all or some of their window coverage installed after they purchased their homes.

Among households reporting having shutters for their windows, most installed them entirely or partially after they bought their homes; only 35.6% reported that their shutters, at whatever level of coverage, had been installed prior to purchasing their home. Furthermore, only 28.1% of homes with 100% of their windows protected bought their homes with shutters already installed. Conversely, nearly 72% of homes with 100% coverage had to have the window protection installed after they moved into their homes. Furthermore, 58% of the homes with 100% coverage had their window protection commercially installed. The point is that, the majority of households residing in single family owner occupied housing had to make a conscious decision, after purchasing their homes, to put shutters on their home. Indeed, the vast majority (72%) of those with 100% coverage, had to make the decision to make sure that they had complete coverage.

2.7. Just over 50% of homes with sliding glass doors have either no or only partial protection and just over 40% of homes with garages do not have hurricane resistant or reinforced garage doors.

When considering sliding glass[10] and garage doors, one must quickly recognize that protection can be achieved in a variety of ways. For example, with sliding glass doors, a home might be considered protected if the sliding glass doors are shuttered or it they are of the new impact glass variety. However. "protection" is also achieved if the home has no sliding glass doors in the first place. Similarly a home without a garage door is at least as protected, perhaps somewhat more protected, than a home with a hurricane impact resistant or reinforced garage door. As a consequence we must consider these variety of situations. The data necessary for these determinations are presented in Tables 11 and 12.

Table 11. Protection for Sliding Glass Doors

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No protection	437	34.7	34.7	34.7
	Some protected	19	1.5	1.5	36.2
	Most protected	16	1.3	1.3	37.5
	total protection	447	35.5	35.5	72.9
	Has no glass doors	335	26.6	26.6	99.5
	not determined	6	.5	.5	100.0
	Total	1260	100.0	100.0	

[10] External French doors were also considered, however to simplify discussion sliding glass doors is used to refer to both sliding glass doors and external French doors.

Table 12. Garage Door Protection

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not protected	317	25.2	25.2	25.2
	Protected	474	37.6	37.6	62.8
	Has no garage	323	25.6	25.6	88.4
	Do not know	146	11.6	11.6	100.0
	Total	1260	100.0	100.0	

Over all, among the homes that have sliding glass doors (72.9% of the sample), 48.6% reported having total protection (shutters or impact resistant glass), while 47.6% have no protection at all, with the remaining households having limited protection. On the other hand, among the homes with garages (62.8% of the sample) nearly 60% claim to have impact resistant or reinforced garage doors. These percentages increase slightly when we consider households with and without glass doors or garages. Just over 62% of the entire sample has either total protection for their glass doors or no glass doors to begin with and similarly, just over 63% of the entire sample either has a protected garage door or no garage door[11].

There is a clear relationships between homes with full window protection using code approved materials and having protection for garage and glass doors. For example, while 48% of households with no window protection reported protected garage doors, just over 76% of homes with full window protection also had impact resistant or reinforced garage doors. An even greater differential is apparent for glass door protection where only 14.6% of homes with no window protection had protection for their glass doors, when compared to slightly more than 88% of homes with total protection. Even when considering "protected" as either having protection or not having a garage or glass doors in the first place, the relationship holds. While 54% of homes with no window protection have garage door "protection" just over 84% of homes with full protection with code approved materials had "protected" garage doors. Similarly while only 38.5% of homes with no window protection had "protected" glass doors, over 90% with the afore mentioned window protection had "protected" glass doors. Clearly, there is a relationship between these different forms of protection; in general there are attempts by homeowners to consistently protect their homes. However, that relationship is far from perfect for undoubtedly a host of reasons. Homes may display a variety of

[11] It is interesting to also note that 11.6% of the sample did not know about the nature of their garage door. Given the nature of special hurricane resistant garaged doors and the extra bracing required to truly reinforce an older door, one might well suspect that at least a portion of those reporting garage doors may not actually know.

forms of protection, and yet if their entire envelope is not protected, then they are at substantially higher risk of suffering hurricane damage. The next section will focus on envelope coverage.

2.8. While 15% of the households surveyed have absolutely no envelope protection, only 18% have complete envelope coverage. On the whole, the weight of the population falls toward the positive end of the distribution, meaning better envelope coverage. Unfortunately, this is due, almost exclusively to homes in Southeast Florida who have significantly higher quality envelope coverage than homes in any other region of the State. Focusing exclusively on coastal counties in these regions does not improve the picture with regard to envelope coverage.

The major reasons for focusing on protection of windows, sliding glass doors, and garage doors is because such protection helps preserve the structural integrity of the home's external envelope, preventing wind from entering the structure. Once a home's envelope is breached, the dynamics of its ability to withstand high wind is dramatically altered. Specifically there is much greater likelihood for roof and subsequently entire structural failure because there are greater lift forces acting on the roof when the envelope is breached. As a consequence, the information window protection, glass door protection and garage protection was combined to form a single scale. The resulting scale ranges from 0, indicating no protection for windows, sliding glass doors, and garage, to 2.89 indicating complete coverage with code approved materials. Figure 7 displays the distribution of the resulting measure.

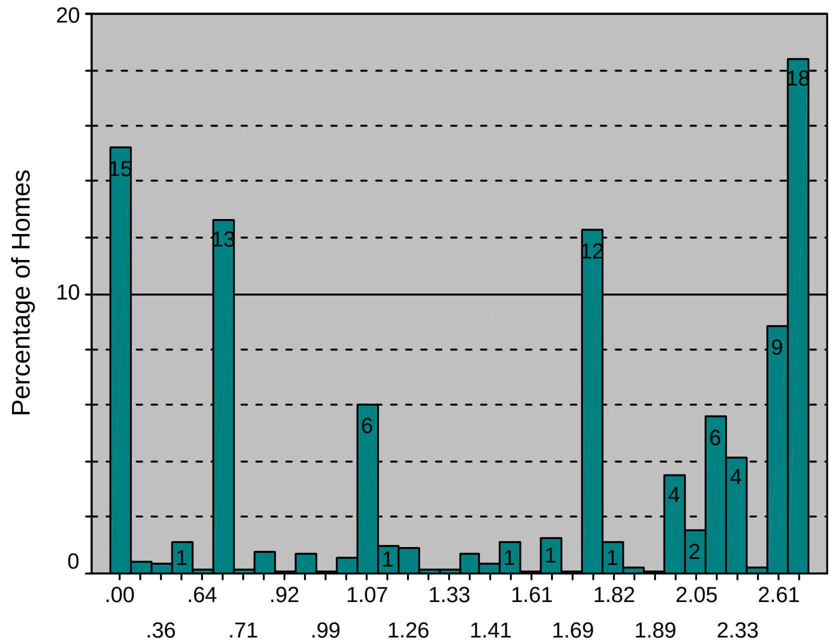


Figure 7. Distribution of Envelope Coverage Statewide

Just over 15% of the sample falls at the lowest point of the scale, 0, indicating that they have absolutely no window coverage, nor protection for their garage door, nor their glass doors. Many more households might be down at this point except they do not have either garage doors or sliding glass doors, hence they benefit by the simply not having these potential opening is their home's envelope. At the other extreme, 2.89, we find 18.4% of the sample. The average envelope score was 1.59, with a median of 1.76. The fact that both of these values are to the right of the middle of the range and that the mean is slightly to the left of the median clearly suggests that the weight of the distribution is to the high side with more extremes at the lower level. This in turn suggests that the majority of households are on the high end, reflecting more protection. Indeed, the lower quarter of cases falls at .70, while the upper quartile falls at 2.61 or above. It should be noted however, that a home with no window coverage, but also no garage or sliding glass doors, would by definition have part of its envelope protected, since it does not have these openings to protect. Hence, the scale is in effect a hurricane safety scale, rather than a measure of a household actively protecting or improving its homes hurricane safety. Nevertheless, in light of the individual components of this measure, one can anticipate that higher scores should be found in Southeast Florida, when compared to other areas. Table 13 presents the basic descriptive statistics for envelope coverage for each region.

Table 13. Descriptive Statistics and Confidence Intervals for Envelope Coverage

NENVELOP

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min.	Max.
					Lower Bound	Upper Bound		
Southeast Florida	396	2.1371	.82414	.04141	2.0556	2.2185	.00	2.89
Central East Coast	247	1.2487	1.04130	.06626	1.1182	1.3792	.00	2.89
West Coast	334	1.4072	.93820	.05134	1.3062	1.5082	.00	2.89
North Florida	181	1.3181	.97375	.07238	1.1752	1.4609	.00	2.89
Panhandle	91	1.4032	.90918	.09531	1.2139	1.5926	.00	2.89
Total	1249	1.5941	1.00008	.02830	1.5385	1.6496	.00	2.89

As anticipated above, homes located in Southeast Florida have the highest levels of envelope coverage. Indeed, the mean for homes in the Southeastern region is significantly higher than the means on other regions. While there are some minor variations among the other regions, no difference is statistically worse or better. This implies that homes in Southeast Florida have significantly better envelope coverage than homes in any other region of the state. Furthermore, the standard deviation is smaller in the Southeast as well, implying that the homes are more similar in their envelope protection. The larger standard deviations in other areas, implies much greater intra regional variation when compared to homes in Southeastern Florida.

Table 14. Descriptive Statistics and Confidence Intervals for Envelope Coverage: Coastal Counties

NENVELOP

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min.	Max.
					Lower Bound	Upper Bound		
Southeast Florida	396	2.1371	.82414	.04141	2.0556	2.2185	.00	2.89
Central East Coast	120	1.4636	1.05046	.09589	1.2738	1.6535	.00	2.89
West Coast	289	1.3602	.94405	.05553	1.2509	1.4695	.00	2.89
North Florida	106	1.2665	.97107	.09432	1.0795	1.4536	.00	2.89
Panhandle	65	1.3851	.91263	.11320	1.1590	1.6113	.00	2.89
Total	976	1.6796	.98724	.03160	1.6176	1.7416	.00	2.89

Unfortunately, the picture is not much improved by only comparing homes in coastal counties; indeed, for some areas the situation actually appears worse. Table 14 displays the statistics on envelope coverage for just home located in coastal counties in each region. Again, Southeastern homes have the highest levels of envelope coverage and its level of coverage is significantly better than coastal homes in any other region. Furthermore, while there appear to be variations in envelope coverage among homes in other regions, none of these differences represent significant improvements. Indeed, comparing these means with those in Table 13 above, the means for the West Coast, North Florida, and the Panhandle actually drop, implying poorer envelope coverage, on average, for coastal homes in these regions. Fortunately however, most of these differences are not significant. The exception is in the West Coast region, where the mean for inland counties is actually higher than it is for coastal counties.

2.8 Statewide, just over 47% of those without window protection indicated that the reason they had no protection, was because they did not need it. However, a sizable percentage, nearly 29%, also indicated that expense was the primary reason they had no window protection. When considering only coastal counties, substantial percentages mentioned that cost was the primary factor for not having shutters. Specifically, among coastal county respondents without protection, 45% in the Southeast, 36% in the Central East Coast, 31% in the West Coast region, and even 26% in the Panhandle mentioned cost as the primary reason for not having window protection.

When households with no window protection were asked why, a variety of reasons were given. As shown in Table 15, a substantial percentage of just over 47% indicated that the principal reason they had no protection was that they did not need it, which for some in inland counties may well be the case. However, a sizable percentage of nearly 29% also said they could not afford them. In addition, almost 5% had never though about it and 3.5% suggested that they were going to get to it at some point. Nearly 16% gave other reasons and a few of the predominant reasons were that they had not needed them as of yet or that they would not look good[12]. Interestingly several mentioned that they had just moved into their home and simply could not afford to get them at this point but, hoped to get them soon as well as a few that said they had just bought their home and since it did not have window protection when they bought it, they figured that they did not need it. These response patterns do change somewhat when we consider only coastal counties statewide. Unfortunately, just over 40% of households residing in coastal counties also feel that they simply do not need window protection and nearly 5% had never though about it. The percent of households citing expense as the primary

[12] Even more frightening were the few that indicated that they did not need window protection because they had bars on their windows, trees in their yard, used tape, or worse of all, because they would "open the windows to neutralize the pressure..."

reason does increase to just over 32%, with an additional 4% that just have not gotten around to it, although they have been meaning to.

Table 15. Why no window protection

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Do not need them	267	21.2	47.3	47.3
	Expense	162	12.9	28.7	75.9
	Never thought about	27	2.1	4.8	80.7
	Procrastination	20	1.6	3.5	84.2
	Other reason	89	7.1	15.8	100.0
	Total	565	44.8	100.0	
Missing	DK/NR	22	1.7		
	System	673	53.4		
	Total	695	55.2		
Total		1260	100.0		

Figure 8 displays the responses for why households have no window protection for coastal counties in each region. Rather sizable percentages of households simply feel that they do not need window protection. While this is more understandable for households in coastal counties in the North Florida region, which portions of these counties are outside of the wind debris profiles for ASCE-7-98, the fact that over 52% in Panhandle households without window protection consider that they do not need window protection is perhaps not consistent with more objective assessments. But equally significant are the percentages that mentioned expense. This is particularly evident in the Southeast, an area with the highest envelope coverage and window protection rates. In this area, it is clear that cost is a major impediment with over 45% mentioning cost at the major reason for not having window protection. Similarly, in areas such as the Central East Coast (36%) and West Coast (31%) regions, rather substantial proportions list expense as the most important factor. Indeed, even in the Panhandle, more than one-quarter of the respondents without window protection report that cost was a factor. In light of these figures, it should not be surprising that low income houses, in both the Southeastern and West Coast regions were much more likely to mention cost as the major reason for not having window protection.

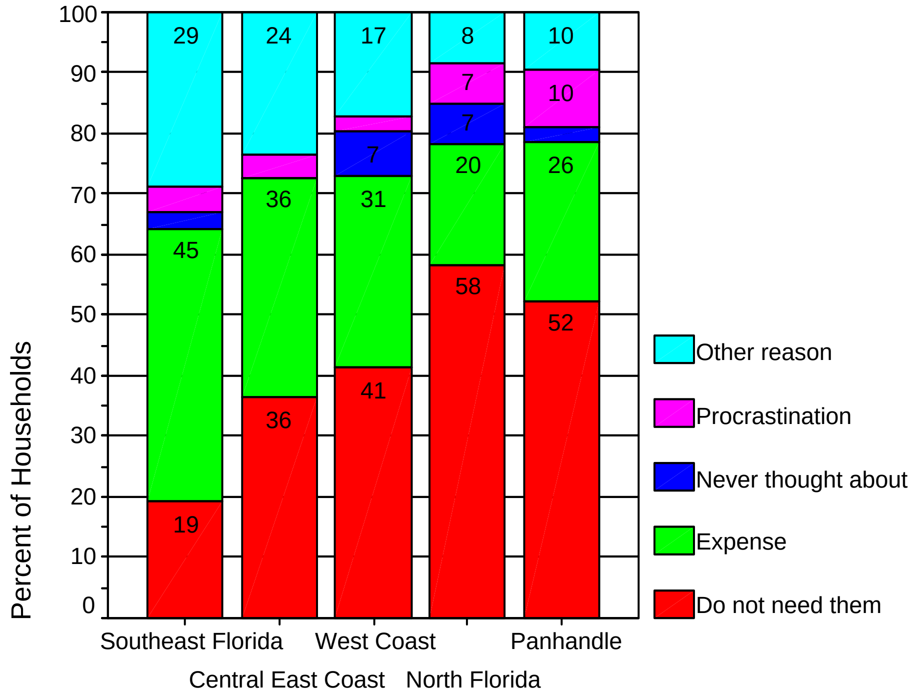


Fig. 8. Reasons for no protection: regional coastal counties

Summary of Housing Characteristics and Hurricane Mitigation Status and Policy Implications*:* The evidence suggests that the situation among owner occupied single family detached housing had improved considerably since Hurricane Floyd threatened the entire Atlantic coast of Florida in 1999. However, the picture is far from pretty. Significant percentages of this housing, particularly in coastal counties, are still lacking in window protection and total envelope coverage must significantly improve. Younger housing is more likely to have code compliant protection, but it is also likely to have no protection as well. The new statewide building code will have a positive impact for areas included in the new wind-borne debris regions. However, some areas that many would feel needed to be included, particularly in the panhandle, will not benefit from this at all. The age of housing, particularly in the Southeast, does suggest that as windows are replaced and re-roofing is undertaken there will be opportunities to improve the mitigation status of homes. However in areas not under the new wind-borne debris requirement this will not happened and even in areas where the new code is likely to improve the mitigation status of homes as repairs and maintenance is being undertaken, home owners need to know what to look and ask for from their contractor. As a consequence these are significant opportunities to help inform and educate the pubic that must be address. Furthermore, the building profession must also be encouraged to provide the public with the options to significantly up-grade the hurricane safety of their homes. Roofers, for example, often do not want to change normal ways of business, by offering to add additional nails or screws. Once the new roof is down, however, the opportunity is lost.

The data clearly suggest that cost is increasingly mentioned as a major impediment to improving the mitigation status of homes. Programs and policies that help bring down, offset or subsidize, in some fashion, the coast associated with improving a home's hurricane safety must continue to be explored. This is particularly so for low income and some minority households.

3. How much has been spent, is necessary to spend, and likely to spent to better protect family and home[13].

In light of the data suggesting that expense is an important factor inhibiting households from investing in window protection, and probably by extension, other more substantial hurricane safety features, it might be interesting to explore how households report spending to help protect their home and family, and how much they perceive it would be necessary to spend.

3.1 Statewide, households estimate that they have spent on average of $3,477 to make their home safe from hurricanes since it was purchase. Furthermore, they estimate that they will need to spend, on average, an additional $2,800. Unfortunately, the great majority of households will, at best, only be able to spend a small part of that amount in the near future.

Respondents were asked to estimate how much they spent to protect their homes and families from potential hurricane damage since they purchased their home Statewide the average expenditures was $3,477. However, the median was $0. These statistics clearly indicate that we are dealing with an extraordinarily skewed distribution, in which a substantial proportion have spent very little, although at least some have spent a good deal. To get a somewhat better handle on these data, Table 16 presents the figures for estimated expenditures by region. Not surprisingly, given the findings so far, households in Southeast Florida report spending considerably more than households in any other region. Indeed, this amount is significantly different than the average amounts spent in a number of other regions. Just as significant is the median value for Southeast Florida. Given the highly skewed nature of these distributions in all regions, the fact that the

[13] These questions were added at the request of DCA in a modified form, from the FLASH survey of likely voters.

median for Southeastern Florida is $2000, while it is $0 for other regions, certainly suggest that that the typical household residing in single family housing in Southeastern Florida has spend substantially more on preparing their households, than have households in other regions. These findings change very little even if only coastal counties in each region are examined.

Table 16: How Much Spent by Region

Amount spent

State Regions	Mean	Median	Std. Deviation	N
Southeast Florida	5692.68	2000.00	11318.503	315
Central East Coast	3196.08	.00	15412.171	209
West Coast	2085.82	.00	6197.682	280
North Florida	2433.57	.00	6974.205	154
Panhandle	2250.68	.00	4552.079	73
Total	3476.50	.00	10412.192	1031

Statewide, respondents report that they will need to spend, on average $2,854 to make their home safe, and yet again, the median amount is $0. Regionally the means and medians are remarkably similar. Table 17, presents the basic descriptive statistics for the amounts households think they will need to spend to make their homes safer. The most remarkable feature of this table is the similarity of average amounts across regions; indeed, there are no statistically significant differences between any of these figures. This is surprising given the previous results that clearly indicate that Southeastern households reside in much better protected housing, having spent considerably more then their counterparts in other regions. Perhaps, in that context, it is not all that surprising that very little in any real differences emerged.[14]

Table 17. Estimate Amount That Will Need to be Spent

Estimated cost to protect family and home

State Regions	Mean	Median	Std. Deviation	N
Southeast Florida	2868.46	.00	10896.384	344
Central East Coast	2455.50	.00	6162.954	209
West Coast	3090.07	.00	9090.175	282
North Florida	2936.36	.00	10474.281	154
Panhandle	2838.57	.00	12319.577	70
Total	2853.87	.00	9680.748	1059

Of the amounts estimated each household will need to spend to make their home safer, about 23% of households indicated that they will spend most of it, 18% say they will

[14] Interviewers reported that these questions were among the most problematic asked in the survey.

spend about half it, 26% indicate that they will spend only some if it, and 32% suggest that they will not be able to spend any of it.

Summary of spent/spending findings: On the whole these data at least suggest that in areas that do have somewhat better mitigation status significantly more has been spent than in areas with significantly lower mitigation status. Furthermore, the average amount spent in the Southeast is not insignificant in and of itself for many of these households. However, the fact that the estimated amounts that need to be spent are essentially equivalent across regions suggests that households may not have an accurate idea of what it might take to fully address the hurricane safety of their homes. In this context programs such as a hurricane safety audit program, similar to FPL's energy audit program, that will inspect homes and make recommendations on how to effectively improve the mitigation status of ones home may well help households better understand their mitigation options and possibilities. These types of programs are addressed further below.

4. Hurricane Safety Features When Purchasing a Home.

4.1. The majority, 54%, of current homeowners in Florida indicated that hurricane safety features were important when purchasing their homes. This finding is consistent when comparing across regions and even when comparing only coastal counties across regions. Hence, hurricane safety features are indeed being considered as important in home purchases statewide

A critical factor in shaping the future safety of Florida's homes is of course the way today's homes are being build and the hurricane safety features they include. The South Florida Building code is undoubtedly one reason shy Southeast Florida's homes generally include more hurricane safety features than homes elsewhere in the state as we have seen above. However, another important factor in making our homes safer will be increasing the market demand for housing that includes hurricane resistant features. To gauge current demand, respondents were asked how important hurricane safety features were to them at the time they purchased their home. Overall nearly 23% indicated that hurricane safety features were very important and an additional 31.7% felt that they were somewhat important. Thus, over 54% considered that their home's hurricane safety features were somewhat or very important when purchasing their home. An even more interesting trend emerges when these responses are considered in relation to when homes were purchased.

4.2. Over the last twenty years there has been a clear trend toward increasing importance of hurricane safety features when purchasing a home. Nearly 65% of homeowners that purchased their homes during the last 5 years considered hurricane safety features as somewhat or very important in their decision.

Figure 9 displays the responses related to the importance of hurricane safety features when purchasing their homes by how long ago a home was purchased. These responses show a clear and definite trend. In the last 20 years, hurricane safety features have become increasingly more important for a larger percentage of homebuyers in Florida. Over twenty years ago only 12% thought hurricane safety features were very important when selecting their homes, however since that period the percentage has steadily increased until now 28% think hurricane safety features are very important. If those that thought these safety features were very and somewhat important are combined, we see that 65% think hurricane safety features are important in their decision making for those who have purchased their homes in the last 5 years.

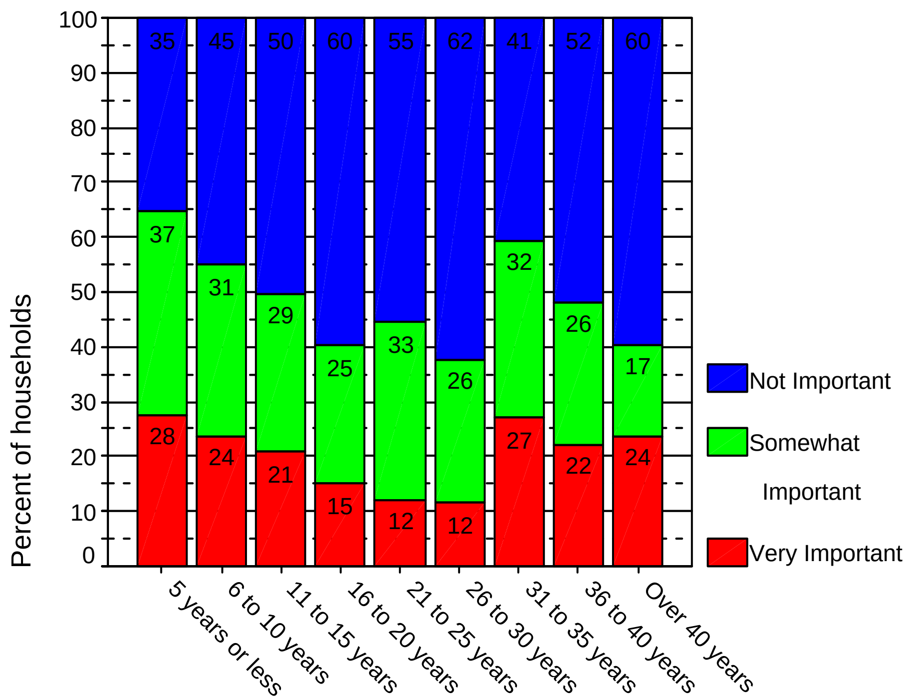


Fig 9. Importance of Hurricane Safety by when purchased

4.3. The types of hurricane safety features mentioned as important include building materials (CBS construction) (47%), window protection (39%), and roof materials or bracing (32%).

Figure 10 presents the types of hurricane safety features most often mentioned by respondents. Specifically, respondents were asked to list as many hurricane safety features that they thought were important when making their decision to purchase a home. The three most important features mentioned were building materials, such as concrete block, at 47%, window protection at 39%, and roof material (i.e., tile roofs) or bracing at 32%.

***Summary of the importance of hurricane safety features when purchasing ones home*.** Clearly there has been a clear shift in the importance of how a home's hurricane safety features are evaluated when purchasing a home over the last 20 years, particularly since Hurricane Andrew. Even more important is the fact the percent considering such features as very important in their decision-making is rising. This represents a golden opportunity to shape the market demand for these features, if effective educational materials can be provided to potential home buyers when they are making their purchasing decisions. The State should look into mechanisms to help educate the consumer even further about what to look for and how to evaluate a home's hurricane safety features. Hurricane safety features should be part of any home inspection guide, and professional home inspectors should be trained to discuss such matters with prospective buyers who hire them to inspect homes. Hurricane safety features should be part of the standard home inspection checklist and should also be included on the standard real estate tax portfolio information that real estate professionals and buyers often consult. Furthermore, since this finding is consistent across the state, home build industry would do well to accentuate a homes hurricane safety features when marketing property and the real estate industry as well should also discuss and highlight hurricane safety features to prospective clients.

The responses to questions about why their household did not have window protection suggest yet another consideration regarding the purchase of a new home. A number of respondents noted that they had just purchased their homes and hoped to shutter them later, because they did not have sufficient money to do so at this time. If there were incentives to motivate prospective homebuyers to increase their mortgages slightly so they might finance major hurricane mitigation expenditures, such as shuttering at the time of purchase, then perhaps they would do so. Mortgage companies would also have to be open to and perhaps even encourage such an arrangement as well. Over the life of a mortgage, financing $5,000 dollars of shutters would add little to a monthly mortgage payment, yet would significantly enhance the hurricane safety of the home. The state and county might reduce fees and taxes when homebuyers undertake the option to improve the mitigation status of their new home as an incentive.

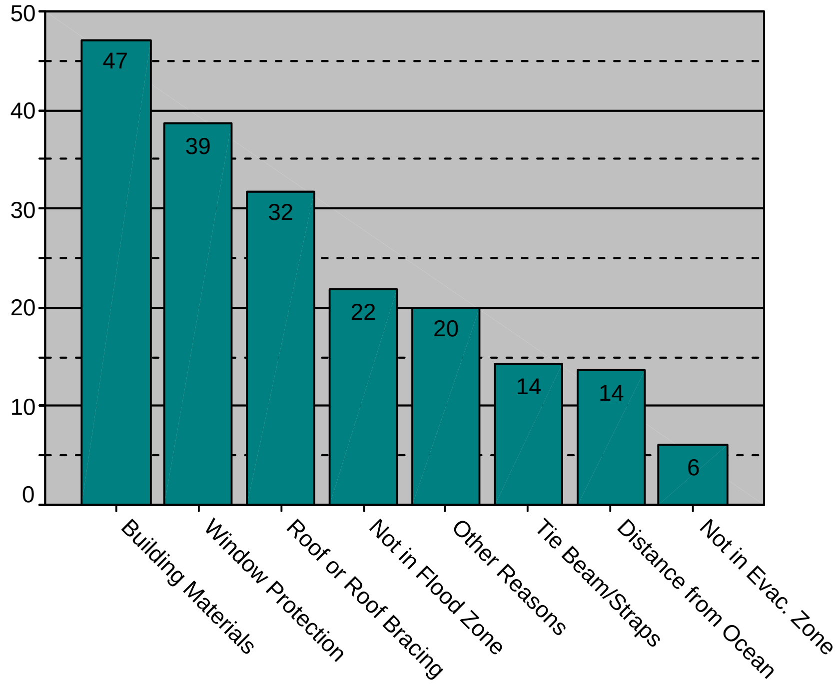


Figure 10. Types of Features Important

5. Hurricane Season Preparation

5.1. Just over 74% of households statewide and 77% in coastal counties engage in routine preparatory activities prior to hurricane season. The vast majority gather supplies, check shutters, and check on or purchase battery powered radios. Not surprisingly, households in Southeastern Florida are significantly more likely to engage in these activities and less likely to do nothing than households in all other regions, with the exception of Panhandle households that gather supplies and do not do anything to prepare. These observations hold even when comparing only households residing in coastal counties in each region.

While having a home that has total window protection as well as protection for sliding glass doors and garage openings often requires decision making, preplanning, and major expenditures be undertaken long before a potential storm is on the way, there are many actions that can be taken by a household to make their households, if not their home, more hurricane safe. In particular, there are often a host of activities such as gathering supplies, revisiting or making hurricane emergency plans, buying or checking for a battery powered radio, etc. Respondents were asked if their household routinely does thing to prepare their household for up-coming hurricane season. Statewide, just over 74% said they did something prior to hurricane season, however there were significant regional variations. Over 87% of households in Southeast Florida undertook preparatory actions every hurricane season, followed by 77% in the Panhandle, 69% in the Central East Coast, 68% in the West Coast region, and 64% in North Florida. These percentages do not change dramatically when focusing exclusively on coastal counties in each region as is displayed in Figure 10. On the whole, significantly higher percentages of households in Southeast Florida prepare for hurricane season and than in any other regions, with the exception of the Panhandle.

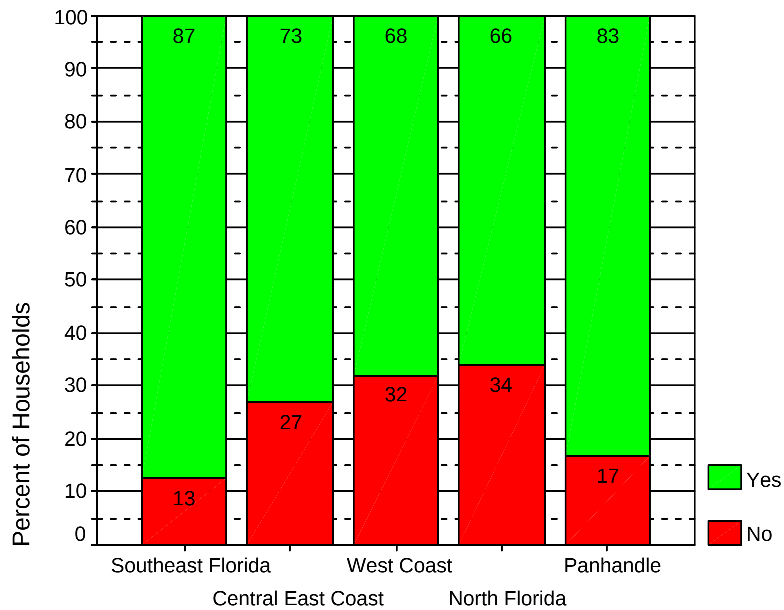


Figure 11. Hurricane Prep. Activites, Coastal Counties Only

Figure 12 below displays the types of activities undertaken by households prior to hurricane season and the percentage of households undertaking each activity – included in this graph are the nearly 26% of households that do nothing as well. Over 63% mentioned that they gather supplies for their hurricane kit, consisting of food, water, medical supplies, etc. While the other activities are not quite as prevalently practice as the gathering supplies 38% do check their shutters or window protection, 35% buy or check their battery powered radios, 21% do other things, 8% trim trees, and 7% revisit or make evacuation plans.

There are again significant regional variations in the activities undertaken by households. Specifically there are significant regional variations in the percentages that gather supplies, check shutters, and do not do anything. These differences hold even when only examining households residing in coastal counties in each region. For example, while 75% of Southeastern households gather supplies, and 71% of Panhandle coastal households do the same, the percentages for coastal households in other regions are all in the 50% range. Conversely, only 13% of Southeastern households and 16% of coastal households in the Panhandle do nothing, while the percentages among coastal county households in other regions are predominantly in the 30% range. There are also variations with respect to purchasing or checking on a battery powered radio and securing things outside the home. On the whole Southeastern household are consistently more likely to undertake specific preparation activities then households, coastal or not, in other regions, with the exception of Panhandle households when it comes to doing nothing and gathering supplies. It should not be a surprise that households with window protection are also more likely to report undertaking these preparatory activities than those without window protection as well.

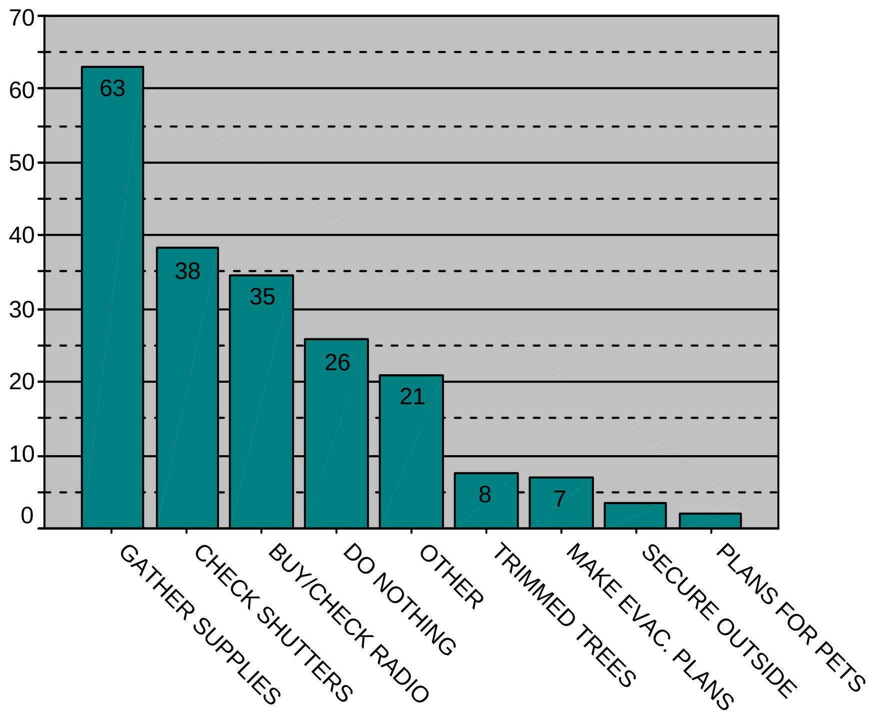


Figure 12. Percent Undertaking Specific Prep. Activites

Summary of Hurricane Season Preparation: The fact that so many households, regardless of region engage in some degree of hurricane preparation is, to a limited extent, a success. It certainly suggests that households are not only cognizant of hurricane season, but that they are also responsive to preparation messages. It is time, particularly with the new wind borne debris regions adopted as part of the statewide building code, to enhance lessons about how to significantly improve the hurricane safety of existing homes. Part of any hurricane preparation guide, should be assistance in locating their home with respect to surge and wind potentials. Literature should help the public pinpoint their location not only vis-à-vis the wind borne debris region, but perhaps even wind probability maps, such as the ASCE-7-98 peak gusts contours, or even the TAOS wind return time contours developed as part of the statewide LMS, so that households they can better assess the wind damage potential for their home's location and what they might do to improve the structural integrity of their homes. Households need to better understand their hurricane hazard risk as part of their preparation.

6. Hurricane Experience

6.1. More than three-quarters of Florida Single family homeowner households include someone with hurricane experience.

A wide majority (77%) of respondents reported at least one adult member of their household had "experience" with hurricanes. This percentage remains remarkably high across all regions although there are also statistically significant differences. The region reporting the highest percentage of households with hurricane experience was Southeast Florida (87.2%) followed closely by the Panhandle (85.9) and then the Central East Coast (72.5%), West Coast (64.4%), and North Florida (66.1%).

6.2. When experience is defined as damage however a substantially lower 28.3% report having an adult member that has actually lived in a home damaged by a hurricane and 20% of these individuals report that the damage was major.

The difficulty in asking about hurricane experience is defining what "experience" really means. It could run the gambit from being somewhere near a hurricane event, perhaps even only under a warning, to suffering extensive damage. In order to gauge the type of experience, respondents were asked whether an adult member of their households had actually lived in a home damaged by a hurricane. While 75% of the households surveyed had experienced a hurricane, only 28.3% had actually had a home damaged. Of those reporting damage, 51.7% report that the home suffered slight damage, 28.1% moderate damage, and 20.2% major damage. What are even more interesting are the regional differences in damage.

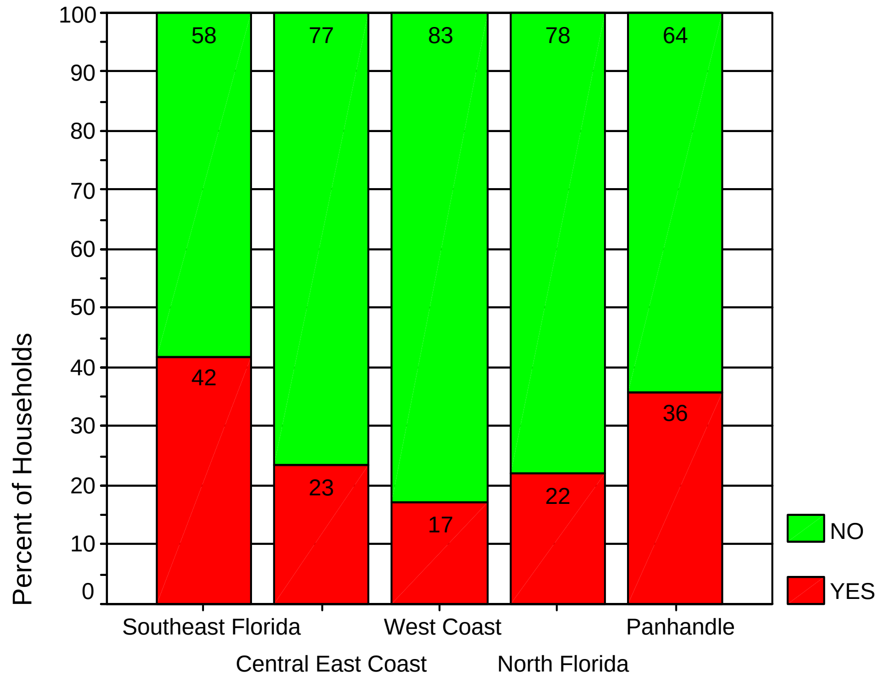


Figure 13. Adults that have experienced hurricane damage

Southeastern Households (42%) were the most likely to report having lived in a home damaged by a hurricane, followed by households in the Panhandle (36.2%), Central East Coast (23%), North Florida (22%), and lastly, households along the West Coast (17%). Even more interesting were the variations in damage. Southeastern households had higher percentages reporting members experiencing major damage (28.1%), followed by Central East Coast households (15.5%), North Florida households (15%), Panhandle households (12.1%), and then West Coast households (10.3%).

Summary of Hurricane Experience Section: The difference between reporting "hurricane experience" and "damage experience" is quite interesting. There are clearly substantial numbers of households that consider themselves experienced when it comes to hurricanes and yet have not suffered any damage from them. These variations are likely to have important consequences for how people anticipate and prepare for hurricanes; indeed research has clearly shown that "experience" does have consequences for mitigation. It is often reported that many more people have experienced a hurricane miss than a hit and this can be part of the problem. A point of potential concern is the substantial proportions of Florida's homeowners that have experience a miss, and hence "successfully survived another hurricane" even when they were not properly prepared. This "experience" promotes thinking that households do not need hurricane mitigation technologies such as shutters, because they survived the last hurricane. One has to only think about the many near misses along the Panhandle since hurricane Andrew and the type of findings mentioned above about not needing shutters to perhaps consider that it may be important to undertake a public education program about how yesterday's near miss or safe "hurricane experience," may not provide an accurate picture of ones actual hurricane risk nor the likelihood of the next hurricane hitting their area.

7. Hurricane and Other Natural Hazard Risk Perception:

Respondents were asked a host of questions regarding their perceptions of risk, concern and worry about hurricanes and others hazards. The following sections present these findings.

7.1. Over 51% of respondents indicated that, of the many potential natural hazards they might be exposed to, they were most concerned about Hurricanes. An additional 31% also expressed concern about tornados. There were some regional variations where in general, hurricanes were more of a concern to residents in Southeastern Florida, tornadoes were a bit more of a concern to Panhandle residents, and wildfires were a bit more of a concern to the residents of the Central East Coast and North Florida.

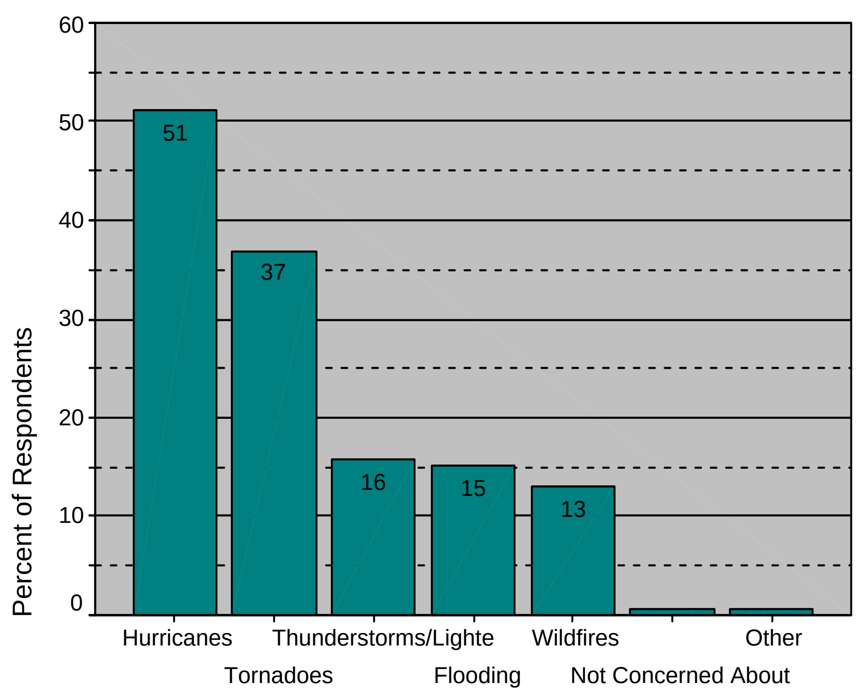


Figure 14. Hazards Concerns

On the whole, the majority of respondents expressed concern about hurricanes (51%), although a substantial percentage also were concerned about tornadoes (37%), and still smaller percentages with lightening (16%), flooding (15%), and wildfires (13%). Overall there were not consistent regional differences, although there were some more specific differences among regions. The exceptions were hurricanes, where a greater concern was expressed in Southeastern Florida when compared all other regions (although some of these differences if only coastal counties in each region are compared) and Tornadoes, where Panhandle residents express somewhat higher concerns, and Wildfires, where residents of the Central East Coast and North Florida regions express higher levels of concern. In other words, hurricanes were more of a concern to residents in Southeastern Florida, Tornadoes were a bit more of a concern to Panhandle residents, and wildfires were a bit more of a concern to the residents of the Central East Coast and North Florida.

7.2. Southeast Florida homeowners tend to be much more worried about hurricanes than homeowners in other regions, although a substantial proportion in all other regions, around 40%, express some worry about hurricane impacting their communities.

Often times perceptions of risk can be better assessed by asking a question that places a threat into a more salient context, such as ones home or community. As a result, respondents were also asked about their level of worry about hurricanes hitting *their community*. Overall only 10.1% of the respondents indicated that they were 'very worried.' However, 36.5% suggested that they were at least somewhat worried, with an additional 32.5% indicated they were a little worried. Approximately 21% responded said that they were not worried at all. As shown in Figure 15, the percent not worried was fairly constant across regions, with the exception of the relatively low 14% figure for Southeast Florida. On the other hand, the 16% of Southeastern respondents reporting that they are very worried is double or more the percentages found in other regions. On the whole, households in Southeast Florida are much more likely to express worry about hurricanes actually hitting their community. However, the fact that at close to 40% of individuals in all regions are very or somewhat worried does reflect the general level of concern with hurricanes statewide.

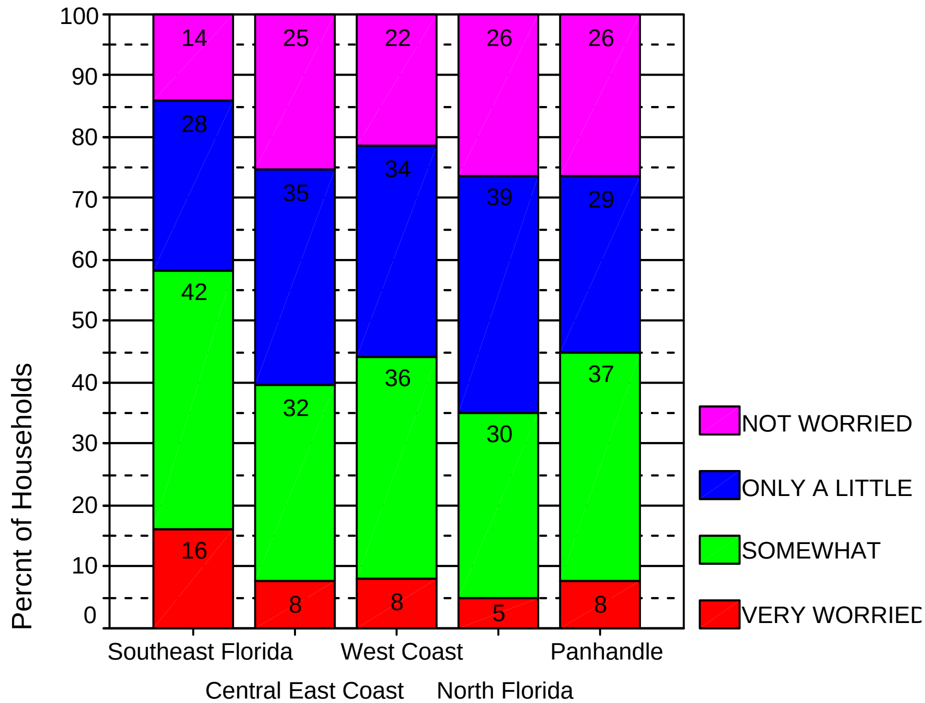


Figure 15. Hurricane Worry in Each Region

7.3. Nearly 58% of respondents think it is very likely that a hurricane will disrupt their daily routines this hurricane season. Significantly higher proportions are found in both Southeast Florida, 70.2%, and in the Panhandle, 61%.

The salience or significance of hurricanes for the lives of Florida's residents can to a certain extent be gauged by how likely they think hurricanes will disrupt their normal daily and work activities. Just at 34% of the respondents thought that a hurricane would be very or somewhat likely to disrupt their work activities during the next season and nearly 58% think that a hurricane is likely to disrupt their daily activities this next season. Similar regional patterns are found for both of these questions. For example, Figure 11 displays the regional findings in terms of the likelihood that a hurricane will disrupt normal daily activities. Relative high percentages of respondents in both Southeast Florida (20%) and in the Panhandle (18%) think it is very likely that their daily routines will be disrupted by a hurricane this season. Furthermore, over 60% of respondents in the Panhandle and 70% in Southeast Florida think this is very or somewhat likely that a hurricane will disrupt their daily routine this season. This in part account for why respondents in these two areas are most likely to engage in routine preparatory actions every hurricane season.

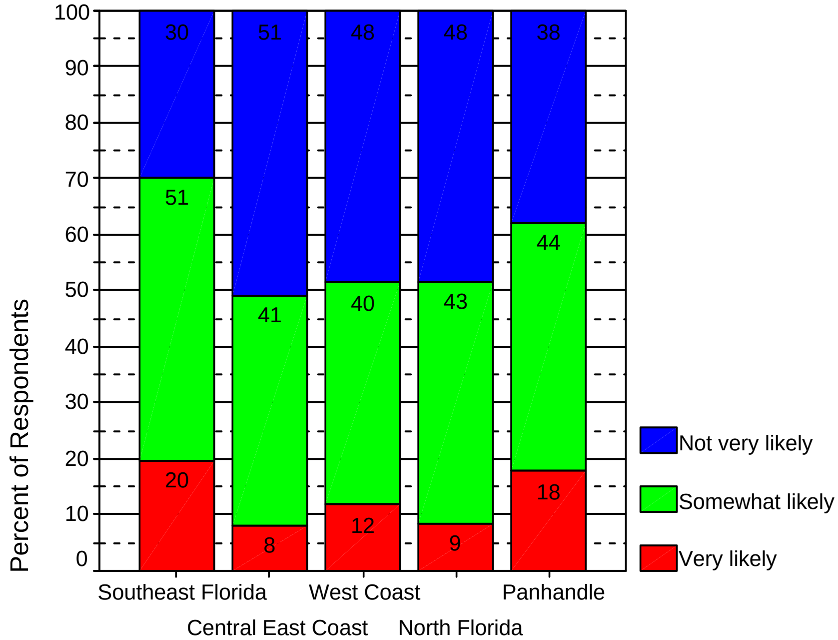


Fig. 16. Likelihood of Hurricane Distuption of Daily Routine

7.4. A substantial proportion of just over 43% of Florida's single family homeowners believe it is very or somewhat likely that a Category 3 or higher hurricane will impact their home this year. There are however considerable regional variations with over 56% in the Southeast compared to only 30% in North Florida considering such an event as very or somewhat likely. These differences however, diminish somewhat if only coastal counties in each region are compared.

When asked how likely is it that a major hurricane, Category 3 or greater, will impact their home this year, 8.7% of Florida's homeowners rated the probability as very likely and an additional 34.4% saying it was somewhat likely. The remaining 56.8% felt it would not be very likely at all. There were, as one might expect, regional variations, which are displayed in Figure 17. While 13.5% of Southeast Florida respondents indicated that it was very likely for a major hurricane to damage their home this season, nearly 10% of respondents in both the panhandled and along the west coast also considered this very likely. The major variations are most pronounced when combining very and somewhat likely. Nearly 57% of respondents in the Southeast think it is very or somewhat likely that a major hurricane will damage their homes this season. Over 41% of respondents in both the panhandle and along the Central East coast think it is very or somewhat likely that their home will be impacted by a major storm this season, while the other two regions have percentages that fall in the 30% range. Clearly, Southeastern homeowners consider it much more probable that their homes will be impacted by a major hurricane this season, when compared to other regions.

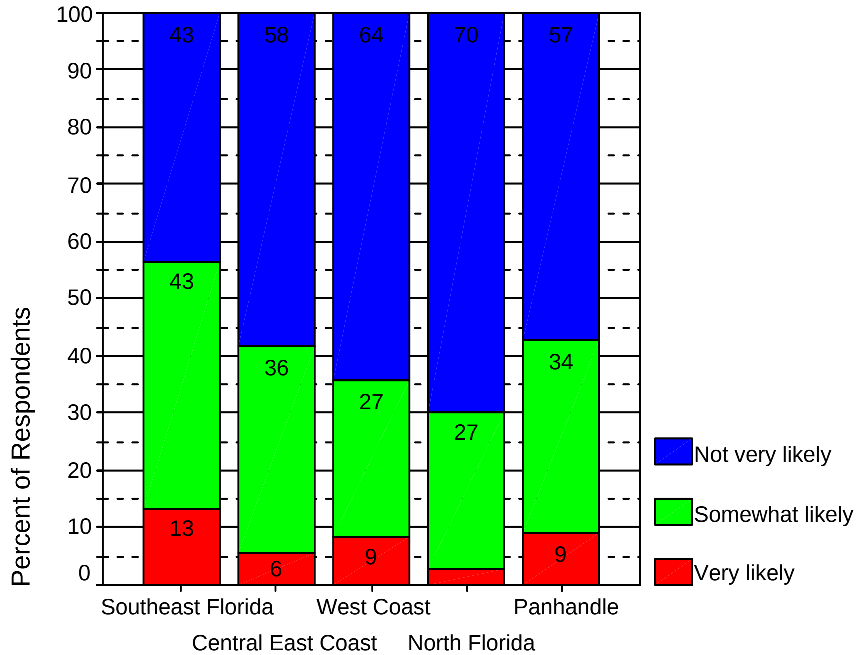


Fig. 17. Likelihood Major Hurricane Impacts Home this Season

If however, we consider only Coastal Counties in each area, then the differences diminish somewhat, with higher percentages considering such an event as very likely and the combined very and somewhat likely distinctions also diminish as well, (see figure 18).

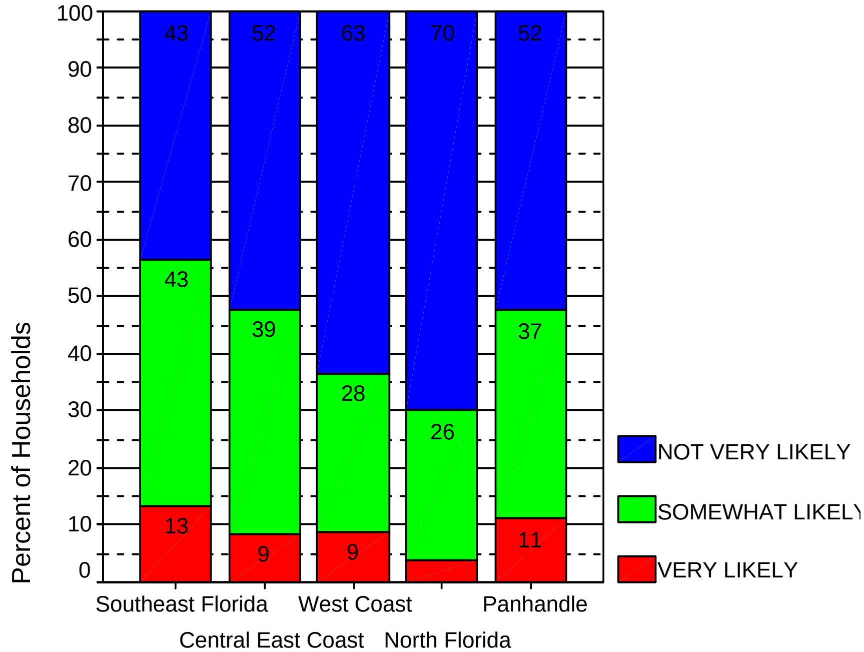


Figure 18. Likelihood of Major Hurricane Impact: Coastal Co.

Summary of Hurricane and Other Natural Hazard Risk Perception: The scientific literature has clearly shown that risk perception is a potentially important contributor to motivating households and individuals to mitigate and households with higher hurricane risk perceptions are much more likely to make their homes more hurricane safe in Florida. The recent debates over the new wind borne debris regions – how expansive they are, who is exempt and why, etc. – only adds to the potential confusion about the nature of hurricane risk and what it should mean for household preparation and mitigation. Much more needs to be done to help households better understand their potential risks and how to translate that risk into action. With the confusion, mis-statements, and contradictions, inaction is often the preferred course of action. To get people to act, they must understand more clearly why they should act and they must hear a consistent factual message. Continued education on hurricane, and other hazard risk for the entire State of Florida is a must.

8. Knowledge about Hurricane risk, damage, and mitigation

8.1. Most respondents, report that their households are highly knowledgeable about hurricane risk, 56%, the damage caused by hurricanes 56%, and how to prevent hurricane damage 60%. These findings were consistent across regions with only exception having to do with knowledge about how to prevent hurricane damage. A higher percentage of respondents in Southeast Florida felt their households were more knowledgeable about preventing hurricane damage than did respondents in other areas.

The majority of respondents felt their households had substantial knowledge related to assessing hurricane risk, understanding the types of damage that can be caused by a hurricane, and about how to prevent hurricane damage. Specifically, most (56%) reported that their household was highly knowledgeable and that they understood the types of damage that can be caused by a hurricane. In addition, nearly 60% felt that their household was highly knowledgeable about how to prevent hurricane damage. In general, these percentages held across all regions. The only significant variation occurred with respect to knowledge related to mitigation. As can be seen in Figure 19, when compared to other regions, respondents in the Southeast were more likely to rate their household as highly knowledgeable about how to prevent hurricane damage. Nevertheless, the parentages were very high across the board.

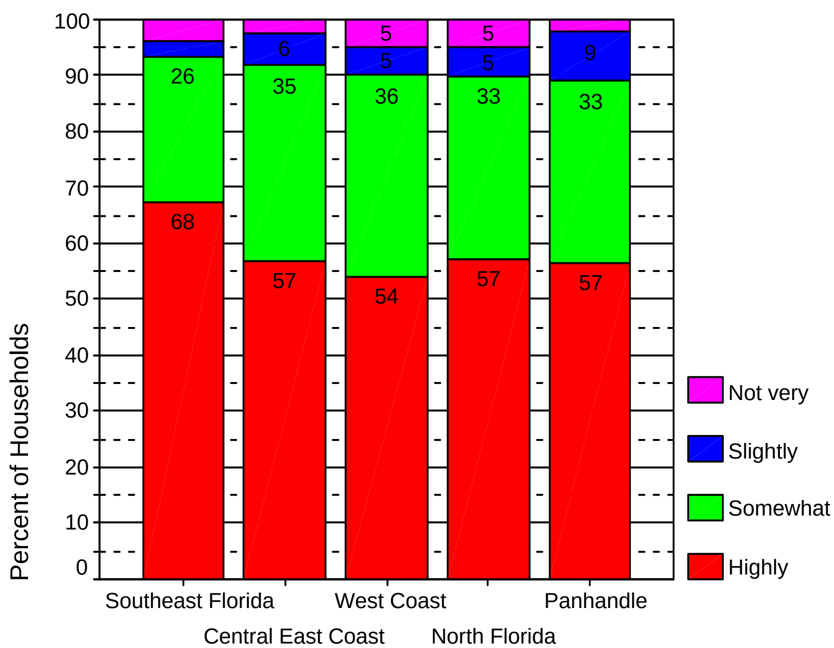


Fig.19. How Knowledgeable, Reducing Hurricane Damage

8.2. Despite perceived high levels of knowledge about hurricanes and hurricane mitigation, with the exception of safe rooms, far fewer of Florida's single family homeowners have heard of additional mitigation techniques such as: extra gable end bracing (44%), adding additional nails or screws to ones roof when reproofing (39%), or adding adhesive to joint between truss and roof (20.7%) than might have been anticipated.

In light of the rather high levels of perceived knowledge of hurricane issues by Florida's households, as assessed by respondents, it is interesting to examine the responses to a number of questions regarding hurricane mitigation techniques that were asked of respondents. As part of the survey respondents were asked about additional structural modifications that might be undertaken, in addition to shutters, by homeowners that might improve the ability of their homes to withstand hurricane impacts. Specifically respondents were asked if they had heard of any of the following modifications: 1) having a safe room or reinforced inner room in their homes; 2) adding additional braces to the gabled ends of a homes roof; 3) adding a bead of adhesive to the joint between the trusses and the roof, and lastly, 4) adding additional nails or screws to their roof when they are having their roof replaced.

Figure 20 presents the percentage of respondents indicating that they had heard of each modification. Of the four modifications, having a safe room was clearly the best known. Indeed, nearly 86% of the sample had heard of this modification. Additional gabled end bracing and adding nails or screws to ones roof were known at much lower levels of 44% and 39% respectively. Adding a bead of adhesive to the joint between the truss and roof was clearly the least often heard of modification. Surprisingly, in light of other findings, there were essentially no regional variations in order of these findings, nor were there any significant variations with respect to any one of these items regionally. On the whole, relative to the high levels of perceived knowledge regarding how to protect ones home from hurricane damage, with the exception of adding a safe room, the findings are probably lower than might have been expected. Additionally, it should be noted that respondents were simply asked if they had "heard" of these modifications. Someone may well have "heard of" these modifications, without having any really knowledge of them, much less have seriously considered undertaken these modifications. Given these findings, it is likely that there is much room for improvement and education of the public about additional measure that might be undertake by a homeowner to help prevent hurricane damage.

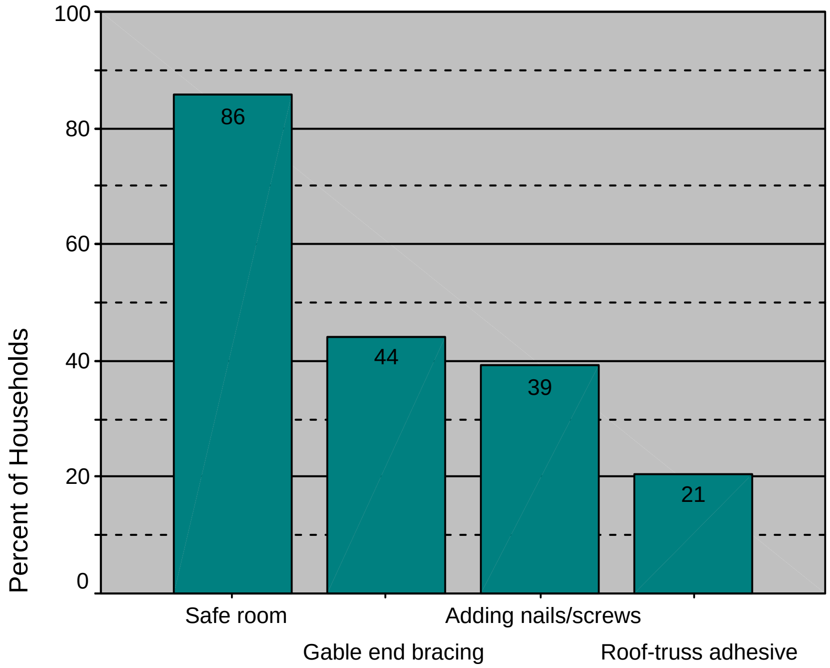


Figure 20. Knowledge of Additional Hurricane Mitigation Techniques

Summary of Knowledge about Hurricane Risk, Damage, and Mitigation: Despite the very high percent of respondents that considered their households as highly knowledgeable about hurricanes in general and hurricane mitigation in particular, the results about even just hearing about specific hurricane mitigation technologies strongly suggest that much more needs to be done to educate homeowners about what they can do to effectively make their homes more hurricane safe.

9. Sources, Methods, and Trust in Public Information About Hurricanes[15]

9.1. Just less than half, 49.5%, of the sample reported recently receiving or seeing information on making their homes more hurricane safe. Statewide, the residents of North Florida (38.7%) and the Panhandle (45.7%) were less likely than homeowners elsewhere to report receiving such information.

[15] These questions are modifications of the FLASH survey added at the request of DCA. A major modification was an attempt to differentiate between the mechanisms used to get the information to respondents (media, mailing, etc) versus the producers of the information itself, which may have been confounded in the original format. The attempts to differentiate this information by our modifications was not very successful, in part because of being unable to properly pre-test their adequacy prior to implementation of the survey. However, they may shed some light onto information transmission.

Respondents were asked if they have recently received or seen information about making their family and home safer from hurricanes. Just less than half (49.5%) the sample indicated that they had recently received information on making their home safer, and about 96% had received this information within the last year. Somewhat surprisingly there significant regional variations with over 50% of respondents in the Southeastern, Central East Coast, and West Coast regions reporting getting such information. That figured dropped to 46% in the Panhandle and even lower, to nearly 39%, in North Florida. However, these differences become less pronounce if only coastal counties in each region are compared.

9.2. Television (46%) was the most important way respondents got information about making their homes hurricane safe, followed by newspapers (34%), the mail (24%), and brochures and flyers (17%)

Figure 21 displays the responses for how respondents received information regarding making their homes and families more hurricane save for those individuals reporting recently receiving information. Respondents were allowed to select all mechanisms through which got information. Clearly, the greatest number depends on the television (46%) followed by newspapers (34%), the mail (24%) and brochures or flyers (17%). The majority of the latter were picked up at grocery stores, such as Publix, or hardware centers, such as Home Depot. The remaining mechanisms garnered less than 10% of the sample.

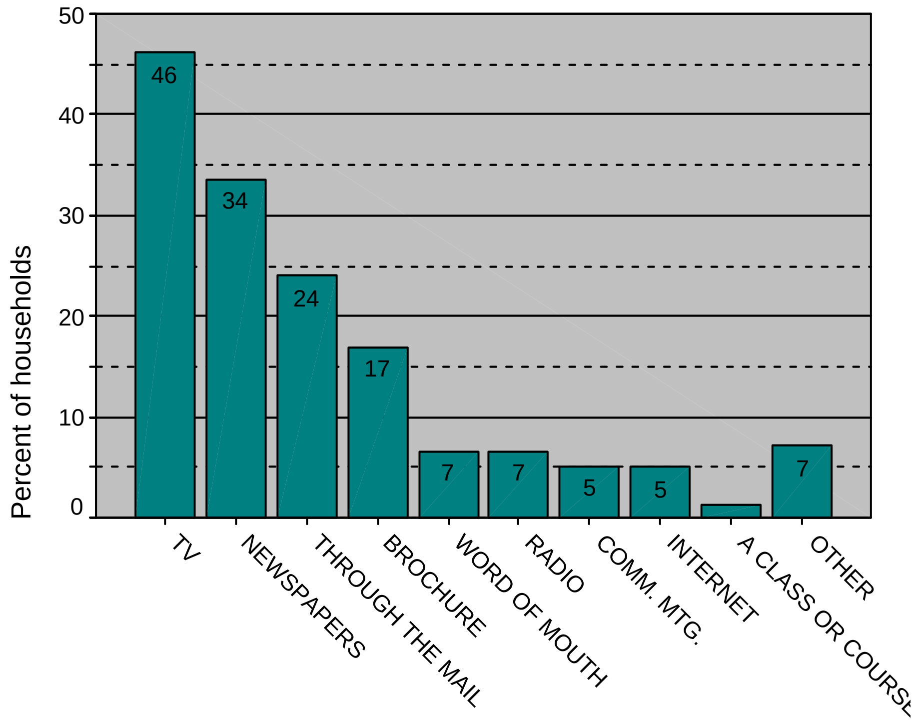


Figure 21. Mechanisms for Hurricane Safety Information

There were some minor regional variations, with the West Coast respondents ranking newspapers higher than some other regions and Southeastern and Central East Coast respondents mentioned brochures and flyers more often than other regions.

9.3. Television stations (47%) and newspapers (30%) are perceived most often as the principal provider of hurricane safety information. The next highest source was a government agency (11%) of some form.

Respondents were then asked who was providing the information they received. Figure 22 displays the responses. Yet again, respondents report that Television stations (47%) and newspapers (30%) are the most significant sources providing information on hurricane safety. Government agencies were cited by about 11% of the respondent. These agencies ran the gambit from the federal government to local. For example, the National Hurricane Center, local emergency management, county government, are some of the agencies mentioned by respondents. Again there were some minor regional variations. Respondents in the West Coast region were more likely to cite newspapers as important sources than were respondents in other regions. For the most part however, there were not major regional differences.

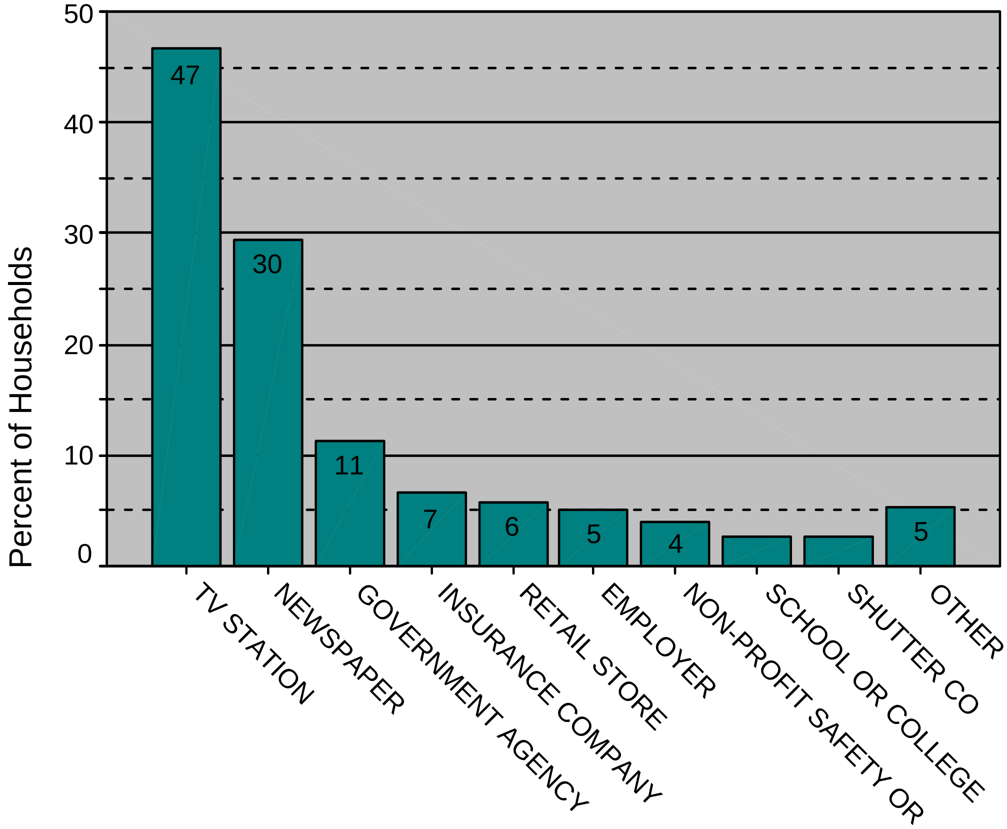


Figure 22. Who Provided the Information

Table 17. The Most Effective Way to Communicate

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	TELEVISION	731	58.0	58.7	58.7
	MAILING OR NEWSLETTER	197	15.6	15.8	74.5
	NEWPAPER OR MAGAZINE	154	12.2	12.4	86.9
	INTERNET	67	5.3	5.4	92.3
	RADIO	44	3.5	3.5	95.8
	MEETING OR CLASS	23	1.8	1.8	97.7
	SOME OTHER WAY	23	1.8	1.8	99.5
	ALL SOURCES	6	.5	.5	100.0
	Total	1245	98.8	100.0	
Missing	DK/NR	15	1.2		
Total		1260	100.0		

9.4. Most respondents reported that the most effective way to communicate hurricane safety information to their household was the television (58.7%), followed by newspapers (15.8%) and direct mailings (12.4%).

All respondents, not just those that reported receiving information, were asked which was the most effective way of communicating hurricane safety information to their household. Nearly 59% of respondents indicated that the television was the most effective way to communicate hurricane safety information to their household. This was followed by direct mailings (15.8%) and the newspaper (12.4%). Here again there were some minor but nevertheless significant regional variations. The Central East Coast and West Coast respondents were slightly less likely to select television (television was still the selection for the majority, but it was not quite as high as other regions), and respondents in these areas were slightly more likely to select newspapers and direct mailings.

9.5. For most respondents (46%) television was the most trusted source for information to help make their homes and family safer from hurricanes. Television was followed by non-profit organizations at 28% (like the Red Cross) and governmental agencies at 26%.

Finally respondents were asked who would they most trust to provide them with hurricane safety information to help make their family and home safer. They were free to give multiple responses and include any other source they might like. Figure 23 displays the responses. Perhaps it is not surprising, given the major reliance upon television for information, that television (46%) is seen to be a very trusted source for information for the vast majority of respondents. However a far from insignificant percentages also mentioned non-profit organizations (28%) and government agencies (26%). The Red Cross[16] was the non-profit organization most often mentioned by respondents while the government agencies mentioned ranged from local emergency management to FEMA, and most often, the National Hurricane Center. In terms of overall trust, following governmental organizations, newspapers are next at 15%, followed by insurance companies (11%) and school (8%).

[16] This may be a function of the question itself, which mentioned Red Cross if respondents were unclear as to what was meant by non-profit organization.

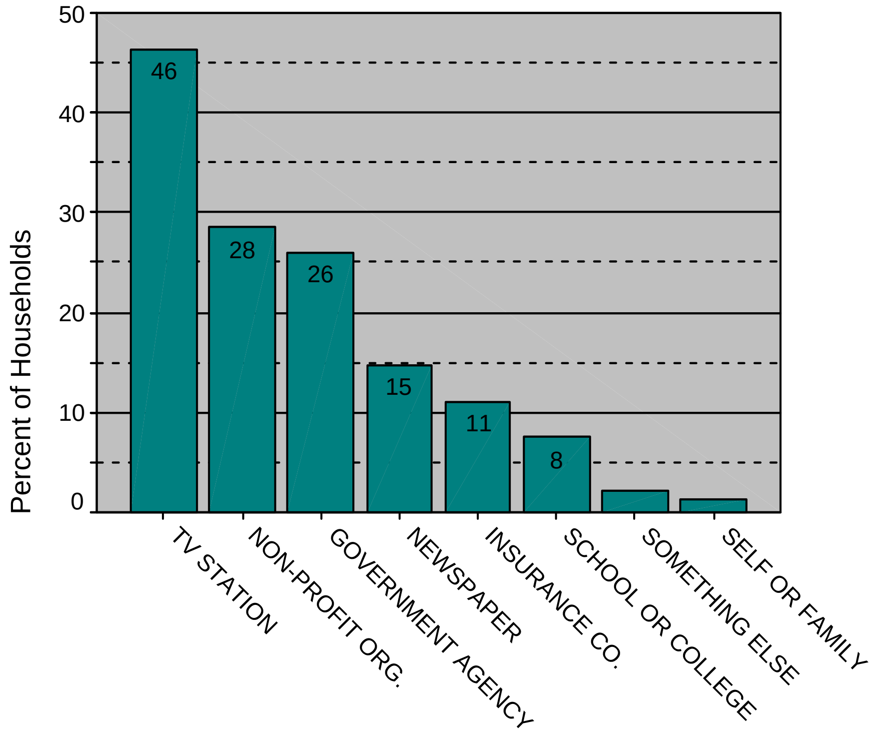


Figure 23. Who Would You Most Trust for Information

This pattern of response was substantially the same throughout Florida. The only exception, again, was that respondents along the West Coast were more likely to rate newspapers as more trustworthy than in other areas.

***Summary of Sources, Methods, and Trust in Public Information about Hurricane Safety**:* Television is the clear winner here. The National Hurricane Center has done a wonderful job of working with local television stations to get the message out on hurricane situations when areas are threatened. But the groundwork for that is laid far ahead of time by working with the media, providing short courses and training, and assisting local channels when producing their own programs on hurricane preparedness. Perhaps the State should take a lesson and begin working with regional media outlets, assisting them in producing hurricane preparation programs that included information on making homes safer, assessing hurricane risk and acting on that risk. The considerable resources assembled, for example, when promoting the LMS, such as the mapping and GIS tools could also be provided to local television stations, helping them pinpoint vulnerable areas and zones where their attention should be in the case of a natural hazard. The point is to begin developing that relationship so that, much like with the NHC, DCA can be more influential and hence better assured that consistent, on message, information is getting to the public about how to effectively prepare their homes for hurricanes.

10. Awareness of State Government Programs and Organizations Active in Promoting Hurricane Safety.

10.1. On the whole less than 20% of Florida's single-family homeowners are aware of organizations and State programs that have been initiated to help promote hurricane safety. Just at 16% have heard of Florida's Showcase Community program, however less than 10% report having heard of programs such as LMS, RCMP, or HLMP.

Respondents were asked if they were aware of various State Government programs and organizations that have been active in attempting to assist, educate, or otherwise inform homeowners and the public about hurricane safety issues. Specifically respondents were asked if they had ever "heard" of a particular state program or organization. It is important to realize that respondents were not asked anything about these organizations or programs, simply whether or not they had "heard" of them. Thus, this represents minimal recognition of these programs and organizations. The programs/organizations asked about were: the Residential Construction Mitigation Program (RCMP), the Blue Print for Safety Program, Local Mitigation Strategy, the Institute for Business and Home Safety (IBHS), the Federal Alliance for Safe Homes (FLASH), and Florida's Showcase Community. Figure 24 presents the findings. In general, these programs and organizations are not readily recognizable by many of Florida's single-family homeowners in that fewer than 20% have heard of any of them. Just at 16% had heard of Florida's Showcase Community, but less than 15% had heard of FLASH or IBHS. Unfortunately, even fewer have heard of the Hurricane Loss Mitigation program (8%), the Residential Construction Mitigation Program (7%), or the Local Mitigation Strategy (5%). There were few regional variations with regard to these programs or organizations, the only exception being that respondents in West Coast region were more likely to mention the Florida's Showcase Community program than were respondents in other regions, particularly than those in Southeastern Florida.

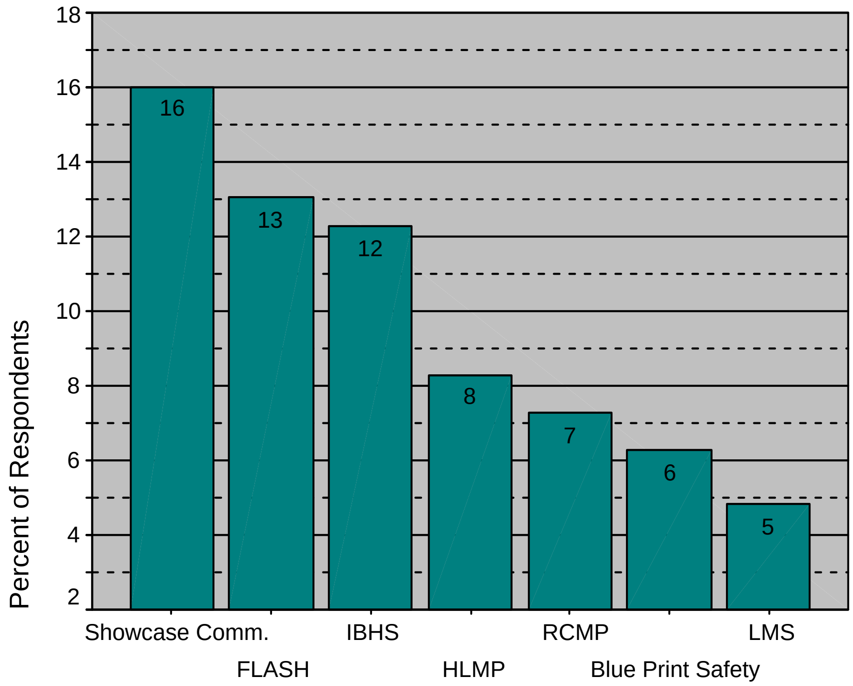


Figure 24. Awarness of Organizations and State Programs

Summary of Awareness of State Government Programs and Other Organizations Active in Promoting Hurricane Safety*:* While name recognition should not be a goal of State programs or departments, it is unfortunate that such a small percentage of this population – the owners of single-family detached residences, a population that is often the target of such programs and efforts – is aware of these important state programs. Nevertheless, it must be pointed out, that State agencies often channel these programs through private non-profit organizations, such as FLASH, and through local county governments and agencies. As a consequence, the general public rarely is aware of or comes into contact with these programs or the State agencies funding and guiding/directing them. Furthermore, these programs, much less the state agencies behind them, are not highlighted as the funding mechanisms or sponsors, making it all but impossible for the public to potentially recognize these programs in the first place. Nevertheless, there may well be advantages to increasing recognition, at least of the programs seeking to promote hurricane safety in part because it lends weight to the importance of hurricane safety for all of Florida's households and citizens. In other words, the more individuals sees State agencies and programs out in front, or at least walking hand in hand, with local government the private sector to promote hurricane safety, the more seriously homeowners are likely to hurricane mitigation.

11. Incentives to Shutter

A variety of questions were asked in this survey regarding incentives that might encourage Florida's homeowners to make their homes safer, particularly as it relates to the use of window protection such as hurricane shutters. Since the focus of most incentive programs are homeowners without hurricane protection, most of the following questions were asked of only those households that indicated that they did not have window protection[17]. During the survey information was collected on a variety of potential incentive packages including: low interest loans, forgivable interest loans, lower insurance premiums, and a program similar to Florida Power and Light's energy audit/voucher program. However, before examining these particular programs and focusing only on those households without window protection, this discuss will begin with incentives currently offered by some insurance underwriters in Florida.

11.1. Nearly 22% of the single-family homeowners are receiving some form of insurance discount for their home's hurricane safety features. Unfortunately nearly 46% of homeowners have no idea if their insurance carrier offers any form of mitigation incentives.

Nearly 98% of households in single-family owner occupied housing have homeowners insurance, sometimes with their wind hazard coverage carried by a company other than the company carrying their regular coverage. When asked if their insurance carrier offers some form of discount for hurricane safety features, 38.6% indicated that it did, 15.6% indicated that it did not, and a rather high 45.6% simply did not know. Of those offering discounts, 54.4% report getting discounts for their home's hurricane safety features. Take as a whole, that means that 21.7% of the entire sample is receiving insurance discounts.

11.2. Property tax reduction (67%) and lower insurance premiums (66%) are the two incentives that garner the most favorable response from homeowners without window protection. The reductions suggested by respondents are considerable. On average respondents would like to see a property tax reduction of 28% and insurance premium reduction of 29%.

[17] Previous research has suggested that responses of those individuals living in households with protection are significantly different than those without. Since, the purpose of this research is to ascertain the likelihood that incentive programs will stimulate households without proper protection to undertake mitigation, it makes no sense to include responses of those who have already some protection. Much of the following discussion then focuses only individuals that reported they did not have window protection in the form of impact resistant glass and/or some form of shutters.

As discussed above, homeowners without window protection were asked about a variety of incentives and whether or not such incentives would motivate them to undertake hurricane protection measures. Figure 25 presents the percentage of respondents that indicated they would be either very likely or somewhat likely to be motivated by property tax reduction, lower insurance premiums, a five year forgivable loan, or simply a low interest loan to undertake hurricane protection measures such as installing shutters or impact resistant glass.

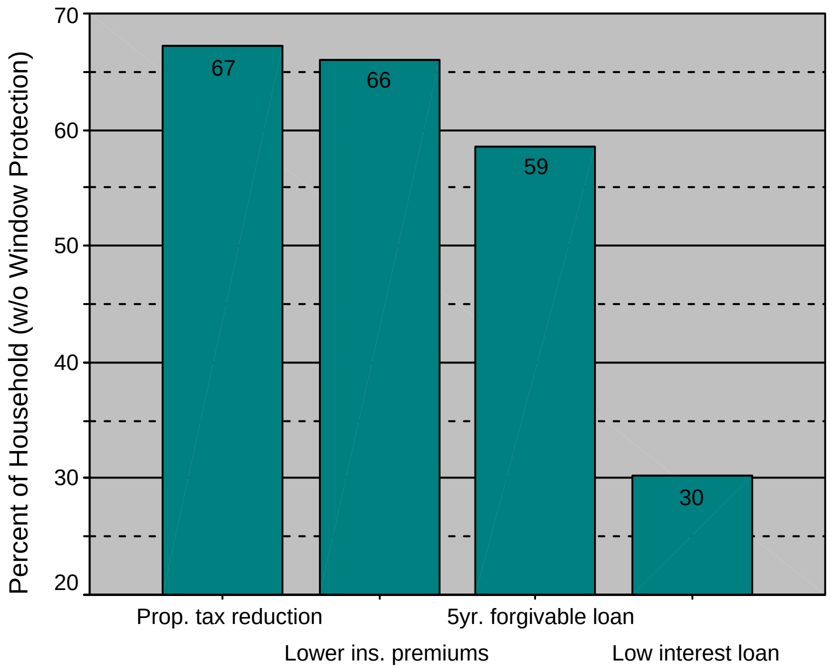


Figure 25. Positive Response to Different Incentives

Clearly, property tax reduction (67%) and lower insurance premiums (66%) are the two incentives that garner the most favorable response from homeowners without window protection. Unfortunately the amounts of the reductions also mentioned by respondents are considerable. On average respondents would like to see property tax reduction of 28% and insurance premium reduction of 29%. In both cases the medians reductions are 25% each. Figures 26 and 27 give a better idea of the percent of respondents suggesting different levels of insurance and property tax reduction.

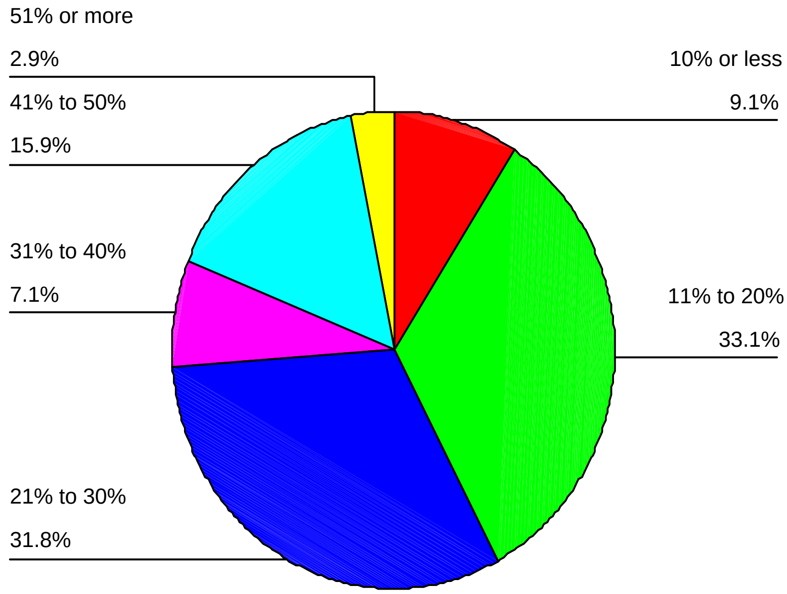


Figure 26. Insurance Reduction to Motivate

Less than half of the respondents in each case would be satisfied with a 20% reduction or less in their insurance premiums or property tax to enable or motivate them to undertake necessary hurricane protection measures to their homes. The majority in both cases would like to see reductions greater that a 20%.

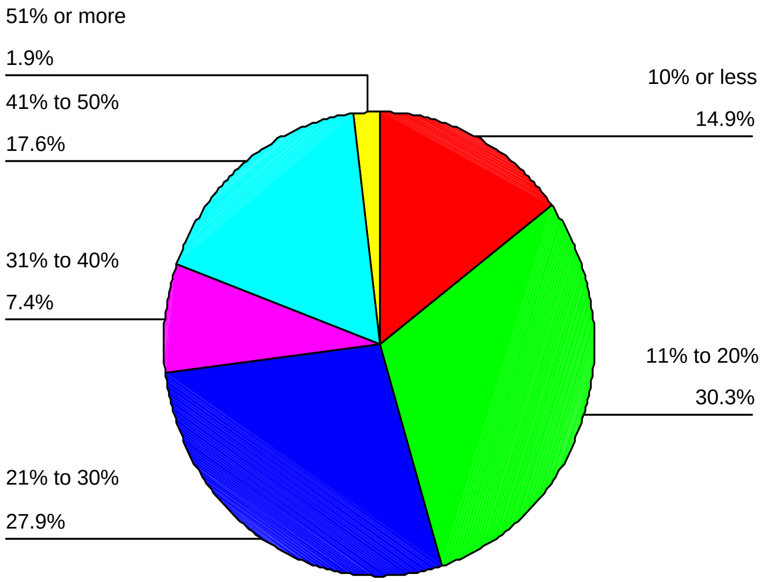


Figure 27. Property Tax to Motivate

Clearly, these levels of reductions are not likely; indeed, many in government and the private sector would argue they are not even economically feasible. However, rather than considering one incentive program as the magic bullet that will insure large scale mitigation, a portfolio of incentives that combines savings, perhaps even coupled with low interest loans may well provide incentives to enable or motivate homeowners to undertake hurricane mitigation.

11.3. More than 46% of Southeastern single family homeowners without shutters would be very likely or somewhat likely to be motivated to employ mitigation technologies by a low-interest loan whereas the percent in other regions is consistently below 30%.

There were significant regional variations in responses to the four incentive programs. Figures 28 through 31 display the regional breakdowns with respect to each of the incentive discussed above. In general, homeowners without window protection in Southeastern Florida are much more likely to respond that any of the four incentive would very likely motivate or enable them to undertake protective measures.

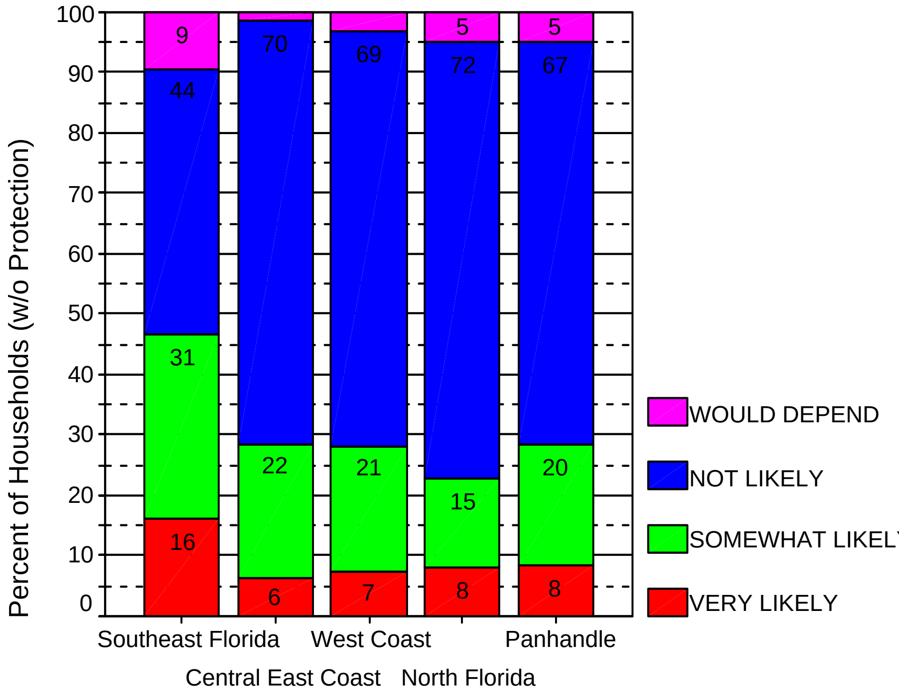


Figure 28. Low Interest Loan Motivate

Figure 28 visually displays the difference between Southeastern homeowners with no window protection compared to those in other regions. Nearly 45% of single-family homeowners in Southeast Florida are either very or somewhat likely to entertain the idea of using a low interest loan to make their homes safer, in other areas this percentage is consistently below 30%. It should be recalled that the Southeastern region is also the region that displayed the highest number of households without window protection that indicated that the cost or expense of such protection was a major reason they did not have protection.

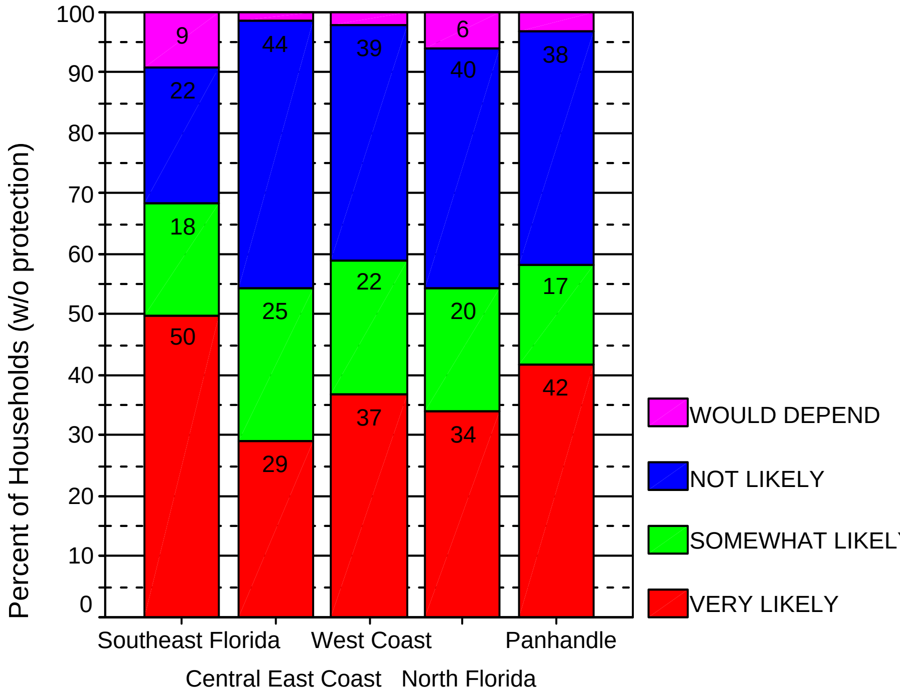


Figure 29. Forgivable Loan Motivate

11.4. More than 65% of Southeastern single family homeowners without shutters would be very likely or somewhat likely to be motivated to employ mitigation technologies by a forgivable loan. Rather substantial percentages of between 50% to almost 60%, of households in other regions also responded as being very likely to somewhat likely to be motivated by a forgivable loan.

In figure 29, one again can see considerable differences between single-family homeowners in Southeast Florida when compared to those in other regions with respect to the motivating potential of a forgivable 5-year loan. Half of homeowners in this area respond “very likely,” whereas this percentage is lower in other areas. And yet, a sizable percentage of Panhandle residents (42%) would also consider themselves to be “very likely” to pursue hurricane safety features if a 5-year forgivable loan was a possibility. Furthermore, things increase considerably across the board when combining the percentages that are very and somewhat likely. While the percentage in the Southeast climbs to over 65%, between 50 to 60% of single-family homeowners in other regions also consistently indicate that they too would be very or somewhat likely to be motivated as well.

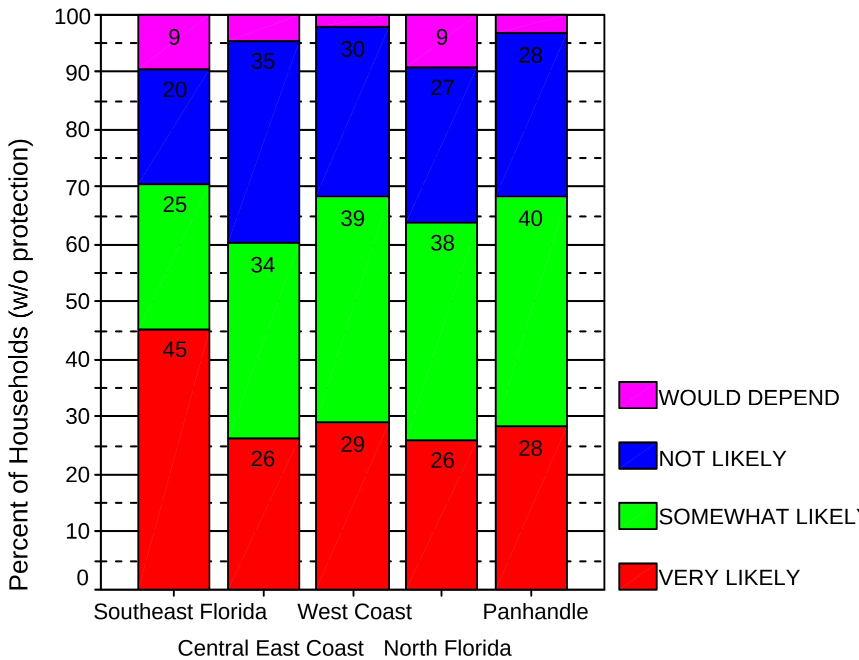


Figure 30. Lower Insurance Premiums Motivate

11.5. The most consistent responses across regions were for lower insurance premiums or lower property taxes. More than 60% of household in owner occupied single family detached housing indicated that reductions in property taxes or insurance premiums would be very or somewhat likely to motivate, or enable, them to undertake hurricane mitigation improvement to their homes. The major variation among regions, is that significantly higher percentages of homeowners in Southeast Florida indicated that they would be "very likely" to be motivated by reductions in these two areas.

In both Figures 30 and 31, significant differences are most clearly evident when comparing "very likely" responses across the regions. Southeastern single-family homeowners are much more likely to respond in this manner. However, yet again in both cases, the differences attenuate markedly when "very" and "somewhat" likely response are combined. Whether one is considering property tax reduction or lower insurance premiums, the responses all hover between 60 to 70% of the respondents.

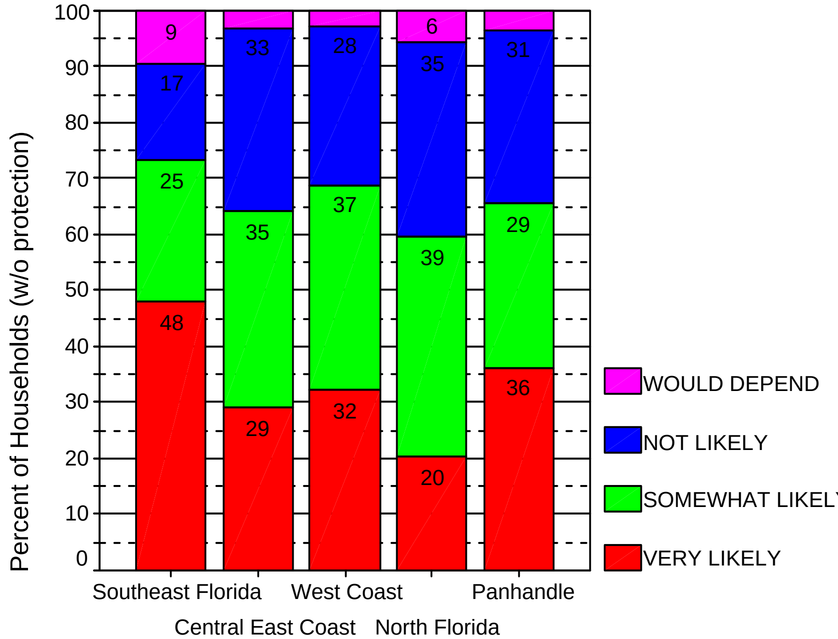


Figure 31. Property Tax Reduction Motivate

11.6. Nearly 68% of homeowners without window protection indicated they would very (26.2%) or somewhat (41.3%) interested in a hurricane mitigation audit program similar to FPL's energy audit program.

While motivating homeowners to mitigate is important, it is also important that they undertake mitigation actions that will effectively protect their homes. In considering programs to encourage homeowners to mitigate, particularly when it comes to installing shutters, and guide them in how to do so effectively, Florida Power and Light's (FPL) energy audit program is often seen as an exemplar. This program offers a free energy audit in which a home is inspected and recommendations, such as adding insulation, tinting to windows, installing a new air-conditioning system, or reworking air ducts, are made that would improve energy efficiency. Homeowners are told what types of work should be undertaken, provided a list of certified installers, and a voucher that can be used toward the cost of work to be completed at a subsidized rate. A similar program might be designed to examine for hurricane safety features. The Residential Construction Mitigation Program funded by DCA and implemented by county agencies on a limited in a few counties in the past is an example of such a program, although it included had the added benefit, for a select few households, of a forgivable low interest loan to help homeowners undertake improvements.[18]

The survey included a series of questions about FPL's energy audit program and potential interest in a similar program concerned with hurricane mitigation. Slightly more than 64% of homeowners without window protection indicated that they were aware of such energy audit program and nearly 37% of homeowners who were aware of the program had participated. Nearly 68% of homeowners without window protection indicated they would very (26.2%) or somewhat (41.3%) interested in participating in a similar program related to hurricane inspection.

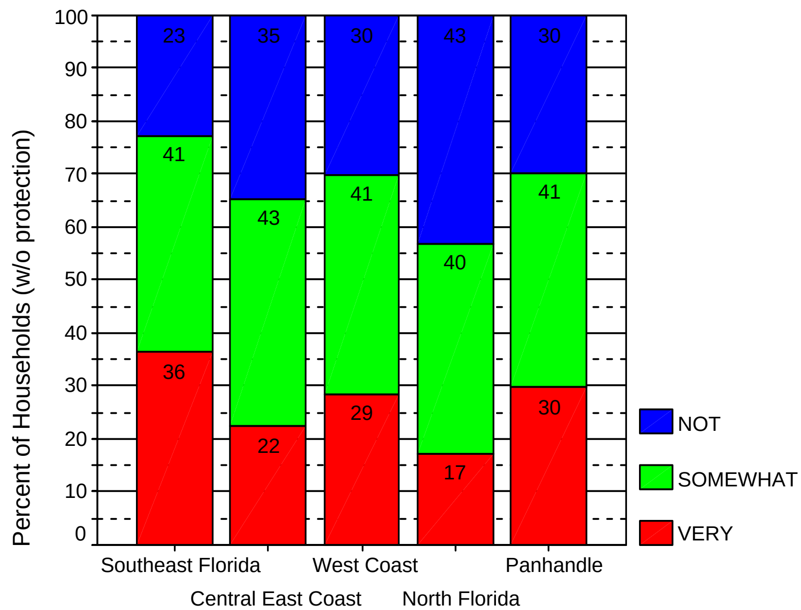


Figure 32. Interest in a Hurricane Audit Program

There are some minor variations across regions. As with incentive programs, homeowners in Southeast Florida are slightly likely to respond that they are very likely to participate in such a hurricane audit program. Overall, just over 77% of homeowners without window protection in the Southeast were very or somewhat interested in such a program, followed by 70% in the Panhandle and in the West coast region, 65% in the

[18] For a complete discussion, see Peacock, Walter Gillis, Betty Hearn Morrow and Hugh Gladwin. 1998. South Florida Mitigation Baseline Survey Report: Volume I. Miami: Lab for Social & Behavioral Research, International Hurricane Research Center and the Institute for Public Opinion Research, Florida International University. www.fiu.edu/orgs/ipor/dca.

Central East Coast region and nearly 60% in North Florida. These general findings hold for homeowners in coastal and inland counties, with little variation. In light of these results it is likely that such a program would meet with some success; however, given the sizable proportion that are only somewhat interested or not interested at all much will have to be undertaken to sell its merits to a significant proportion of homeowners. Indeed, research elsewhere suggests that if the county runs such a program, it may well fail because many homeowners are extremely hesitant to invite county inspectors on their property, even if they are not from code enforcement offices.

Summary of incentive programs: On the whole, Southeastern homeowners, who lack protection, are much more likely to respond favorably to all four types of incentives than are similar homeowners in other areas. However, substantial percentages of homeowners in other areas also respond quite favorably, particularly to reductions in property taxes and insurance premiums as incentives to help motivate or perhaps enable them to undertake hurricane protection measures. Given the size of the reductions suggested by respondents, it is however a major point of speculation as to whether any of these incentive programs are likely to significantly impact decisions, because programs with those levels of reductions are simply not feasible. Nevertheless a combination of incentives is more likely to impact decision-making than a single small incentive program. Since some insurance companies are already offering some incentives, perhaps even a minor reduction in property taxes will help draw attention to the importance of homeowners to begin the process of implementing hurricane protection options. However, insurance companies must also do a better job of making their incentive more readily available and must publicize the possibility to the homeowners they are underwriting. In addition, some form of a hurricane mitigation audit program might also be considered to help insure that effective mitigation technologies are implemented. Such a program would probably be more effective if operated by a non-governmental organization such as a non-profit.

V. SUMMARY

The previous sections have pointed out some gains that have been made in increasing hurricane preparedness among homeowners of single-family detached housing in Florida. However, it is equally clear that much more needs to be done to insure greater proportions of these families and households are safe when the next hurricane threatens the State. In each of the above sections the summaries have introduced or simply mentioned ideas about the types of policies or educational initiatives that might facilitate this process. A key element underlying these ideas is to identify key points or opportunities to expedite and enhance the process whenever households find themselves at a decision point. The ideal is to enhance an individual's or household's thinking or the nature of their evaluations about which path to take such that the path they select promotes greater hurricane safety. Equally important are attempt to alter the way business is normally carried out by contractors, real estate professionals, mortgage brokers, insurance companies and the media such that more, consistent, and factual information regarding hurricane safety is presented to the public as they are making decisions and evaluating what types of decisions they should be making in regards to hurricane safety. As with the case of incentive programs discussed above, one program or policy will not result in dramatic changes, however a portfolio of programs and policies, might well move the State's population closer to being more hurricane prepared and safe.

Appendix A.
Hurricane Loss Mitigation Program Statewide Baseline Survey

Hello[19], I am _______, calling from Florida International University. We're conducting a survey for the International Hurricane Research Center here at FIU about homeowner's perceptions of hurricane threats and damage reduction. The identity of people answering our questions will be kept completely confidential, but the tabulated answers will help Florida be better prepared the next time a big hurricane approaches. I need to talk to one of the adults responsible for your household, 18 or older? Would that be you? [IF NOT, Is there another person available, 18 or older, who's responsible for your household? IF NOT, When would be a good time to call back?]

Q:HOME ** [Type of home] **
First, I want to ask if your home is a single-family detached home?
1 YES
2 NO

Q:HOME2 ** [Type of home] **
Do you own or rent your single-family detached home?
[INTERVIEWER NOTE THAT THIS IS A TWO PART QUESTION. ASK BOTH AND THEN SELECT THE APPROPRIATE QUESTION. WE ARE INTERESTED IN INTERVIEWING RESPONDENTS OWNING SINGLE FAMILY DETACHED HOME NOT ANY OTHER TYPE OF HOME,AND NOT RENTING]
1 YES - OWN A SINGLE-FAMILY DETACHED HOME
2 NO - RENT A SINGLE-FAMILY DETACHED HOME
3 NOT A SINGLE-FAMILY DETACHED
4 DON'T KNOW/NO RESPONSE

Q:Q1 ** [Yrs. permanent resident of Fla] **
How many years have you been a permanent resident of Florida?
[IF LESS THAN A YEAR, PUT "0"]

Q:Q2 ** [Years at residence] **
How many years have you or other members of your household lived at this residence?
[IF LESS THAN A YEAR, PUT "0"]

[19] Please note, the question numbers are not continuous in this instrument because just prior to its utilization, after the original instrument was pre-tested and entered into the CATI system at IPOR, at the request of DCA a number of additional questions were added and others originally included were dropped.

Q:Q3 ** [Natural event: greatest concern] **
I want to begin with questions about natural hazards and hurricane risk. Please keep in mind that there are no correct answers to these questions, we are only interested in getting your feelings and ideas. Which of these natural hazards are you most concerned about? Hurricanes, severe thunderstorms, flooding, tornadoes, or wildfires?
[INTERVIEWER, PLEASE MARK ALL THAT APPLY Codes 0 = no 1 = yes]
q3_1 HURRICANES
q3_2 SEVERE THUNDERSTORMS
q3_3 FLOODING
q3_4 TORNADOES
q3_5 WILDFIRES
q3_6 OTHER, SPECIFY
q3_7 DON'T KNOW/NO RESPONSE
q3_8 NO MORE

Q:Q4 ** [How likely hurricane prevent from working] **
How likely do you think it is that a hurricane will prevent you or members of your household from being able to work or go to your jobs THIS UP-COMING HURRICANE SEASON? Do you think that the chances are very likely, somewhat likely, or not very likely?
[HURRICANE SEASON RUNS FROM JUNE 1 TO NOVEMBER 30]
1 VERY LIKELY
2 SOMEWHAT LIKELY
3 NOT VERY LIKELY
4 DON'T KNOW/NO RESPONSE

Q:Q5 ** [How likely hurricane disrupt daily activities] **
How likely do you think it is that a hurricane will disrupt your daily activities THIS UP-COMING HURRICANE SEASON? Do you think that the chances are very likely, somewhat likely, or not very likely?
1 VERY LIKELY
2 SOMEWHAT LIKELY
3 NOT VERY LIKELY
4 DON'T KNOW/NO RESPONSE

Q:Q7 ** [How likely major hurricane this season] **

As you may know, hurricanes vary in strength, ranging from a minimum, category 1 hurricane, to a major category 3 hurricane, all the way up to extreme, category 5 hurricanes. How likely do you think it is that a major hurricane, category 3 or higher, will potentially damage your home THIS UP-COMING HURRICANE SEASON (June to November)? Do you think that the chances are very likely, somewhat likely, or not very likely?
1 VERY LIKELY
2 SOMEWHAT LIKELY
3 NOT VERY LIKELY
4 DON'T KNOW/NO RESPONSE

Q:Q9 ** [How knowledgeable about hurricane probability] **
Considering both yourself and other adults in your household, in general how knowledgeable do you feel your household is when it comes to understanding the chances of a hurricane directly impacting your home? Would you say that your household is highly knowledgeable, somewhat knowledgeable, slightly knowledgeable, or not very knowledgeable?
1 HIGHLY KNOWLEDGEABLE
2 SOMEWHAT KNOWLEDGEABLE
3 SLIGHTLY KNOWLEDGEABLE
4 NOT VERY KNOWLEDGEABLE
5 DON'T KNOW/NO RESPONSE

Q:Q10 ** [How knowledgeable about possible damage] **
Again, considering both yourself and other adults in your household, in general how knowledgeable do you feel your household is about the type of damage your home might suffer if a hurricane were to hit the area in which you live?
1 HIGHLY KNOWLEDGEABLE
2 SOMEWHAT KNOWLEDGEABLE
3 SLIGHTLY KNOWLEDGEABLE
4 NOT VERY KNOWLEDGEABLE
5 DON'T KNOW/NO RESPONSE

Q:Q11 ** [How knowledgeable about damage reduction] **
And one more time, considering both yourself and other adults in your household, in general how knowledgeable is your household of the things you might do to reduce potential hurricane damage to your home?
1 HIGHLY KNOWLEDGEABLE
2 SOMEWHAT KNOWLEDGEABLE

3 SLIGHTLY KNOWLEDGEABLE
4 NOT VERY KNOWLEDGEABLE
5 DON'T KNOW/NO RESPONSE

Q:Q12 ** [Adult has experienced hurricane] **
Have you or any adults in your household experienced a hurricane before?
1 YES
2 NO
3 DON'T KNOW/NO RESPONSE

Q:Q13 ** [Adult has lived in hurricane-damaged home] **
Have you or any adults in your household ever lived in a home that was physically damaged by a hurricane?
1 YES
2 NO
3 DON'T KNOW/NO RESPONSE

Q:Q15 ** [How badly was home damaged] **
How badly was it damaged? Would you say the damage was slight, moderate, or major?
[IF DAMAGED OCCURRED MORE THAN ONCE, RECORD THE HIGHEST LEVEL OF DAMAGE]
1 SLIGHT
2 MODERATE
3 MAJOR
4 DON'T KNOW/NO RESPONSE

Q:Q18 ** [How worried about hurricanes affecting community] **
In general, how worried are you about hurricanes affecting your community? Are you very worried, somewhat worried, only a little worried, or not worried at all?
1 VERY WORRIED
2 SOMEWHAT WORRIED
3 ONLY A LITTLE WORRIED
4 NOT WORRIED
5 DON'T KNOW/NO RESPONSE

Q:Q19 ** [How often you think about hurricanes & safety] **
About how often do you think about hurricanes or hurricane safety? Would you say that you think of them very often, somewhat often, occasionally, rarely, or never?

1 VERY OFTEN
2 SOMEWHAT OFTEN
3 OCCASIONALLY
4 RARELY
5 NEVER
6 DON'T KNOW/NO RESPONSE

Q:Q20 ** [How often you discuss hurricanes & safety] **
About how often are hurricanes or hurricane safety discussed among members of your household? Would you say that these things are discussed very often, somewhat often, occasionally, rarely, or never?
1 VERY OFTEN
2 SOMEWHAT OFTEN
3 OCCASIONALLY
4 RARELY
5 NEVER
6 DON'T KNOW/NO RESPONSE

Q:Q21A ** [Received information about safe home] **
Have you recently received or seen information about how to make your family and home safer from hurricanes?
1 YES
2 NO
3 DON'T KNOW/NO RESPONSE

Q:Q21B ** [When received] **
When did you receive or hear the most recent information? Was it within the last six months, within the last year, within the last 2 years, or was it longer ago than that?
1 WITHIN THE LAST SIX MONTHS
2 WITHIN THE LAST YEAR
3 WITHIN THE LAST 2 YEARS
4 LONGER AGO THAN THAT
5 DON'T KNOW/NO RESPONSE

Q:Q21C *** [Channel of information] [multiple response] ***
From which source or sources did you most recently receive information about how to make your family and home safer from hurricanes? Was it from TV, newspapers, radio, internet, through the mail, a class or course, a community event or meeting, or something you were told by a person?

[MULTIPLE RESPONSE Code 0=no 1=yes]
Q21C_1 TV
Q21C_2 NEWSPAPERS
Q21C_3 RADIO
Q21C_4 INTERNET
Q21C_5 THROUGH THE MAIL
Q21C_6 A CLASS OR COURSE
Q21C_7 COMMUNITY EVENT OR MEETING
Q21C_8 SOMETHING YOU WERE TOLD BY A PERSON
Q21C_9 OTHER, SPECIFY
Q21C_10 DON'T KNOW/NO RESPONSE
Q21C_11 NO MORE

Q:Q21D *** [Source of information] [multiple response] ***
Who sent or gave you this information? Was it a TV station, a newspaper, an insurance company, a school or college, a government agency, a non-profit safety organization like the Red Cross, or something else?
[MULTIPLE RESPONSE] Code 0=no 1=yes
Q21D_1 TV STATION
Q21D_2 NEWSPAPER
Q21D_3 INSURANCE COMPANY
Q21D_4 SCHOOL OR COLLEGE
Q21D_5 GOVERNMENT AGENCY
Q21D_6 NON-PROFIT SAFETY ORGANIZATION
Q21D_7 SOMETHING ELSE, SPECIFY
Q21D_8 DON'T KNOW/NO RESPONSE
Q21D_9 NO MORE

Q:Q21E ** [Effective way to communicate] **
Which of the following would be the most effective way to let you know about ways to make your family and home safer from hurricanes? Would it be television, radio, internet, newpaper or magazine, a mailing or newsletter, a meeting or class, or some other way?
1 TELEVISION
2 RADIO
3 INTERNET
4 NEWPAPER OR MAGAZINE
5 MAILING OR NEWSLETTER
6 MEETING OR CLASS, OR

7 SOME OTHER WAY, SPECIFY
8 DON'T KNOW/NO RESPONSE

Q:Q21F ** [Trust] **
Who would you most trust to provide you with information about how to make your family and home safer from natural disasters? A TV station, a newspaper, an insurance company, a school or college, a government agency, a non-profit safety organization [like the Red Cross], or something else?
[MULTIPLE RESPONSE] Code 0=no 1=yes
Q21F_1 TV STATION
Q21F_2 NEWSPAPER
Q21F_3 INSURANCE COMPANY
Q21F_4 SCHOOL OR COLLEGE
Q21F_5 GOVERNMENT AGENCY
Q21F_6 NON-PROFIT SAFETY ORGANIZATION
Q21F_7 SOMETHING ELSE, SPECIFY
Q21F_8 DON'T KNOW/NO RESPONSE
Q21F_9 NO MORE

Q:Q22A ** [prepare for hurricane season] **
Do you and your family generally do anything to prepare yourselves oryour home for hurricane season?
[HURRICANE SEASON RUNS FROM JUNE 1 TO NOVEMBER]
1 YES
2 NO
3 DK/NR

Q:Q22B *** [types of preparation] [multiple response] ***
What types of things do you and your household do to prepare your home for hurricane season?
[INTERVIEWER DO NOT READ RESPONSES, CHECK ALL THAT APPLY]
[MULTIPLE RESPONSE] Code 0=no and 1=yes
Q22B_1 CHECK SHUTTERS/WINDOW PROTECTION
Q22B_2 GATHER SUPPLIES [FOOD, WATER, MEDICAL, DRUGS]
Q22B_3 PURCHASED/CHECK BATTERY POWERED RADIO
Q22B_4 TRIMMED TREES
Q22B_5 MAKE PLANS FOR WHERE TO EVACUATE
Q22B_6 MAKE PLANS FOR PETS
Q22B_7 OTHER, SPECIFY

Q22B_8 DON'T DO ANYTHING
Q22B_9 DON'T KNOW/NO RESPONSE
Q22B_10 NO MORE

Q:Q23 ** [Year home was built] **
Now I would like to ask you some specific questions about your home and hurricane protection. First, do you know the actual year or can you tell me roughly when your home was built?
[INTERVIEWER, ENTER 4-DIGIT ACTUAL YEAR. IF KNOW ROUGHLY, ENTER]
40=1940s OR EARLIER,
50=1950s
60=1960s
70=1970s
80=1980s
90=1990s
00=2000s
99=DON'T KNOW/NO RESPONSE

Q:Q24 ** [Year home was purchased] **
What year did you purchase your home?
[INTERVIEWER, ENTER 4-DIGIT ACTUAL YEAR. IF KNOW ROUGHLY, ENTER]
40=1940s OR EARLIER,
50=1950s
60=1960s
70=1970s
80=1980s
90=1990s
00=2000s
99=DON'T KNOW/NO RESPONSE

Q:Q25 ** [When purchasing home how important was hurricane safety] **
At the time when your household was making the decision to purchase your home, in general how important was hurricane safety? Was it very important, somewhat important, or not important at all at that time?
1 VERY IMPORTANT
2 SOMEWHAT IMPORTANT
3 NOT IMPORTANT AT ALL
4 DON'T KNOW/NO RESPONSE

Q:Q26 ** [Types of protection from hurricanes important] **
What type of things about the house did you consider important for protecting against hurricanes?
[DO NOT READ-CHECK ALL THAT APPLY. Code 0=no 1=yes]
Q26_1 SHUTTERS
Q26_2 DISTANCE FROM OCEAN/WATER
Q26_3 NOT IN FLOOD ZONE
Q26_4 NOT IN EVACUATION ZONE
Q26_5 ROOF OR ROOF BRACING
Q26_6 TIE BEAM/STRAPS
Q26_7 CONSTRUCTION MATERIAL (CBC CONCRETE BLOCK ETC)
Q26_8 OTHER, SPECIFY
Q26_9 DON'T KNOW/NO RESPONSE
Q26_10 NO MORE

Q:Q27 ** [Has hurricane shutters or coverings] **
Do you have any types of hurricane shutters or protective coverings for your home's windows, or are your windows newer hurricane impact resistant windows?
[THESE WINDOWS WOULD ONLY BE FOUND ON HOMES BUILT IN THE LAST FEW YEARS OR WITH WINDOWS RECENTLY INSTALLED]
1 YES, SHUTTERS OR PROTECTIVE COVERINGS
2 YES, NEW HURRICANE IMPACT RESISTANT WINDOWS
3 YES, COMBO SHUTTERS/COVERINGS & IMPACT RESISTANT WINDOWS
4 NO
5 NO, BUT HAVE FILM ON WINDOWS
6 NO, BUT USE TAPE ON WINDOWS
7 DON'T KNOW/NO RESPONSE

Q:Q28 ** [Has impact resistant windows] **
Specifically are all, most, some or none of your windows, impact resistant windows?
1 ALL
2 MOST
3 SOME
4 NONE
5 DON'T KNOW/NO RESPONSE

Q:Q29 ** [Has shutters or coverings on regular windows] **
Do you have shutters or protective coverings for all, most, some, or none of the other regular windows of your home?

1 ALL
2 MOST
3 SOME
4 NONE
5 NA [NO WINDOWS]
6 DON'T KNOW/NO RESPONSE

Q:Q30 ** [Has shutters or coverings on windows] **
Specifically, do you have shutters or coverings for all, most, some, or none of your windows?
1 ALL
2 MOST
3 SOME
4 NONE
5 NA [NO WINDOWS]
6 DON'T KNOW/NO RESPONSE

Q:Q31 ** [Types of shutters or coverings on windows] **
What type(s) of shutters or protective coverings do you have on your windows? Are they plywood, awnings or bahama shutters, storm panels, accordion or roll-down shutters, some other type of commercial shutters, or do you have a combination of types?
1 PLYWOOD
2 AWNINGS OR BAHAMA SHUTTERS
3 STORM PANELS [STEEL, ALUMINUM, OR CLEAR]
4 SLIDING ACCORDION SHUTTERS
5 ROLL DOWN SHUTTERS (AUTOMATIC OR MANUAL)
6 OTHER TYPE OF SHUTTERS [SPECIFY TYPES OF MATERIALS]
7 DON'T KNOW/NO RESPONSE
8 NO MORE

Q:Q32 ** [Were shutters commercially installed] **
Were your shutters commercially installed or installed by you or someone in your household?
[COUNT INSTALLED BY NON PROFESSIONAL FRIEND OR RELATIVE THE SAME AS SELF-INSTALLED]
1 COMMERCIALLY INSTALLED
2 SELF-INSTALLED
3 BOTH

4 DON'T KNOW/NO RESPONSE

Q:Q33 ** [Were shutters installed before or after home bought] **
Were all or some of your shutters installed before you bought your home or after?
1 ALL BEFORE
2 ALL AFTER
3 SOME BEFORE AND SOME AFTER
4 DON'T KNOW/NO RESPONSE

Q:Q34 ** [Has shutters or coverings on sliding glass doors] **
How about sliding glass doors or French doors, if you have them? Do you have shutters or protective coverings for all, most, some, or none of your sliding glass doors or French doors?
1 ALL
2 MOST
3 SOME
4 NONE
5 NA [NO SLIDING GLASS DOORS/FRENCH DOORS]
6 DON'T KNOW/NO RESPONSE

Q:Q35 ** [Sliding glass doors made of hurricane resistant glass] **
Are all, most, some, or none of your remaining sliding glass doors made of Hurricane impact resistant glass?
1 ALL
2 MOST
3 SOME
4 NONE
5 NA
6 DON'T KNOW/NO RESPONSE

Q:Q37 ** [garage door prep] **
If you have a garage door, is it a new hurricane impact resistant rated door or an older door that has been reinforced to make it hurricane resistant?
1 YES - NEW HURRICANE IMPACT RESISTANT DOOR
2 YES- AN OLDER REINFORCED HURRICANE RESISTANT DOOR
3 NO
4 DO NOT HAVE GARAGE DOOR
5 DON'T KNOW/NO RESPONSE

Q:Q38 ** [Neighbors have shutters for windows] **
Do all, most, some, or none of your neighbors have shutters for their windows?
1 ALL
2 MOST
3 SOME
4 NONE
5 DON'T KNOW/NO RESPONSE

Q:Q39 ** [Reason doesn't have shutters or coverings on windows] **
If you do not have shutters or coverings for your windows, is the main reason because you feel you really don't need them, you cannot afford them, or is there some other reason?
1 DO NOT NEED THEM
2 CANNOT AFFORD THEM
3 OTHER REASON (SPECIFY)
4 DON'T KNOW/NO RESPONSE

Q:Q40 ** [Heard of additional nails or screws to strengthen roof] **
In addition to shutters, a number of other modifications to a home have been suggested that might make a home safer from hurricane damage. I would like to ask you if you have heard of any of these. Please remember that it's okay if you have never heard of these, they may not be widely known in your area. There are no right or wrong answers here! We are just interested in if you have ever heard of any of these modifications. For example, it has been suggested that a homeowner might have additional nails or screws added to the plywood under the roof when having their roof replaced, to make it stronger. Have you ever heard of this suggestion before?
1 YES
2 NO
3 DON'T KNOW/NO RESPONSE

Q:Q41 ** [Heard of adding bead of adhesive between trusses and roof] **
It has also been suggested that by adding a bead of adhesive or glue to the joint between the roof trusses and the roof sheathing or plywood might make the roof able to stay on better in a hurricane. Have you ever heard of this suggestion before?
1 YES
2 NO
3 DON'T KNOW/NO RESPONSE

Q:Q42 ** [Heard of adding additional bracing to roof at gabled ends] **

It has been suggested that adding additional bracing to one's roof, particularly at the gabled ends, will make it more hurricane resistant. Have you ever heard of this suggestion before?
1 YES
2 NO
3 DON'T KNOW/NO RESPONSE

Q:Q43 ** [Heard of having a safe room or reinforced inner room] **
And, lastly it has been suggested that homes could have a "safe room" or a specially reinforced inner room where household members might wait out a hurricane. Have you ever heard of this suggestion before?
1 YES
2 NO
3 DON'T KNOW/NO RESPONSE

Q:Q44 ** [Market value of your home] **
Now just a few more questions about your home. What is the approximate market value of your home?
[IF NECESSARY READ CATEGORIES]
1 IS IT BELOW $50,000?
2 BETWEEN 50,001 TO 75,000
3 BETWEEN 75,001 TO 100,000
4 BETWEEN 100,001 TO 150,000
5 BETWEEN 150,001 TO 175,000
6 BETWEEN 175,001 TO 225,000
7 BETWEEN 225,001 TO 300,000
8 OR OVER 300,000
9 DON'T KNOW/NO RESPONSE

Q:Q44A ** [Amount spent] **
Since you bought your home, about how much money have you spent to make it safer from hurricanes?
[INTERVIEWER, NO ANSWER OR REFUSAL = 9]

Q:Q44B ** [Estimated cost to protect family and home] **
Suppose over the next year you were able to do everything you could to make your home safe from hurricanes. Roughly, how much would you have to spend to do this, or is your home already safe enough?

[INTERVIEWER, IF THEY SAY "NOTHING" OR "HOME IS SAFE ENOUGH" ENTER '0',
NO ANSWER OR REFUSAL = 9]

Q:Q44C ** [How much will spend?] **
Of this amount, how much do you think you will be able to spend over the next year? Would you say most of it, about half of it, some of it, or none of it?
1 MOST OF IT
2 ABOUT HALF OF IT
3 SOME OF IT
4 NONE OF IT
5 DON'T KNOW/NO RESPONSE

Q:Q45 ** [Currently has homeowner's insurance] **
As you may know, there have been many problems and concerns about homeowner's insurance in Florida since Hurricane Andrew, so I would like to ask you some questions about your insurance. Do you currently have homeowners' insurance?
1 YES
2 NO
3 DON'T KNOW/NO RESPONSE

Q:Q49 ** [Insurance offers discounts for hurricane safety features] **
Does your insurance company offer any discounts or lower deductibles for homes that have hurricane safety features like shutters?
1 YES
2 NO
3 DON'T KNOW
4 NO RESPONSE

Q:Q50 ** [Getting discounts for hurricane safety features] **
Are you getting any discounts or lower deductibles as a result of your home having some form of protection from wind damage such as shutters?
1 YES
2 NO
3 DON'T KNOW/NO RESPONSE

Q:Q51A ** [Heard of Residential Construction Mitigation Program or RCMP] **
Okay, we're getting near the end. I now want to ask you about hurricane safety programs. The State of Florida funds a number of programs and works with some

organizations that are informing and helping Florida's citizens better prepare for Hurricanes. I would like to mention a number of programs and organizations. As I do so, please let me know if you have ever heard of the program or organizations? Again, do not be concerned if you are not aware of these programs or organizations, because they may not be operating in your area. Simply tell me yes if you have heard or are aware of the program or organization. First, have you heard of the Residential Construction Mitigation Program or RCMP?
1 YES
2 NO
3 DON'T KNOW/NO RESPONSE

Q:Q51B ** [Heard of The Blue Print for Safety Program] **
[Have you heard of] The Blue Print for Safety Program?
1 YES
2 NO
3 DON'T KNOW/NO RESPONSE

Q:Q51C ** [Heard of Local Mitigation Strategy or LMS] **
[Have you heard of] the Local Mitigation Strategy or LMS?
1 YES
2 NO
3 DON'T KNOW/NO RESPONSE

Q:Q51D ** [Heard of Institute for Business and Home Safety or IBHS] **
[Have you heard of] the Institute for Business and Home Safety or IBHS?
1 YES
2 NO
3 DON'T KNOW/NO RESPONSE

Q:Q51E ** [Heard of Federal Alliance for Safe Homes or FLASH] **
[Have you heard of] the Federal Alliance for Safe Homes or FLASH?
1 YES
2 NO
3 DON'T KNOW/NO RESPONSE

Q:Q51F ** [Heard of Florida's Showcase Community] **
[Have you heard of] Florida's Showcase Community?
1 YES
2 NO

3 DON'T KNOW/NO RESPONSE

Q:Q51G ** [Heard of Hurricane Loss Mitigation Program or HLMP] ***
[Have you heard of] the Hurricane Loss Mitigation Program or HLMP?
1 YES
2 NO
3 DON'T KNOW/NO RESPONSE

Q:Q52 ** [Aware of community hurricane safety events] **
In many communities, often at the beginning of hurricane season, there will be community events or meetings about hurricane safety and preparation at local malls, home improvement centers, fire stations, or at the Local Offices of Emergency Management. Are you aware of these types of events being held in your community?
1 YES
2 NO
3 DON'T KNOW/NO RESPONSE

Q:Q53 ** [Attended community hurricane safety event] **
Have you or any members of your household ever attended one of these events?
1 YES
2 NO
3 DON'T KNOW/NO RESPONSE

Q:Q54 ** [Has regular access to internet] **
Does your household have regular access to the Internet or the World Wide Web from your home, work or both?
1 YES, HOME
2 YES, WORK
3 YES, BOTH
4 NO
5 DON'T KNOW/NO RESPONSE

Q:Q55 ** [Visited websites dealing with hurricane protection] **
Have you ever visited any websites that deal with hurricane protection and preparation?
1 YES
2 NO
3 DON'T KNOW/NO RESPONSE

Q:Q56 ** [Low interest loan motivate hurricane protection measures] **

I would now like to ask you some questions about incentives to encourage people to undertake hurricane protection measures, such as installing shutters or impact resistant windows. How likely would a low interest loan motivate your household to undertake hurricane protection measures? Would a low interest loan be very likely, somewhat likely, or not likely at all to motivate your household to undertake hurricane protection measures?
1 VERY LIKELY
2 SOMEWHAT LIKELY
3 NOT LIKELY AT ALL
4 IT WOULD DEPEND/NOT SURE
5 DON'T KNOW/NO RESPONSE

Q:Q57 ** [5 yr. forgiveness loan motivate hurricane protection measures] **
How likely would a loan, which would be forgiven if you remained in your home for five years, encourage your household? Would it be very likely, somewhat likely, or not likely at all to motivate your household [to undertake hurricane protection measures?]
1 VERY LIKELY
2 SOMEWHAT LIKELY
3 NOT LIKELY AT ALL
4 IT WOULD DEPEND/NOT SURE
5 DON'T KNOW/NO RESPONSE

Q:Q58 ** [Lower insurance premiums motivate hurricane protection measures] **
What about lower annual insurance premiums? Would that be very likely, somewhat likely, or not likely at all to motivate your household [to undertake hurricane protection measures?]
1 VERY LIKELY
2 SOMEWHAT LIKELY
3 NOT LIKELY AT ALL
4 IT WOULD DEPEND/NOT SURE
5 DON'T KNOW/NO RESPONSE

Q:Q59 ** [Amount reduced insurance motivate hurricane protection measures] **
How much of a reduction in a homeowner's insurance premium would be necessary to motivate your household to act? Can you give me a percentage amount?
[ENTER THE ACTUAL PERCENTAGE, 999 DON'T KNOW/NR]

Q:Q60 ** [Property tax reduction motivate hurricane protection measures] **

How about a property tax reduction? Would it be very likely, somewhat likely, or not likely at all to motivate your household to undertake hurricane protection measures?
1 VERY LIKELY
2 SOMEWHAT LIKELY
3 NOT LIKELY AT ALL
4 IT WOULD DEPEND/NOT SURE
5 DON'T KNOW/NO RESPONSE

Q:Q61 ** [Amount reduced property tax motivate hurricane protection measures] **
How much of a reduction in property tax would be necessary to motivate your household to act? Can you give me rough percentage amount?
[ENTER THE ACTUAL PERCENTAGE, 999 DON'T KNOW/NR]

Q:Q62 ** [Aware of programs that inspect energy efficiency] **
Are you aware of any electric company or utility offering a program, where they will inspect the energy efficiency of your home and provide you with vouchers to help you pay for suggested improvements?
1 YES
2 NO
3 DON'T KNOW/NO RESPONSE

Q:Q63 ** [Participated in energy efficiency program] **
Have you participated in such a program?
1 YES
2 NO
3 DON'T KNOW/NO RESPONSE

Q:Q64 ** [Interested in hurricane preparedness inspection program] **
If a similar no-cost inspection program were available to inspect your home and offer suggestions to make it more hurricane resistant, how interested would you be in participating? Would you be very interested, somewhat interested, or not interested at all?
1 VERY INTERESTED
2 SOMEWHAT INTERESTED
3 NOT INTERESTED AT ALL
4 DON'T KNOW

Q:Q74 ** [Including self, how many in household] **

Finally, I just have a few general background questions and we will be finished. Including yourself, how many people live in your household?

[INTERVIEWER ENTER THE ACTUAL NUMBER.DON'T KNOW/REFUSED = 99, IF ONLY ONE PERSON LIVING IN HOUSEHOLD = 1]

Q:Q75 ** [Respondent age] **

Would you please tell me your age?

[INTERVIEWER ENTER THE ACTUAL AGE, DON'T KNOW/REFUSED = 999]

Q:Q76 ** [Number in household under 12] **

How many people living in your household are under 12 years old?

[INTERVIEWER ENTER THE ACTUAL NUMBER, DON'T KNOW/REFUSED = 99]

Q:Q77 ** [Number in household 65 or over] **

How many people living in your household are 65 or older?

[INTERVIEWER ENTER THE ACTUAL NUMBER, DON'T KNOW/REFUSED = 99] [IF ONLY ONE PERSON LIVING IN HOUSEHOLD & AGE >= 65 PLEASE ENTER 1]

Q:Q78 ** [Marital status] **

What is your marital status?

1 SINGLE
2 MARRIED
3 LIVING TOGETHER NOT FORMALLY MARRIED
4 WIDOWED
5 DIVORCED
6 SEPARATED
7 NEVER MARRIED
8 OTHER
9 DON'T KNOW/NO RESPONSE

Q:Q79 ** [Zip code] **

What is your zip code?

[INTERVIEWER ENTER THE ACTUAL NUMBER, DON'T KNOW/REFUSED = 99999]

Q:Q80 ** [Highest grade completed by adult] **

What is the highest grade of school completed by an adult member of your household?

1 GRADE SCHOOL
2 SOME HIGH SCHOOL
3 HIGH SCHOOL GRAD
4 SOME COLLEGE
5 COLLEGE GRADUATE
6 GRADUATE DEGREE
7 DON'T KNOW/NO RESPONSE

Q:Q81 ** [Race] **
With which of the following racial groups do you identify yourself-White, Black, Asian, American Indian, or something else?
1 WHITE
2 BLACK
3 ASIAN
4 AMERICAN INDIAN
5 SOMETHING ELSE
6 DON'T KNOW/NO RESPONSE

Q:Q82 ** [Hispanic or not] **
Are you of Hispanic descent?
1 HISPANIC
2 NOT HISPANIC
3 DON'T KNOW/NO RESPONSE

Q:Q83 ** [Language in home] **
What language is most often spoken in your home?
1 ENGLISH
2 SPANISH
3 BOTH ENGLISH AND SPANISH
4 OTHER, SPECIFY
5 DON'T KNOW/NO RESPONSE

Q:Q84 ** [Annual household income] **
Approximately, what is your annual household income-is it..?
1 UNDER $5,000
2 $5,000 - $10,000
3 $10,000 - $20,000
4 $20,000 - $30,000
5 $30,000 - $50,000

6 $50,000 - $ 75,000
7 $75,000 - $100,000
8 OVER $100,000
9 DON'T KNOW/NO RESPONSE

Q:Q85 ** [Comments] **
Well, that concludes the interview. I'd like to thank you for taking the time to complete the interview. Do you have any comments that you would like me to write down on hurricane issues or this survey?
1 YES
2 NO

Q:Q86 ** [Written comments] **
WRITE COMMENTS

Q:THANKS ** [Thanks again] **
Again, thank you for your participation.

Q:D1 ** [gender] **
[INTERVIEWER PLEASE ENTER THE GENDER OF THE RESPONDENT]
1 MALE
2 FEMALE

3.3 FEASIBILITY OF HURRICANE LOSS REDUCTION INCENTIVE PROGRAMS FOR SITE BUILT HOUSING

Summary of Goals for 2002-2003 Research Year

The purpose of the study during the 2002-2003 effort was to examine the feasibility of incentives for homeowners to adopt and implement hurricane loss reduction techniques for site-built housing. The final objective of this research is to build on the mitigation solutions identified by previous structural testing and program evaluation carried throughout the duration of the Hurricane Loss Mitigation Program.

How would an incentives program be beneficial? An incentives program would allow home owners not only to save money but would also give them the opportunity to reinvest in their homes making them more resistant to hurricanes, promoting hurricane loss reduction. An incentives program would send a clear message to homeowners that Federal, State, and local governments value and support mitigation efforts.

Prior research has examined the feasibility of creating better incentives for homeowners insurance. The main objective of this research was to identify existing incentive programs in other sectors, assess the programs and determine if they are applicable towards hurricane loss reduction, and then assess the possibility of either using that existing program or creating a similar program.

Summary of Previous Findings

During the 2000-2001 year for the Hurricane Loss Reduction for Residences and Mobile Home in Florida" project (HLRP); researchers assessed possible incentives and barriers to mitigation r4elated to homeowners insurance. Research was conducted by examining the regulatory environment, conducting Internet searches and by way of surveys targeting mobile home residents.

Findings from the 2000-2001 Research IHRC Team revealed the following:

(a) Homeowners of conventional site built homes enjoy discounts and premium credits for Risk Mitigation Measures (RMMs), which reflect their potential for achieving some degree of hurricane loss reduction. The credit for hurricane shutters ranges from 5 – 10% depending on a variety of other mitigating factors. For example homeowners insurance premium credits are given only if all possible openings are covered with shutters including garage doors.

(b) Individual discounts vary significantly among insurers in Florida, but the net result is almost equal given the competitive nature of the industry. Of the three major forms of insurance, windstorm premiums get the most benefit from the Building Code Effectiveness Grading Schedule (BCEGS) and RMMs, in some cases enjoying discounts of up to 60%.

(c) There are few such discounts offered on RMMs for manufactured housing. Reasons for lack of discounts range from potential for damage by uncontrollable wind-borne debris to the general perception that the integrity of the installation is compromised. Homes built according to HUD's 1994 code enjoy approximately a 5% premium credit. Some companies offer new homes an extra 5% credit in the first year. Discounts, credits or rate differentials of 9% are enjoyed for Windstorm Protection Insurance on mobile homes constructed to comply with the American Society of Civil Engineers Standard ANSI/ASCE 7- 88 adopted by the US Department of Housing and Urban Development on July 13, 1994.

(d) While numerous incentives are in place for mitigation measures of conventional site-built homes there are few for manufactured homes. There is a small reduction in homeowner insurance premiums of around 5% for mobile homes built after 1994. As long as these homes are located within two miles of a coastal region (as defined by FWUA) there are automatic surcharges for windstorm protection.

(e) There appears to be a general consensus among insurers that improvement in the quality and installation of tie-downs could reduce the cost of hurricane loss protection and hence premiums. However given the nature of these tie-downs, many in the insurance industry believe that continuous inspections are critical to the allotment of reduced premiums. The potential for hurricane loss reduction can be in the range of 10 – 20% based in the installation of extra tie-downs and regular inspections of tie-downs to ensure continued safety.

Underlying these findings several critical issues were also identified:

1. What could be the impact of catastrophic losses, such as those from a hurricane strike, on the insurance industry?
2. How can the insurance industry contribute to reducing the potential for damage from hurricane impact thereby reducing its own risk, and maintaining its capacity for indemnifying losses?
3. While reference if often made to the *insurance industry* it must be made clear that it is the *individual insurer*, as licensed by a specific state, who acts as a

stand-alone entity. This insurer, who can ultimately be affected by catastrophic loss, may have interest and the wherewithal to promote specific loss-reduction measures.

4. While there is a general consensus that the pre-1994 built homes have the greater potential for loss, the lack of viable alternatives for their replacement exacerbates the problem of risk-management, especially when older units are in close proximity to newer ones.

Discussion of Current Approach

The first objective was to identify existing programs in other industries that may be applicable toward the promotion of hurricane loss reduction. The second objective was to assess the feasibility of developing similar initiatives that might involve financial institutions and insures for hurricane loss reduction for site-built housing.

The IHRC Team collected data by examining various sources pertinent to the research. Further research was conducted through personal communication by telephone or through e-mail.

Several industries were examined during this study including renewable energy programs and affordable housing programs. Incentives that were assessed included: energy audits, rebates, tax incentives, and "code plus" programs.

Findings

Renewable Energy Programs

Renewable energy programs have various energy-saving programs and corresponding incentives. Incentives could include green pricing programs, rebates towards feasibility studies by a professional engineer to assess the integrity of the home, utility rebate programs which would include rebates from utility's revenues to be placed towards new equipment, and solar energy equipment sales tax exemption. The following sections provide more detail about these individual incentive programs.

<u>Tax Exemptions and Tax Credits</u>

The federal government offers a number of tax and other financial incentives that are designed to promote the development and use of renewable energy resources. The government does not offer federal income tax incentives for homeowners however rebates from electrical utilities for residential solar systems are exempt from federal taxation. Several federal programs for financial and tax incentives for businesses, municipal entities, and non-profit entities exist such as production tax credit and modified accelerated cost recovery systems.

Various states offer tax exemptions or tax credits for those residents that install "solar devices". In most case solar devices include equipment that use solar energy to generate electricity; to heat or cool a structure or provide hot water for use in a structure, or to provide solar process heat.

In States such as Arizona, a retail sales tax exemption will be applied to the consumer when purchasing qualified systems (also known as the transaction privilege tax). Arizona law provides an individual taxpayer with a solar energy credit for installing a solar energy device. The solar energy credit is equal to 25 percent of the cost of the devise. The maximum credit in a taxable year cannot exceed $1,000, and the cumulative solar energy credits allowed for the same residence cannot exceed $1,000. The maximum credit a taxpayer may take for all the solar energy devices installed in the same residence cannot exceed $1,000 in the aggregate. A taxpayer is eligible for the credit for a solar energy device that the taxpayer installs in his or her residence without regards to whether the taxpayer rents or owns that residence.

Massachusetts also offers a program where tax incentives and tax credits are offered to individuals and business that install renewable energy systems at their homes or offices. The credit is 15% of the net expenditure (including installation) for the system, or $1,000, whichever is less. State law exempts from the state sales tax, the sale of equipment directly relating to any solar, wind, or heat pump system to be used as a primary or auxiliary power system for heating or otherwise supplying the energy needs of a person's principal residence in the state.

As of May 11, 2000 a new bill was signed into law that allows Maryland State income tax credits for specified solar energy property and for electricity produced from qualified energy resources. This bill allows taxpayers to take a credit against their personal or corporate income taxes equal to 15% of the total installed cost of the solar energy system they purchase up to $1,000 for solar water heating property and up to $2,000 for photovoltaic property. The Maryland Clean Energy incentive Act –Sales Tax Reduction is a state law that went into effect July 1, 2000 and repeals the state sales tax on certain Energy Star labeled clothes washers, refrigerators, and room air conditioners. The law also established as excise tax reduction on several electric and hybrid- electric vehicles. The new law specifies a number of tax exemptions and tax rebates for energy efficient products and electricity generation.

California has also enacted a tax credit known as the "Solar or Wind Energy System Credit" which can be used by taxpayers against their net tax in an amount equal to the lesser of 15% of the cost paid for the purchase and installation of a solar or wind energy system after deducting the value of a municipal, a state, or federal sponsored financial incentives, or $4.50 per rated watt of the solar or wind energy system. In order to assess eligible systems, the evaluation process utilizes a worksheet and lists of approved equipment, which taxpayers can use to determine on their own whether their systems are certified and eligible for a tax credit.

Homeowners in Oregon can get a credit on income taxes for making their homes more energy efficient and helping preserve the environment. Oregon offers a tax credit of up to $1,500 for residential solar energy projects, which is applied after the project has been completed. Systems that are applicable include solar domestic hot water systems, solar electric systems (photovoltaic), and solar space heating systems. The Oregon Office of Energy offers a listing of certified solar contractors to assist customers in obtaining tax credit certification. Additional property value resulting from the installation of solar equipment is exempt from property taxes under Oregon state law.

The Florida "Solar Energy Equipment Sales Tax Exemption" statute provides an exemption from the state's 6% sales tax for the purchase of solar energy equipment. It is worth noting that Florida does not have a state personal income tax that led to few other options for a tax incentive, which would impact all consumers. While the incentive demonstrates that the state supports solar energy, it is expected that sale increases, as a direct result of the incentive, will be modest. The Florida Solar Energy Industries Association and the Florida Solar Energy Association led the tax exemption effort.

Unfortunately none of the above mentioned tax exemptions could be applied directly towards mitigation efforts. It is clearly stated in most of the laws that the tax credits and or exemptions can only be applied to certain solar devices, none of which could aid in hurricane mitigation efforts. However it is important to mention that many of these incentives apply to both homeowners and renters. This is a very important concept in that renewable energy programs recognize that homeowners that are leasing the property may not always be motivated to make improvements due to the fact that it would not directly affect them. Instead renters may feel the need to make changes to the home, and these laws provide incentives to do so.

Energy Audits

Another program that is often offered by renewable energy programs are audits to assess the integrity of a home. In many cases the Consumers can perform online energy home energy surveys to determine if they have an energy efficient home. The survey also recommends specific ways to save money on electric bills. Other audits require a “small” fee; however there are usually “perks” that accompany the fees such as rebates and discounts on recommended “upgrades”.

Energy Audits are very commonplace throughout the United Stated. The New York State Energy Research and Development Authority offers an audit in a price range from $200 - $600. Although this particular type of audit comes with a price tag, the money aids the consumer in making more informed decisions about implementing an energy efficiency strategy.

Montana Power Company offers a residential on-site energy audit that is free to residential customers that have not had an audit in the past and whose home is at least 5 years old. The audit may include free installation of a water heater, pipe insulation, an energy efficient showerhead, and faucet aerators. An audit report provides a breakdown of usage by endues and energy efficiency measure recommendations. Mail-in surveys are another option for residential customers who use electricity for lights and appliances only.

Tampa Electric is another example of a company that offers home energy audits where the home is inspected and areas where the homeowner is wasting valuable energy are identified. Homeowners schedule an audit and an energy analyst is sent to the home to identify major problems and recommend steps that can be taken to use energy more wisely. Homeowners receive customized recommendations on how to conserve electricity and conserve utility bills. Tampa Electric will also supply links to information on the current energy-efficiency programs offered by Tamps Electric.

The “Build Smart Program”, currently implemented by Florida Power and Light (FPL), is a “plus-code” program that encourages energy conservation through offering a home inspection throughout the construction process for residential single-family detached homes and making suggestions as to how the homeowner could conserve energy improving the efficiency of the home and saving the homeowner money. The objective of the BuildSmart program is to encourage energy conservation that cost-effectively reduces FPL’s coincident peak load and customer’s energy consumption through the building of energy efficient residential new construction. It has been estimated that BuildSmart homes save up to 30% on energy bills, compared to homes that simply comply with the Florida building code.

Both homeowners and building contractors may participate in the program provided that the existing or future home comply with all national, state and local codes and ordinances, be a residential single-family detached home, serviced by FPL, and have a central cooling system installed. The participant must also supply FPL with floor, elevation, and site plans of the home. Once all the information has been supplied a FPL representative will inspect the home, perform an “Energy Performance Index” (EPI) calculation, and make recommendations as to how the energy efficiency of the home can be improved. Participants must correct all deficiencies identified during the inspection in order to be awarded an appropriate BuildSmart Certificate which are based on the energy efficiency rating produced by the current Florida Energy efficiency Code for Building Construct Energy Performance Index (EPI) rating. Three tiers exist for the BuildSmart certification level. To qualify homes must achieve a minimum EPI rating. Major items that will be examined during the inspection include Air Ducts, HVAC systems, Heat Recovery Unit systems.

The charges to participate in the project are minimal and are reported in the Energy Conservation Cost Recovery True-up and Projections filing with schedules CT-2 and C-2. The range for service options can ranges from $125 to $300 depending on how many inspections take place (Initial, mid-point, and final)

The major incentive for this program is that the homeowner receives some sort of piece of mind knowing that a professional has assessed and made recommendations as to how the home could be improved. The homeowner can be rest assured that all the necessary precautions have been addressed and recognized. Although this program offers an excellent platform for home energy efficiency, none of the “incentives” that are offered can transfer directly to hurricane loss reduction effort. Many of the energy efficiency solutions take place within the structural envelope of the building. However this is another example of a “code-plus” program that will improve the energy performance of a home.

There are several “code-plus” programs currently on-going whose focus is residential mitigation. The Federal Alliance for Safe Homes (FLASH), a non-profit charitable educational organization, established an educational program entitled Blueprint for Safety that is designed to provide accurate, current and reliable information about disaster-safety building techniques that would help families become better prepared for floods, hurricanes, wild fires and windstorms. This program was created after the consultation with architects, building professional, and engineers. This “code-plus” program offers the homeowner guidance as to how the structural integrity of the home could be improved beyond national, state, and local building codes. Blueprint for Safety adheres to the policy that all wind recommendations are based of the criteria that the structure meets the design requirements based on wind loads calculated according to ASCE 7-98 using a Basic wind speed defined by ASCE 7-98. The purpose of this program is not to replace the council of licensed professionals; only to arm the consumer with a wealth of knowledge as to other options for designed a more hurricane resistant residence.

The “Fortified…for Safer Living…” is a program currently run by the Institute for Business and Home Safety that specifies construction, design and landscaping guidelines to enable homes to increase their resistance to natural disasters. This is an inspection-based program that is being piloted in Florida. This program provides new homebuilders and buyers a set of criteria for optional upgrades that can help reduce the risks posed by windstorm, wildfire and floods. The Fortified program address such issues as windows, garage doors, entry doors, roofs, gables, exterior walls, exterior structures, and landscaping. The prescriptive requirements were developed based on the 110 mph requirements from SSTD-10-00 Standard for Hurricane resistant Residential Construction. The cost for the construction upgrades can be considered significant, in many case it was cost 9.8 percent increase on the base cost from building a fortified home.

Most energy audit programs offer very little cash incentives for homeowners, although some programs do offer rebates for various types of improvements. Instead these programs offer the homeowner “peace of mind” knowing that there home if energy efficient. This concept is very similar to various “code-plus” programs offered in the State of Florida; such as the Blueprint for Safety and the Fortified Program. Currently the homeowner that participates or prescribes to suggested retrofit measures will not receive any cash incentives nor any break on insurance rates; hoever the program does allow a homeowner security in knowing that actions have been taken to make their home more hurricane resistant. Professionals working in this industry are working hard with various insurance companies trying to create an incentives plan for homeowners; however a program has yet to be developed.

Affordable Housing Incentives

The U.S. Department of Housing and Urban Development offers several affordable housing incentives, many of which use a combination of Federal tax incentives and flexible grant funds. However the majority of these incentives are geared towards parties interested in redeveloping large areas and not the individual homeowner. The Low-Income Housing Tax Credit (LIHTC) enables states to issue Federal tax credits for the acquisition, rehabilitation, and new construction of affordable rental housing. Tax increment financing is another option that HUD implements to redevelop urban areas and create opportunities for affordable housing. HUD also offers several home disaster grants and disaster recovery grants, all of which are initiated post damage or post disaster. Generally, program funds may be used for tenant assistance, housing rehabilitation, and housing reconstruction for low-income families.

The HUD Affordable Housing Study Commission recommends improvements to public policy to stimulate community development and revitalization and to promote the production, preservation and maintenance of safe, decent and affordable housing for all Floridians. This commission states that it has long recognized that housing must be more than a mere shelter and that an affordable home should not be inferior and a cheaper version of a typical market valued home. In the 2001-2002 annual report released by the commission, affordable housing and design was a major concern. Design objectives that were underlined by the commission included 1) contain construction and lifecycle costs, 2) support neighborhood and community fit, 3) adapt to household changes, 4) be universally accessible, 5) meet high aesthetic standards, 6) promote energy and resource efficiency, 7) ensure healthy indoor environment, 8) ensure physical safety and security. All HUD projects would need to adhere to local building code protocols and other physical safety standards; however there is never any mention of mitigation strategies that should be implemented for these housing developments.

HUD offers some suggestions to contractor as to how they can decrease their costs during construction. During this preliminary research it was found that many of HUD's cost saving remedies actually might decrease the possibility for a more hurricane resistant structure. For example one document mentions that switching from plywood to oriented strand board or laminated fiberboard could be a cheaper route during construction. This document also mentions cheaper alternatives for framing including increased spacing of framing members and 2x3 partition studs. Although these prescriptive measures may lead to cost-savings during the construction of a home, the document makes no reference to how these changes may or may not affect the overall structural integrity of a home during hurricane force winds. More research should be implemented to determine what type of cost-saving construction recommendations are made for hurricane prone areas.

Other Natural Disasters: Earthquake Mitigation

Local governments throughout California have created incentive programs to encourage owners to retrofit their vulnerable buildings, including both residential and commercial properties. These incentives include: waivers or reductions of building permit fees, waivers of zoning and parking requirements, loans with easier qualifying requirements or below-market interest rates, and various grants.

The State Assistance for Earthquake Retrofitting (SAFER) is a program currently under revision in California that refers homeowners to trained professionals who will strengthen their homes to resist earthquake damage. Upon completion of the retrofit, all California Earthquake Authority policyholders are eligible for an insurance premium discount of 5%. The CEA is a public agency regulated as a private insurer by the California Department of Insurance. The CEA also help homeowners pay for the retrofit by arranging low-interest loans through participating banks.

Individual cities within California offer residents' incentive plans to put forth earthquake mitigation. The City of Berkley for instance has implemented the "Berkley Seismic Retrofit Incentive Program" which offers financial incentives to owners of properties within the city limits. Such incentives include a waiver of building permit fees for all qualified retrofit projects and a rebate of up to one-third of the City's % property transfer tax if the funds are used for qualified projects. Another example of a large, effective incentive program implemented by the city is Berkeley's Transfer Tax. This incentive has enabled Berkeley to achieve more than three times the number of retrofitted buildings of adjacent cities.

The above mentioned tax incentives can only be received in the State of California and would not be applicable to hurricane prone states. However, California offers an interesting insight into the possibility of State and local tax incentives that would demonstrate to homeowners the importance and seriousness of hurricane mitigation. California's earthquake mitigation incentive plans should be used as a platform for other states burdened with the constant threat of natural disasters.

Conclusions and Recommendations Based on Current Year Findings

The research conducted during this fiscal year just "scratched the surface" examining existing incentive programs and their applicability towards hurricane loss reduction. Owners have many reasons for not addressing the risks of hurricane damage toward a piece of property. In additional retrofitting is typically not the highest priority for the expenditure of limited funds. It can be perceived that governments convey mixed messages about hurricane risk by not requiring retrofits or "code-plus" practices, or offering affordable solutions. Instead retrofitting decisions for site-built residential housing are left to the owners. Yet governments have a stake in the future of their community's buildings, in protecting both human life and economic continuity.

Even nominal incentives would most likely send a clear message to building owners that governments value hurricane mitigation efforts. The positive public relations generated by offers of incentives have offset opposition to retrofitting proposals. Larger incentives will clearly produce more meaningful retrofit results and may change market conditions and increased numbers of homes being retrofitted.

Findings and recommendations for future research are as follows:

- Various incentive programs for site-built housing are currently in affect; however none of the incentives researched in this study could carry over into hurricane loss reduction incentives.

- Researchers need to determine an estimate of potential levels of participation for both owners and renters and estimated offsets in revenue.

- Hurricane prone states, such as Florida, Texas, and Louisiana, should use California's earthquake mitigation incentives as a platform for developing state and local programs.

- One recommendation for continuing research would be to examine the HUD Cost-Saving Construction Opportunities for building methods and materials in more detail. HUD financial incentives such as federal tax incentives and grant opportunities may be transferred to the hurricane loss reduction effort; however more research needs to determine if HUD's cost-saving construction opportunities have the potential to meet hurricane mitigation efforts; making a home more hurricane resistant.

- Upon creating an incentives plan for hurricane loss reduction efforts, a tiered rating plan for home resistance should be implemented. The Insurance Institute for Highway Safety currently offers a tiered vehicle program that provides specific measurements to assess the structural performance of vehicles. The vehicles receive a rating of "poor, marginal, acceptable, or good". The three factors evaluated in the frontal offset crash test – structural performance, injury measures, and restraints/dummy kinematics – determine each vehicles overall crashworthiness evaluation. This information is highly valuable for the consumer when purchasing a vehicle based on tested risk. Taking this concept a step further, a program that offers insight as to the structural integrity of various home designs with varying degrees of mitigation techniques would allow the consumer to make a more educated choice when retrofitting or constructing a more hurricane resistant home. A tiered program would illustrate the varying degrees of safety for fasteners, fastening schedules, architectural impact modifiers, etc.

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