



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
Under Contract 03-RC-11-13-00-05-012**

FINAL REPORT

For the period July 1, 2002 to June 30, 2003

VOLUME 1

REPORTING REQUIREMENT NO. 6

Due July 30, 2003

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

July 30, 2003

Mr. Ted Court
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, FL 32399-2100

RE: Residential Construction Mitigation Program (RCMP)
Contract # 03-RC-11-13-00-05-012

Dear Mr. Court:

Enclosed herewith please find the Final Report for the research project ***Hurricane Loss Reduction for Housing in Florida*** conducted by the International Hurricane Research Center (IHRC), at Florida International University (FIU), under the contract of the reference. As required, this report is being submitted to you as one printed (paper) and one digital original.

This Final Report covers various activities and research carried-out during the period from July 1, 2002 to June 30, 2003. The report consists of three volumes complemented by relevant information, data and pictures in our ad hoc web site. Please take the time to visit this web site at <http://mitigation.fiu.edu>. Submission of this Final Report fulfills our contractual obligations for the period indicated.

A total of forty-nine researchers, research assistants and support staff from five academic institutions comprising the IHRC Team participated in this effort. On their behalf, as Principal Investigator for this project, I would like to express our gratitude to you and others at DCA for your support and guidance.

Our work over this past year has resulted in findings having the capability, once applied, for benefiting millions of Floridians by reducing millions of dollars in potential hurricane damage on an annual basis. The IHRC Team looks forward to continuing to work with you to be of service to the residents of our state.

Please call me should you have any comments or questions about the Final Report.

Sincerely

Ricardo A. Alvarez
Deputy Director

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FOREWORD

Another fiscal year has ended in Florida and here we stand at a symbolic crossroads marked by this Final Report. Several questions press for answers as we gather the information and data for this report: (a) Is this a destination or a point of departure? (b) Does the Final Report represent the end of an effort or a foundation for new work in our quest for knowledge? (c) What have we contributed to the cause of hurricane loss reduction for housing in Florida over the past year? (d) Where do we go from here?

The period from July 1, 2002 to June 30, 2003, during which the research was conducted, was indeed a critical time for the Hurricane Loss Mitigation Program or RCMP and all of the researchers and institutions, as well as administrators and the policy-makers who are in one way or another involved with it.

The legislative session focused on critical budgetary problems and a proposed reinvention or reorganization of our state government. Other critical issues required a series of especial legislative sessions that kept bringing our legislators back to Tallahassee even after the session had ended.

Despite uncertainties fostered under this difficult environment, DCA staff provided a continuous and much needed thread of support for the many individuals and institutions engaged in the RCMP effort.

In contrast with these uncertainties and other distracting challenges, important initiatives and critical research work continued during this period. As a result the IHRC Team can report on positive developments and findings highlighted by the following:

- (1) Both DCA and the RCMP Advisory Council supported approval of an ambitious research agenda that drew heavily of the foundation of knowledge from and on work initiated during the 2001-2002 period. This has provided the much-needed continuity advocated by our IHRC Team and others.
- (2) Work by the IHRC Team on the role of several types of fasteners (nails) on the performance of roof sheathing under hurricane loads has led to a practical application, with the potential for benefiting millions of Floridians and residents of other hurricane vulnerable states.

- (3) The IHRC submitted, in April 2003, a proposal to modify the Florida Building Code with respect to the nail type used to attach roof sheathing to its supporting structure in the High Velocity Hurricane Zone. A Technical Review Committee of the State Building Code Commission approved the proposed modification in June 17, 2003. Now the proposal goes to the full State Building Code Commission in August 2003. If approved by the Legislature this modification will be officially incorporated within the Florida Building Code as of July 1, 2004. What is exciting about this initiative is its potential for improving the performance of roofing under hurricane impacts by a factor of 130% WITHOUT increasing the cost of construction. How often can you deliver a better housing product for the same price? This work, a direct result of work carried out by the IHRC funded by the RCMP, has the capability for reducing millions of dollars of potential hurricane damage annually for houses built in the High Velocity Hurricane Zone. This is a clear example of the return on investment our State Government obtains by funding the RCMP.

A significant and critical additional benefit from the RCMP – Hurricane Loss Mitigation Program is the improvement of in-state capabilities to conduct research, deliver practical applications and education/outreach efforts on the issue of hurricane loss mitigation. The IHRC can unequivocally state that our research capabilities and related support infrastructure has been enhanced as a direct result of the RCMP work conducted by our team.

As the most hurricane-vulnerable state in the nation, our enhanced research and educational/outreach capabilities, indeed our much-improved search for and delivery of hurricane loss mitigation made possible by the RCMP, directly address critical needs for the benefit of millions of Floridians.

Following our policy of strengthening the research team by engaging other individuals and institutions in order to deliver the highest quality possible to the Hurricane Loss Mitigation Program, this year's results are possible through the work and dedication of forty-nine researchers, research assistants, students and support staff from six institutions. Periodic team working-meetings and continuous communication via e-mail and telephone conferences have also contributed to keep our effort on target and within established timelines.

In the Final Report for the research period 2000-2001 the IHRC Team stated that housing touches the lives of practically every permanent or temporary resident of Florida as well as the rest of the nation. Housing addresses the essential and basic

human need for shelter, but it is also a critical component in a tapestry of interwoven elements such as community character, development, infrastructure and services, transportation and sources of employment and the many other factors that contribute to the welfare of the people.

In preparing this 2002-2003 Final Report we reflect upon the statement above and can only conclude the IHRC Team, within the activities of the RCMP, is truly making an important contribution to the issue of housing. Even more, with its work focusing on hurricane loss reduction to housing the IHRC Team is making a critical contribution by ensuring that houses throughout Florida will have a better chance of surviving future impacts from hurricanes.

EXECUTIVE SUMMARY

FINDINGS AND RECOMMENDATIONS

This section highlights the main findings from work during the 2002-2003 period. The second part of this section provides additional and complementary information on the work conducted by the IHRC Team on each of the research tracks included in the scope of work.

The main purpose of this section is to provide the reader with brief and clear information about the results of this work funded under the RCMP. If the reader wants detailed information regarding a particular research track or a specific finding, Volumes 2 and 3 provide an extended narrative describing the work completed under each of the research tracks.

Before addressing the findings it is important to recognize that the State Legislature and DCA, as the funding agency, have expressed an interest in assessing how effective the RCMP has been in fostering hurricane loss mitigation across Florida. In other words: how much bang is the State getting for its buck?

In response to this concern the IHRC offers one specific example from its research work as evidence that RCMP funding is meeting its main objective of delivering cost-effective methods and techniques for hurricane mitigation for housing in Florida.

The specific example in question is the result of two years of work that the IHRC Team has spent researching the role of various types of fasteners in modifying the performance of roofing under hurricane winds. This refers to the nails used to attach roof sheathing to its supporting structure. Given the critical importance of roof sheathing in contributing to the integrity of the building envelope, the main line of defense in housing for the protection of life and property during hurricanes.

After testing numerous full-size roofing panels and several types of nails the IHRC has found that the 8d ring-shank nail (a 2-3/8" nail) can improve the performance of roof sheathing, meaning its resistance to uplift under hurricane winds, by an average factor of 130% over roofing attached with the combination of 8d common bright (2-1/2" nail) and 10d common bright (3" nail) nails currently prescribed by the Florida Building Code. A complementary finding is that such improvement in performance can be achieved at no increase in cost and possibly at a slight reduction in cost.

This example not only validates what the RCMP is about, but it also shows how applied research by academic institutions in Florida can make important contributions toward the objective of hurricane loss mitigation. The specific example described above has the potential for benefiting thousand of new homes build every year by reducing millions of dollars in potential damage on an annual basis.

Regarding this discovery of the effectiveness of ring shank nails in improving the performance of roof sheathing under hurricane impacts, it is important to note that last April 18th the IHRC submitted a proposal to modify the Florida Building Code to make the 8d ring shank nail the standard fastener for roof sheathing in the High Velocity Hurricane Zone (HVHZ) in Florida.

Based on this success, the IHRC will continue its research during the 2003-2004 period to assess how effectively the 8d ring shank nail can be used for retrofitting existing homes where the sheathing is ½” plywood, instead of the currently prescribed 5/8” thick plywood, and the nailing schedule is at 12” on center instead of the current standard of 6” on center and 4” on center along the edges.

Continuing below this report summarizes key findings resulting from the work of the IHRC Team in 2002-2003. Findings are presented by each of the research tracks tackled by the IHRC Team during the period.

ELIMINATING STATE AND LOCAL BARRIERS TO UPGRADING EXISTING MOBILE HOMES AND COMMUNITIES

Research on this track involved work in Pinellas, Hillsborough, Polk, Pasco and in Broward counties. This work involved interviews with mobile home owners and renters, mobile home park owners or managers, mobile home manufacturers or agents and brokers. Also architects, engineers, building and planning officials, as well as visits to several mobile home parks.

Additionally the IHRC Team conducted extensive research of existing local land-use laws, codes, plans and regulations.

To complement this work the IHRC Team also undertook a survey of building officials and mobile home dealers to determine the extend of knowledge gaps with respect to regulatory environment regarding the installation of mobile homes. Some problems had been detected in this area during the 2001-2002-research period.

Findings:

- (1) The mobile home sector is reaching a crisis that mainly derives from the lack of a state or local housing policy with respect to this specific type of housing. This approaching potential crisis is evidenced by the numerous mobile home parks that are being shut down as a result of redevelopment efforts in several communities throughout Florida. The net result is the wholesale displacement of residents in those mobile home communities.
- (2) The impending crisis is best put in perspective when one considers that for some of the lowest economic sectors of society mobile homes appear to be the best, if not the only, alternative for affordable housing.
- (3) There is a lack of public policy on this housing sector at the state and local levels. There appears to be an attitude by public officials to let market forces shape the outcome of the problem being faced by mobile home owners and renters. This approach renders the issue into an obviously unfair struggle where most of the resources and power are on the side of those seeking to benefit at the expense of entire mobile home communities being displaced at best, eliminated at worst.
- (4) Redevelopment is a powerful tool being used at the local level to convert mobile home parks into single-family subdivisions of site-built residences or event into multi-family apartment communities. As a result of this process thousands of mobile home residents, many of them in the lower socio-economic levels, are displaced on a yearly basis. Often these displaced individuals have no real recourse.
- (5) Among the many factors that contribute to this problem it is important to mention the following: (a) In many cases mobile home parks are located on land that is zoned for multiple use; (b) Individual lots within a mobile home park have no real legal boundaries; (c) Some parks are located in the flood zone making it impossible for existing homes to be replaced with newer and stronger units; (d) While there is no lack of new affordable residential development that could be used by those being displaced from mobile home communities, such affordability does not apply to the lowest socio-economic sectors of society.
- (6) Case studies conducted by the IHRC Team show a type of catch-22 situation that is present in mobile home parks. One specific example is of a park in the city of Largo. The park was sited in the flood zone and originally platted as a two-

phase single-family subdivision. However mobile homes were allowed from the start. For a variety of reasons the mobile homes have deteriorated. Should this park suffer the impact of a hurricane residents of damaged mobile homes will not be allowed to replace them because these units are not allowed on the flood plain. Nor could these residents opt for substituting with site-built single-family houses because the lot sizes in the subdivision are too small under current zoning.

- (7) Together with this de-facto policy of letting market forces shape the struggle through redevelopment the IHRC has found some ignorance among public officials. This is reflected in the use of confusing and misleading terminology by officials that is. One specific example that illustrates this point is the case of Hillsborough County Commission hearing for an upgrade on existing zoning designation. This change was described during the hearing as being a ‘change from mobile homes to ‘manufactured’ homes”. A visit by the IHRC Team to the site in question revealed it was already occupied by manufactured housing. There wasn’t a single mobile home there. Yet the actual transcript of the hearing refers to “modular homes”. Quite confusing indeed.
- (8) At the individual level the process can be traumatic both emotionally and financially. There is a scarcity of affordable housing alternatives for many of these individuals. Often displaced individuals express regret at the “loss of community” they felt in their former mobile home park.
- (9) Despite the existence of the Mobile Home Relocation Trust Program, it appears its stringent qualification criteria may be keeping many, if not most, displaced mobile home residents from benefiting from this program.
- (10) On the flip side of this issue a majority of those interviewed, that have gone through this displacement, indicated they feel “better off” now than before the move. This finding is worth exploring further to assess if it could be used as a factor in fostering the upgrading of currently deteriorated mobile home communities, perhaps through a program of replacement (“recycling”).
- (11) In line with the previous finding the IHRC Team has used various means to track displaced former mobile home park residents and found that approximately 50% of them are currently residing in newer/better mobile home communities, and the other 50% have gone to other types of housing, but have faced some financial hardship in the process.

- (12) With respect to the knowledge gaps detected during the 2001-2002 research period, the IHRC survey detected the following: (a) Most building officials interviewed are aware and knowledgeable of the regulations that are pertinent to the installation of mobile homes; (b) The previous finding must be contrasted with the knowledge gaps on the same issue discovered among some staff at building departments, unfortunately staff that provides information to the public;(c) More than 48% of the mobile home dealers responding to the survey indicated that buyers are required to have their mobile homes installed by the dealer, which is not correct information; (d) More than 44% of dealers responded “NO” when a “buyer” asked if he could find his own installer for a mobile home, again this is incorrect information; (e) There is plenty of information on the issue of regulations concerning the installation of mobile homes and associated land-use and zoning issues, however such information is dispersed among several sources, so it would be difficult for the general public to become educate on such issues when in the process of buying a mobile home.
- (13) There is a need for implementing an educational and outreach effort designed to solve (“close”) the knowledge gaps mentioned before.

Recommendations:

Based on its assessment of knowledge gained through research, as reflected in the findings section above, the IHRC Team makes the following recommendations with respect to the upgrading of mobile homes and communities:

- (1) Additional research should focus on ways and means to achieve the redevelopment of communities while also **preserving** the mobile home communities. This implies a process of redevelopment through mobile home community preservation rather than by displacement or closure of the same.
- (2) In line with above, future research should focus on existing initiatives in several areas of Florida that seek to balance the rights of land owners to maximize the economic benefits they derive from land tenure with the rights of mobile home owners and renters. A good case study for this research track would be the *Mobile Home Task Force* created by the Pinellas County Board of County Commissioners in March of 2000. This entity has since been renamed the *Manufactured Home Task Force*. The task force set five specific goals to address the issue of the aging and deterioration of one of the largest stocks of mobile

homes in the state, while also recognizing the sense of community and neighborhood experienced by residents of these manufactured home communities. Studying how successful or not the task force has been in meeting its objectives may help communities in other counties.

- (3) Also important is to research some of the remedies used by mobile home communities to stem the pressures for park closures. Some of these remedies include converting mobile home park ownership to a cooperative form of ownership where the mobile home residents buy the park from the owner. As a case study this example would answer questions about the benefit-cost of such a measure in preserving affordable housing while also protecting land ownership.
- (4) Because ongoing land use changes and redevelopment lead to mobile home park closures or displacement, the poorer residents of these communities suffer the most. The IHRC recommends the State create an assistance program, beyond the Florida Mobile Home Relocation Trust Fund, to provide subsidies, monetary instruments and technical support to help mobile home residents preserve their specific communities and affordable housing in general.
- (5) A final recommendation is to emphasize the role of consumer education to better prepare mobile home communities to confront pressures that may lead to park closures or displacement. This educational and outreach program should include practical knowledge on such issues as: (a) Mobile home installation, (b) Rehabilitation as a method to avoid the degradation of parks that could lead to closure, (c) Alternative land ownership and economic models that can help preserve these communities, (d) The true costs of mobile home ownership, (e) Florida statutes regulating the manufactured housing sector etc.

RESEARCH AND DEVELOP A PROGRAM FOR THE RECYCLING OF EXISTING OLDER MOBILE HOMES

There are approximately 270,000 mobile homes currently in use in Florida that were built prior to the establishment in 1976 of national HUD standards for the manufacturing of these units. Because of having been manufactured prior to the HUD standards, but also because of their age (years in service) and other contributing factors, such as improper maintenance, these housing units are considered to be particularly at risk for sustaining catastrophic damage in the event of a hurricane.

This elevated risk is a central tenet of the proposal that these 270,000 pre-1976 mobile homes should be replaced with post-1994 manufactured homes, which are built to the highest standards. Such replacement program is considered an effective way of achieving hurricane loss mitigation within this housing sector.

The mobile home replacement program is envisioned as a two-step process. The first step involves the recycling of pre-1976 units out of circulation. The second step is to bring in post-1994 units to replace the discarded mobile homes.

The recycling phase involves a number of technical and logistical issues that have been researched and assessed by the IHRC Team during the 2001-2002 and 2002-2003 periods.

Phase two of the replacement program includes the key element of how to finance such massive acquisition of new mobile homes. Both phases of the replacement program must contend and resolve a range of critical social issues that would affect the program.

During the 2001-2002 research period the IHRC Team conducted extensive research on all of the aspects to be considered for the demolition and recycling of these older mobile homes, both the pre-1976 units and the post-1976/pre-1994 stock. This research involved identifying the essential component of the process and the sources of information for estimating the unit cost associated with it.

During the recently concluded 2002-2003 research period the IHRC Team conducted a practical exercise that included the demolition and recycling of several mobile homes, in order to gauge if the theoretical findings of 2001-2002 would match those practical results from the 2002-2003 research activity.

Following are the main findings resulting from work of the IHRC Team on this track:

Findings:

- (1) The 270,000 pre-1976 mobile homes represent a stock of approximately 340,000 singlewide units to be replaced. This is due to the fact that about 37% of the stock consists of doublewide units and 2% represents triple-wide mobile homes. When estimating the costs associated with demolishing and recycling these mobile homes the IHRC Team looked at the per unit cost in order to properly reflect the true cost of all factors to be considered.
- (2) The practical exercise revealed the true cost of the recycling phase of the program is 27.6% higher, on a per-unit basis, than the theoretical costs estimated during the 2001-2002-research period. The IHRC Team considers the 2002-2003 actual unit costs to be more accurate than the theoretical costs estimated during the previous research year.
- (3) The total estimated cost of recycling all pre-1976 mobile homes currently in use in Florida would amount to \$1.71 billion 2003 dollars. The theoretical cost estimate from the 2001-2002 period was \$1.34 billion. If such a program were undertaken over a period of ten years, the annual cost would be \$171 million in current dollars. These figures include the cost of hazardous materials (asbestos and lead) for all units and the abatement of such materials (mainly asbestos) from 60% of the units.
- (4) The IHRC Team also found the actual value of salvageable materials from the recycling was \$528 per unit, or 17.3% higher than the theoretical 2001-2002 estimate of \$450/unit. This is an important finding because it would represent a total of \$179 million in 'extra' revenue for recycling contractors for the total stock of pre-1976 mobile homes. Given the large volume of work – 'business' associated with the program such salvage income could be part of the mix of factors used to reduce the cost of the total program.
- (5) A significant finding by the IHRC Team is the average increase in the retail costs of mobile homes in Florida from 1994 through 2000. Singlewide mobile homes went from \$20,300 in 1994 to \$30,400 in 2000, an increase of 49.8%.
- (6) The retail price of doublewide units in Florida went from \$39,100 in 1994 to \$52,900 in 2000 for an increase of 35.3%. While no actual figures were obtained

the IHRC Team estimated the cost of a triple-wide unit in 2000 was \$65,000 on the average.

- (7) Extrapolating from these numbers the IHRC Team has estimated the 2003 average retail prices for mobile homes in Florida would be \$35,450 for single-units, \$59,800 for double-wide and \$73,450 for the triple-wide homes. These prices are significant because they can be used to estimate the total cost of replacing all pre-1976 mobile homes with post-1994 units.
- (8) Based on these estimated retail prices, phase 2 of program to replace the total stock of pre-1976 mobile homes would cost \$11.6 billion in current 2003 dollars. Certainly a staggering amount even when considering a ten-year period to achieve this.
- (9) When considering the full replacement program, including its two phases (demolition/recycling and purchase/replacement) the total cost of replacing all pre-1976 mobile homes in Florida would be \$13.3 billion in current dollars or \$1.33 billion in 2003 dollars annually over the next ten years or \$665 million annually for a twenty-year program.
- (10) The most critical question when considering the above figures is: Who will pay for such a program and how? Another equally important question is: what are the true benefits, measured as hurricane-loss reduction, to be accrued from such a replacement program?
- (11) During the 2002-2003-research period the IHRC Team continue to explore the range of social issues that must be taken into account when considering all aspects of the mobile home replacement program. One social issue that is salient has to do with the fact that most mobile home owners surveyed for this research are just “not interested” in the replacement program. The other important social issue to consider is that many mobile home residents are renters who could be marginalized by a program that focuses on mobile home ownership as a key factor.
- (12) Two additional findings are worth mentioning: (a) Mobile home dealers offer a range of financial incentives (i.e. discounts) to buyers of new mobile homes. These incentives apply to the purchase of “upgrades” to the mobile home, but none of these upgrades offers a higher performing structural component. (b) The wind zones established by HUD as a way of prescribing higher manufacturing

standards for mobile homes exposed to the higher winds play an important role in the replacement equation. This has to do with the fact that 58% of all pre-1976 mobile homes in Florida are currently installed in Zone 3 counties. In fact less than 10% of mobile homes in Zone 3 counties are post-1994 units.

- (13) Finally it is important to mention the IHRC Team began exploring the potential role of mobile home rehabilitation (“rehabbing”) in strengthening these units to make them more resistant to hurricane impacts. There appear to be interesting possibilities with the approach of considering mobile home rehabilitation as an alternative to replacement.

Recommendations:

The IHRC Team has the following recommendations regarding a replacement program for the older (pre-1976) mobile homes in Florida:

- (1) Given the estimated cost of a replacement program for pre-1976 mobile homes in Florida it is critical to carry out a benefit-cost analysis of such a program to determine its cost-effectiveness. No responsible decision could be made by policy-makers and public officials without first knowing the benefit-cost ratio of such a program. The IHRC Team recommends such benefit-cost study be undertaken in 2003-2004.
- (2) The IHRC Team also recommends a study to determine what funding alternatives exist to pay for the replacement program. In view of the amounts of money identified, it appears paying for the program may be a challenge under the current climate of budget reductions and decreased revenues for state governments. This would help answer the questions of who will pay for the program and how.
- (3) The role of rehabilitation as an opportunity to incorporate structural enhancements to older mobile homes needs to be explored in detail. This study needs to involve not only the technical and practical issues of achieving such structural improvement through rehabilitation, but also the economic, regulatory and legal issues involved,
- (4) Both the replacement program and the role of rehabilitation are based on the axiom that these approaches would achieve a higher performing stock of mobile homes, especially under the impact of hurricanes. The only way to assess if such

improvement in structural performance is achievable is through a program of comparative structural analysis involving the full-scale testing of actual mobile homes. The IHRC recommends undertaking such testing program with support from mobile home manufacturers, HUD, DCA and other agencies.

- (5) The IHRC further recommends a program of education and outreach focusing on mobile home owners to raise awareness of the problem and the reasons, and potential benefits of a pre-1976 mobile home replacement program,

PROGRAM OF RESEARCH AND DEVELOPMENT RELATING TO HURRICANE LOSS REDUCTION DEVICES AND TECHNIQUES FOR SITE-BUILT HOUSING

This track is the third of the areas of research the IHRC must undertake annually to comply with the objectives of the Bill Williams Act as adopted by the State Legislature. Under this area of research the IHRC looks at three types of factors that may contribute to the development of effective hurricane loss mitigation for site-built housing. These three types of contributing factors are:

- (1) Structural and other physical measures that may contribute to the reduction of potential damage from hurricane impact, through the process of design criteria and construction methods.
- (2) Studies that assess the awareness, attitudes and perceptions of people regarding the potential for hurricane damage, and the role of various mitigation measures in reducing such risk.
- (3) Economic incentives that may help homeowners adopt hurricane loss mitigation.

Following below are findings and recommendations by the IHRC Team summarized by each of the specific research topics under this track.

A. Roof Sheathing Fastener Study

The ***building envelope*** comprises the exterior walls and the roof of a house. This is the first line of defense against the impact of a hurricane or other hazards. The building envelope is as strong as its weakest component.

The roof is an integral and perhaps the most critical component of the building envelope. As such, damage to the roof may initiate a cause and effect chain reaction leading to catastrophic structural and interior damage to the house under the impact of hurricanes.

The roof itself involves several components: (a) The roof covering i.e.: tiles, shingles, shakes etc., (b) The underlayment, usually in the form of a waterproof material, (c) The roof sheathing or “deck” which in Florida could be plywood or solid wood, and (d) The structure, usually trusses (wood or metal) or rafters that have a dual function; (i) supporting the roof, and (ii) connecting the whole roof assembly to the walls and structure of the house.

The Florida Building Code has established a **High Velocity Hurricane Zone** (HVHZ) covering those coastal counties where the probability of impact by a major hurricane is the highest. The building code prescribes more stringent structural and construction criteria for roofs in the HVHZ, these include 5/8" nominal thickness for plywood sheathing, 8d common bright nails at 6" on center on the field and 10d common bright nails at 4" on center along the edges of the roof.

Given the important role of roof sheathing in contributing to the integrity of the building envelope, the IHRC initiated research in 2001-2002 on the role of various types of fasteners in modifying the performance of roof sheathing under hurricane winds. The key questions asked by the IHRC was: can a different nail, than those prescribed by the Florida Building Code, make the roof assembly stronger so that it can perform effectively at higher wind speeds?

As a result of its efforts to answer the question above, the IHRC arrives at the following findings and recommendations:

Findings:

- (1) Testing by the IHRC Team has shown that roof sheathing installed in compliance with the Florida Building Code Section 2322 – *High Velocity Hurricane Zones Sheathing*, Subsection 2322.2 – *Roof Sheathing*, will perform effectively and within the prescribed safety margins up to wind speeds consistent with mid-range category 3 hurricanes.
- (2) The effective performance of roof sheathing indicated above is only valid for some categories of exposure and it is also limited by the height of the roof. This limitation of effective performance was restricted further when dealing with the edge of the gable end roof.
- (3) Testing by the IHRC Team, using full size roof panels in its vacuum chamber, shows the 8d ring shank nail will outperform both the 8d common bright and the 10d common bright nails currently prescribed by the Florida Building Code for roof sheathing in the HVHZ.
- (4) The 8d ring shank nail increased the resistance of 5/8" plywood roof sheathing to uplift from wind forces, by a factor of 80% to 130% above that of sheathing using the Florida Building Code current criteria. Of all the roof panels tested during the

2002-2003-research period, all of the panels complying with the Florida Building Code failed before wind uplift forces exceeded 150 psf (pounds per square foot). In contrast several roof panels using the 8d ring shank nail exceeded 300 psf on uplift pressure before failing.

- (5) These test indicate roofs sheathing built with 5/8" plywood using only the 8d ring shank nail for field and roof edge conditions will perform effectively up to high-range category 4 winds, for all exposure categories and roof heights. This includes the critical roof condition involving the gable end.
- (6) A related cost-study conducted by the IHRC Team shows that there is a slight increase of \$0.35 per roofing square (100 square feet of roof) as a result of the somewhat higher cost of materials. This slight increase in the cost of materials may total \$8.75 for a house with 2,500 square feet of roofing.
- (7) The minor cost-increase resulting from the cost of materials is more than offset by an improvement in the efficiency of labor in the fabrication of roof sheathing. This higher efficiency is derived from two key factors: (a) Only one nail, the 8d ring shank, is used to built the whole roof instead of two (8d and 10d common brights), resulting in higher productivity because there is no need to stop and change nail guns or unload/reload nail guns used for the 8d common bright in order to use the 10d common bright on the edge of the roof, (b) The 8d ring shank tested by the IHRC is slightly thinner in diameter than the 8d common bright allowing more nails to be loaded in the nail gun. This allows roofers to drive nails for a longer period before stopping to reload. While not quantifies, the IHRC believes the increased labor efficiency will actually result in a small, but important cost-reduction when the 8d ring shank nail is used to install roof sheathing.
- (8) A recommendation made by the IHRC, based on these findings, to modify the Florida Building Code in order to make the 8d ring shank nail the prescribed standard for roof sheathing in the HVHZ received the full support of the Florida Home Builders Association (FHBA) and from the Institute for Business and Home Safety (IBHS). A Technical Review Committee of the State Building Code Commission approved this IHRC recommendation, in June 17, 2003, and it also recommended it for approval by the full State Building Code Commission at its coming meeting in August.

Recommendations:

- (1) The IHRC recommend future research, during the 2003-2004 period, should continue this line of study, but with a focus on the possibility of using the 8d ring shank nail to retrofit roofs that were built to older building code criteria when ½” plywood was allowed and the nailing schedule was at 12” on center. The objective of this research will be to determine what improvement in performance can be obtained through such retrofitting. The rationale behind this recommendation is that retrofitting opportunities may exist during re-roofing of existing homes, and these may result in improved performance from those older roofs.
- (2) The IHRC recommends further that the use of the 8d ring shank nail should be evaluated for usage in those Florida counties outside the HVHZ in order to determine if it a viable performance modifier in the rest of the state.
- (3) The IHRC also recommend continued research on the use of other fasteners on the construction of roof sheathing in an effort to tabulate the performance criteria for as many fasteners as possible. This information would be valuable for housing construction not only in Florida, but also in other hurricane vulnerable areas in the United States.
- (4) The IHRC recommends each different instance where a fastener is found to improve the performance of roof sheathing under hurricane loads, a cost-study should also be conducted to determine the full impact of using said fastener.

B. Roof-to-Wall Connections Subjected to Combined Loads

Another critical contributor to the integrity of the building envelope, the IHRC Team has studied, is the connection of the roof assembly to the walls of the house. The roof assembly includes all of the elements identified in the previous section:

(a) Roof covering, (b) Underlayment, (c) Sheathing, and (d) Structure.

The connections between the roof structure and the walls of the house are the means by which loads, applied to the roof by hurricane winds, are transmitted to the foundations. These connections provide the path for complex sets of forces acting simultaneously including: (a) Uplift forces on the roof, (b) Shear forces resulting from the reaction of the roof sheathing (or diaphragm) to other loads, and (c) Out-of-plane (eccentric) loads on the walls themselves.

During the 2001-2002 research period the IHRC Team studied roof-to-wall connections used in wood frame construction. During the recently concluded 2002-2003 period the focus was roof-to-wall connections between wood roof trusses and masonry walls. Two specific types of conditions were studied:

(a) Masonry walls using reinforced concrete tie beams, which are common in large areas of South Florida including Miami-Dade and Broward counties, and (b) Walls using CMU grout filled reinforced bond beams as used in masonry construction for much of the rest of Florida.

The main objective of this research was to develop diagrams illustrating the load interaction through the point of connection between the roof structure and the masonry wall. Such load interaction diagram would be useful in arriving at revised design criteria for such connections. In turn, such revised connector design criteria may lead to more effective and perhaps less costly methods of construction.

Work on this area during 2002-2003 lead to the following findings:

Findings:

- (1) The IHRC Team tested twenty full size specimens of roof-structure-to-masonry wall connections. Half of these involved the reinforced concrete tie beam and the other half the CMU grout filled reinforced bond beam. Theses tests consistently showed results indicating typical hurricane straps used throughout Florida may have greater capacities for resisting combined loads that designer are allowed to use.

- (2) Continued work to expand this area of research and to corroborate prior findings may contribute to future development leading to more economical easier to built hurricane straps. This approach would be in line with the emphasis by the IHRC Team in exploring cost-effective methods of construction to improve the design or performance of housing in Florida.
- (3) This line of research by the IHRC Team may lead to reductions in the cost of construction while also maintaining the safety margins required by design-criteria to protect houses under hurricane loads.

Recommendations:

- (1) The IHRC Teams continuing this line of research in future years to corroborate earlier findings.
- (2) The IHRC Team also recommends continued research on this critical area should be coupled with benefit-cost analysis to determine if more economical designs and methods of construction are possible while maintaining the necessary safety margins.
- (3) The IHRC recommends this area of study be expanded to accommodate types of roof structures other than wood trusses, perhaps metal trusses or wood rafters, in order to better assess newer methods of construction.

C. Performance of Roof Coverings

The criticality of the roof assembly in insurance the integrity of the building envelope has already been stated above. This area of research is central to the work of the IHRC and to the RCMP objective of hurricane loss reduction.

Within the roof assembly, roof coverings constitute perhaps the first line of defense against wind induced roof damage. As such the performance of roof coverings under hurricane winds may well be the difference between just having exterior damage to the house, or breaching of the building envelope leading to damage to the interior and contents of the house or even to catastrophic damage.

After hurricane Andrew, as in most other hurricanes, nearly all of the properties filing claims for losses suffered damage to roof coverings.

Recognizing how critical the performance of roof coverings is, the Florida Building Code has established strict requirement for product approval and detailed methods of installation for roof coverings in the HVHZ. Such performance criteria and installation methods depend on testing protocols such as TAS 100 – *Testing Procedure for Wind and Wind Driven Rain Resistance of Discontinuous Roof Systems* and TAS 107 – *Test Procedures for Wind Resistance Testing of Non-rigid Discontinuous Roof System Assemblies*.

Research by the IHRC Team and others has found that little is known about the true loading conditions imposed on roof samples when using these testing protocols. In consequence it could be argued there is a need to learn more about such loading conditions, and also about how closely such testing protocols replicate natural loading conditions under hurricane winds.

Work by the IHRC Team on this area of research has led to the following:

Findings:

- (1) In many, if not most, instances major damage to the house starts by failure of the roof covering. Failure at this first line of defense and the subsequent chain reaction may lead to structural roof failure and breaching of the building envelope.
- (2) Since the performance and prescribed roof-covering installation methods depend to a large degree on the results of test protocols adopted by the Florida Building Code, the IHRC finds there is a need to better assess the validity of test protocols such as TAS 100 and TAS 107.
- (3) There is a specific need to understand the physics of these test protocols, meaning the actual loads placed on roof test specimens when undergoing either TAS 100 or TAS 107.
- (4) The IHRC has found some roof covering installation methods prescribed for the HVHZ may in fact exacerbate the potential for damage. It is important then to conduct research to determine if the test protocols themselves may need to be modified or enhanced.

- (5) The test protocols identified here depend of wind generators to create the necessary wind field and wind loads to apply forces to the test specimens. The IHRC Team has found there is a need to create improved test facilities with the capability of closely replicating the wind field characteristics produced by hurricanes. These involve not only wind speed, but also wind flow characteristics.

Recommendations:

- (1) Continue this line of research concentrating on instrumented tests of roof coverings with the objective of the exact type of loads placed on test specimens, when following TAS 100 and TAS 107 protocols.
- (2) Work on developing and constructing test apparatus to generate wind fields that closely replicate the natural characteristics of hurricane winds. This work may involve modifying test apparatus already owned by the IHRC or the development of new devices.
- (3) The IHRC also recommend extending its research to the methods of used to attach roof coverings in order to determine if their performance under hurricane winds could be improved in an cost-effective way. The focus of this work will be to raise the failure threshold for various roof coverings.

D. Investigation of Influence of Architectural Features on Wind Loads

Researchers at the IHRC from the building design and construction professions intuitively believe the shape of houses, and especially the shape of the roofs of houses, may act as *impact* or *performance modifiers* when the house is subjected to hurricane winds.

Regarding this potential role of building shapes it is important to recognize that building codes provide little guidance for estimating wind loads on buildings with complex shapes or a variety of architectural features.

Even the latest editions of the ASCE 7 – *Minimum Design Loads for Buildings and Other Structures*, that have been incorporated into the Florida Building Code, offer very little with respect to “L” shaped houses, houses with dormers or multi-level roofs, or other combination of house and roof shapes.

A key question regarding this issue has to do with whether architectural roof features, such as dormers or overhangs, dampen the impact of wind thereby protecting the whole house or if, on the contrary, they amplify the impact placing the house under more severe wind loads.

To address this issue and related questions the IHRC undertook tests using reduced-scale models in a Boundary Layer Wind Tunnel (BLWT). A total of five 1:50 scale models built by students at FIU School of Architecture were tested. These models included a variety of house shapes and several architectural features that could be added to the roof or removed.

Knowledge gained from this research will help building designers to better understand how the shape of the building, and various architectural features, could be used to improve the performance under hurricane impacts.

Main findings from this initial work follow:

Findings:

- (1) These types of tests are quite useful for the production of *wind pressure maps* for roofs of houses. Such maps help designers and builders identify the critical areas of each roof and their association with specific architectural features or roof shapes.
- (2) Initial analysis of data collected from the various tests indicates architectural features, such as dormers, do indeed act as impact modifiers. It appears these architectural features modify the wind flow over the roof in such a way as to reduce the occurrence of extreme pressures that often lead to roof uplift.
- (3) Based on the above finding, the IHRC Team believes all of the additional structural blocking and bracing needed to build dormers and other architectural features, contribute to strengthening of the roof structure. In fact the net result is a more rigid and stronger structure with a higher capability to perform under the impact of hurricane winds.
- (4) Not surprisingly the IHRC Team found that maximum (extreme) uplift pressures happened at the edges of roof peaks and overhangs.

- (5) The IHRC Team considers work on this research area during 2002-2003 to be preliminary. Additional work is needed to better understand how the interaction of various roof shapes with one another, either within one house or in the cases of groups of houses, really affect the type and magnitude of wind pressures acting on the roof.

Recommendations:

- (1) Additional works is needed on this area. More tests using models with more complex roof shapes, including larger overhangs and combinations of various shapes.
- (2) The IHRC Team also proposes to extrapolate this work to the issue of *neighborhood design* where tests will be conducted using models to depict clusters of houses around typical conditions found in residential neighborhood, such as a cul de sac or perhaps an intersection. Understanding how the mix of shapes of several houses in a cluster may affect the wind loads impacting each of the individual houses would be helpful for planners and developers.
- (3) The IHRC Team recommends these neighborhood studies should also include models of various types of *mature vegetation* to research its role as an impact modifier. Empirical data from hurricane Andrew shows mature vegetation may have played an important role in modifying the impact of wind in certain neighborhoods.
- (4) This type of work, using reduced-scale models in the BLWT, needs to be combined with testing of full-size roof assemblies. The main purpose of this would be to research ways in which the extreme pressures at the roof edges could be modified in order to reduce the potential for damage. This work would benefit from testing of full-scale assemblies during the 2001-2002-research period.

E. Field Measurements of Wind Loads on Flat Roofs

A good portion of the work of the IHRC Team focuses on the roof as a critical component of the building envelope, both in housing and in larger commercial or institutional buildings. A key objective of this research is to gain a better understanding of how variations in pressure are distributed over the surface of a roof under hurricane conditions. The ultimate objective of doing this is to determine what factors are involved

in creating weak areas on a roof that may lead to potential damage, breaching of the building envelope and eventual structural damage as well as damage to the interior and contents of the house of building.

One method used to do what is described above is to install instruments on the roof to read the variations in wind pressures as a function of wind speeds. One problem that arises when working with flat roofs is the impossibility of attaching any instrumentation to the roof without penetrating the roof covering and underlayment and without causing leaks. The other problem is that water will build up on a flat roof especially during heavy rains, so a data acquisition instrument would have to be elevated in order to avoid being compromised by rising water.

The IHRC Team has actually designed a prototype instrument to acquire the desired data, which can be installed on the flat roof without having to be attached to it, and without being invaded by rising water. In fact the instrument itself is held on the roof by gravity. The weight of the instrument and its design will keep in place even under high winds.

Data collected from an array of these instruments will be used to generate a color-coded pressure map of the flat roof. This will help identify the weakest areas on the instrumented roof.

This pressure map and the supporting data will then be used to identify structural reinforcing measures, or alternate methods of installation that will increase the threshold for damage.

Findings:

- (1) A wind gauge is needed to work in conjunction with the array of instruments on the flat roof. Ideally this anemometer should be installed on an open field near the building so that reading of wind speeds will not be compromised by the building itself interfering with the wind flow.
- (2) Sensors will need to be left on the roof for a whole hurricane season to calibrate their capabilities.
- (3) Current design of these sensors includes a heavy gauge aluminum housing to protect the electronics and the pressure gauge from the elements. Initial tests

have shown the high temperature built-up inside this housing may damage some of the electronics inside it.

- (4) Another finding by the IHRC team was the need to have the whole array of sensors and the data acquisition equipment connected to redundant back-up for electric service to ensure the data acquisition will continue for as long as possible under hurricane conditions, even if the electric utility services has been interrupted.

Recommendations:

- (1) The IHRC team recommends continued data acquisition using the array of sixteen sensors currently installed on the roof of a three-story building at the FIU center for Engineering and Advanced Science through the 2003 North Atlantic hurricane season.
- (2) Analyze the data on a monthly basis and prepare pressure maps of the area of the flat roof that is now instrumented. Before the end of the 2003-2004 research period combine the various maps into one comprehensive map.
- (3) Continue researching the design of the instrument in order to resolve the issue of the high temperature built-up inside the housing. This research should also look into other design considerations with the objective of identifying fabrications methods that would improve the sensor.
- (4) Acquire an array of meteorological instruments that can be mounted on a mobile tower to be deployed near the instrumented building, but on an open field in order to obtain wind-speed readings to calibrate the sensors and the roof-mounted anemometer.
- (5) Fabricate additional sensors to instrument other buildings with flat roofs, but with different orientation and other conditions that the one currently instrumented.

F. Gable-End Overhang Study

The IHRC work with roof and house shapes and other architectural features, as described in the previous section, has confirmed roof and peak edges and overhangs are the most critical areas with respect to extreme wind pressures, and potential initiation points for damage.

The gable end overhang has been found the primary point of initial roof failure under hurricane winds. The IHRC Team has found a complex combination of loads that acts on this area of the roof when subjected to hurricane winds.

A structural framing assembly known as a rake end overhang ladder detail resists this complex combination of forces. During 2002-2003 the IHRC began to develop a diagram of said framing detail including a schematic load diagram.

The IHRC proposes to continue researching this gable end overhang detail in order to assess ways in which it might be reinforced to improve its performance under the complex combination of loads already described. This work may lead to the development of hurricane loss reduction methods of construction.

Findings:

- (1) The complex system of forces acting on the gable end overhang develops when wind flows over the bluff edge of the gable end. Wind action on the windward wall created a positive pressure on it that also extends to the underside of the overhang. At the same time the wind flow separates as it goes over the edge of the roof creating a negative pressure on the top surface of the overhang. Both the underside positive pressure and topside negative pressure combine to subject the overhang to extreme forces. At the same time this forces produce a moment of force where the overhang structural framing attaches to the gable end truss or rafter.
- (2) Nails attaching the roof sheathing to the gable end truss or rafter are critical in resisting the complex combination of forces described above.

Recommendations:

- (1) More research is needed to isolate the total forces acting on these critical roof-sheathing fasteners. This will help the IHRC Team research ways to strengthen the rake overhang framing detail in order to reduce the potential for damage that originates at that point.

G. HLMP (RCMP) Evaluation Program: The Targeted Survey of Building Professionals

The State of Florida invests an important sum to fund the RCMP on an annual basis. These monies are used to pay for a range of projects involving several public and private research institutions and other agencies.

The State DCA, the department through which RCMP funding flows, has instituted a program to measure the effectiveness of the program in delivering results toward the objective of hurricane loss reduction.

The IHRC has been tasked with helping DCA assess how the overall RCMP is meeting its objectives, and also how individual component of the program are performing. For the 2002-2003 period the IHRC Team was asked to assess the performance of an RCMP effort designed to educate pertinent professionals about key components of the Florida Building Code enacted July 1, 2001.

To that end the IHRC Team conducted a telephone survey targeting building design and construction professionals throughout Florida. The focus of this survey was to evaluate the various methods being used to achieve the desired educational results among pertinent professionals in the state.

Findings:

- (1) IHRC Survey results indicate the RCMP is achieving satisfactory results in delivering Florida Building Code education to building design and construction professionals throughout Florida. Such positive results are reflected in the percentage of professionals who had completed the training by June 1, 2003.

- (2) One of the objectives of the State in establishing a statewide building code was to improve compliance throughout the state. A majority of those surveyed, 53% agree that code compliance has improved as a result of the new code.
- (3) About 69% of building professionals feel the adoption of the Florida Building Code will make Florida safer under the impact of hurricanes.
- (4) This feeling about the Florida building Code contributing to a safer built environment is more prevalent among architects than engineers and contractors. In fact 23.9% of contractors disagree with the opinion that Florida will be safer as a result of the adoption of the Florida Building Code, another 12.4% of the contractors responded they were “not sure” when asked about such added safety.
- (5) The educational effort undertaken under the RCMP has raised awareness about the key components of the Florida Building Code among building design and construction professionals. This is an important result given the duration of both the classroom-based and Internet-based methods of delivery being used.

Recommendations:

- (1) The RCMP should continue this educational effort on the Florida Building Code. While the initial effort has achieved good results, additional more detailed and specific efforts might be required to familiarize building professionals with key aspects of the code. This might be especially effective to highlight the requirements of the High Velocity Hurricane Zone.
- (2) The IHRC Team recommends additional educational work related to the Florida Building Code could focus on the issue of the cost of compliance. This would help answer the questions about whether the cost of construction has increased or not as a result of the new code. This should be coupled with an assessment of how building performance may have improved, hence hurricane mitigation, under the new code.
- (3) The IHRC Team recommends other components of the larger program should be targeted for assessment of performance during the 2003-2004 period and in future years. Findings from such assessments will help DCA inform the State Legislature about how effective the RCMP is in obtaining practical results, benefits, from the annual funding provided.

H. HLMP (RCMP) Evaluation Program: the Hurricane Loss Mitigation Statewide Survey

The RCMP has been in place for several years now. Given the nature of the program and the amount of annual funding that it receives, it is important for DCA to continuously gauge how effective the program is in meeting its main objectives. One of those objectives is to raise awareness among Florida residents to the vulnerability of the state to hurricane impacts, the role of hurricane mitigation methods and techniques, and the benefits to be obtained by practicing mitigation.

To a large degree the effectiveness of the program depends on the delivery of the desired message to the public, but also on the attitudes and perceptions of the residents of Florida as receptors of that message.

Important research findings from the RCMP could become knowledge to be transferred to Florida residents to be applied as practical hurricane mitigation measures. How effectively this transfer of knowledge is achieved will depend on how receptive the general public is to the RCMP.

On this topic, one key question is: how much do Florida residents really know about the RCMP and its objectives?

To learn more about this the IHRC was tasked with conducting a statewide survey to establish a baseline of how much the general public knows about the RCMP and the objectives of this program. Such a baseline will be critical in helping gauge what impact the RCMP is really having, through future survey results that can be compared to this baseline.

Findings:

- (1) The statewide survey conducted by the IHRC team has provided a wealth of information regarding the knowledge, perceptions and attitudes of Florida residents with respect to hurricane vulnerability and the role of mitigation in reducing potential for damage to their households.
- (2) This survey will establish a baseline against which future surveys can be compared to measure changes. This method will help DCA gauge how the

RCMP may be contributing to such changes, especially regarding the benefits of hurricane mitigation methods and techniques.

- (3) One important finding, given the ever-expanding diversity of Florida's population, is the need for the State to recognize language diversity and develop ways of addressing it to promote hurricane mitigation. The message needs to be communicated to be understood; using various languages to deliver it will help.
- (4) The survey shows the stock of single-family detached owner-occupied housing is getting "newer" in Florida. Fully 38% of these types of residences have been built since 1990.
- (5) Another important finding is the amount of building envelope protection that is in place in different regions of the state. The survey shows 48% of homeowners residing in single-family detached housing have no form of window protection against hurricane winds and flying debris. On the flip side of this, 40.9% of those surveyed have full or partial protection with 26.6% indicating they have 100% protection using products that meet the product approval requirements of the Florida Building Code.
- (6) On a regional basis the survey shows interesting results. In Southeast Florida 33.3% of residents have no building envelope protection to partial protection. This number is 72% for the east coast of Florida north of Palm Beach County; 70% for residents of the west coast of Florida; 69% for those in North Florida and a high of 77% for those residing in the Florida panhandle.
- (7) The previous finding may be a reflection of the degree of "hurricane experience" among the residents of various regions within the state. For example 42% of the households in Southeast Florida indicate they have or live in a house that was damaged by a hurricane, compared to 36.2% of those in the Florida panhandle.
- (8) The IHRC Team found a good degree of interest among Florida residents on the concept and benefits of mitigation, but very little knowledge about specific mitigation measures that can be implemented. From this it can be concluded that much needs to be done to educate the public about specific mitigation methods and techniques.
- (9) A positive finding was that 68% of these homeowners are interested in a program of *hurricane mitigation audit* similar to FPL's energy audit.

- (10) The IHRC survey found that nearly 65% of homeowners that purchased their homes during the last five years considered hurricane safety features as somewhat or very important in their decision.
- (11) An interesting and important finding has to do with the specific types of hurricane mitigation features mentioned as important by these homeowners: 47% considered type of construction, specifically CBS, as important, 39% mentioned window protection, and 32% mentioned roof materials and bracing. The fact that these homeowners mentioned specific measures is indicative of some degree of knowledge about the risk and about what mitigation is. This finding could be exploited by the RCMP to focus on certain types of research and education/outreach activities in pursuit of its objectives.
- (12) Several questions were added to the survey instrument designed by the IHRC Team at a late date within the established timelines. Also, many of these questions were more of the type used in opinion polls rather than in scientific surveys. As a result of these actions delivery of the survey and its related data analysis took place under a reduced time frame; this is not the best approach to use when conducting this type of important survey. Also incorporating poll type questions created some difficulties in tying the survey instrument into a coherent and effective device.

Recommendations:

- (1) The IHRC Team recommends follow-up statewide surveys should be undertaken every two to three years in order to measure changes with respect to the baseline. Such comparison between baseline and follow-up surveys will be critical in measuring the overall effectiveness of the RCMP in meeting its objectives.
- (2) Poll type questions that need to be posed to the general public for the benefit of other entities collaborating with the RCMP should be provided to the IHRC Team early in the annual research period in order to minimize or avoid time constraints placed on this activity. Also, these types of questions should perhaps be included in a separate instrument that could be delivered concurrently with the main survey.

- (3) DCA and the RCMP Advisory Council should monitor changing objectives within the RCMP in order to advise the IHRC Team of any need for questions to address new areas of interest.

I. Feasibility of Incentives for a Program of Hurricane Loss Reduction for Site-built Housing

DCA and the RCMP Advisory Council as well as the IHRC team and others participating in this program believe it will take a combination of research findings, education and outreach efforts and *incentives* to promote the adoption of hurricane mitigation devices and techniques among Florida residents.

While insurance companies providing homeowners coverage have offered some financial incentives, in the form of premium discounts, for homes that incorporate specific types of hurricane mitigation measures, no other coordinated program of incentives exists to promote the wholesale adoption of hurricane mitigation in housing design and construction.

The IHRC Team was tasked with exploring existing incentives programs applicable to other types of activities to see if they could be adapted to the field of hurricane mitigation. This research also included assessing the possibility of combining devices and techniques used in other fields, i.e.: energy, to see if they could also provide some hurricane mitigation value.

Findings:

- (1) Some financial incentives for incorporating hurricane mitigation measures in site-built housings are already available in Florida. Most of these are in the form of homeowner insurance premium credits or reductions. For example, credits of 5% to 10% are available from insurers for the installation of hurricane shutters, but only when the total building envelope is protected.
- (2) There are some insurance premium discounts available form manufactured homes built to comply with HUD manufacturing standards of 1994.
- (3) IHRC Team research indicates it appears insurers may consider additional incentives for mobile home tie-down improvement programs, but only to the extent that a tie-down inspection program exist to ensure quality and performance.

- (4) There are several incentive programs throughout the country in the energy sector. Some of these involve a so-called “Energy Audit” that is used to identify measures to help improve the energy-efficiency of a house. Once these energy-conservation measures are implemented the homeowner receives tax credits or tax exemptions equal to a percentage of the cost of the installed device. This also applies to solar-energy devices.
- (5) Florida Power and Light (FPL) promotes a “Build Smart Program” that may lead to savings of 30% in the annual energy bill for the house. This program allows individual homeowners as well as building contractors participate.
- (6) Other programs involving better/safer home construction include: (a) The *Blueprint for Safety* sponsored by the Federal Alliance for Safe Homes (FLASH), and (b) The *Fortified for Safer Living*, a program of the Institute for Business and Home Safety (IBHS). Both these programs promote strengthened construction to mitigate the potential for damage from the impact of hurricanes and other hazards, but offer no incentives or subsidies to help pay for the added cost of construction.
- (7) The IHRC Team identified a program that may actually contribute to weakening the house structure increasing the risk of hurricane damage. This is promoted by the HUD Affordable Housing Study Commission that is designed to reduce the cost of construction of a house. Unfortunately some of the construction measures this program promotes, including: (a) using oriented strand board (OSB) or laminated fiberboard instead of plywood for sheathing, (b) Increasing the spacing between structural framing members, or (c) using 2”x3” studs instead of 2”x4”s, really contribute to a weaker structure that may sustain higher damage under the impact of a hurricane.
- (8) California has undertaken a program to promote earthquake safety that carries several financial incentives including tax credits.
- (9) Despite these promising programs of incentives promoting energy conservation or earthquake safety none of them are really applicable to the issue of hurricane mitigation.

Recommendations:

- (1) Explore the HUD construction cost-saving program to assess if its structure could be used as a foundation for a program that would promote cost-effective hurricane mitigation instead.
- (2) Research the details of the California Earthquake safety program, specifically in regards to the incorporation of the building design and construction professionals, and its tax credits structure, to see if these elements could be adapted to a hurricane mitigation program in Florida.
- (3) Research the design of a program centered on hurricane mitigation measures derived from the research of the IHRC in the field of structural mitigation. This program would take advantage of cost-effective or cost-reducing mitigation measures that have shown to improve the performance of building components under hurricane winds, thus mitigating the potential for hurricane damage.

THE BILL WILLIAMS ACT

Work by the IHRC for the *Hurricane Loss Reduction for the Residences and Mobile Homes in Florida* research project is being funded through a legislative earmark under Florida Statutes section 215.559 – Hurricane Loss Reduction Program also known as the *Bill Williams Residential Safety and Preparedness Act*.

The text of this statute follows:

The 2001 Florida Statutes; Title XIV; Taxation and Finance Chapter 215; Financial Matters: General Provisions View Entire Chapter

215.559 Hurricane Loss Mitigation Program.--

(1) There is created a Hurricane Loss Mitigation Program. The Legislature shall annually appropriate \$10 million of the moneys authorized for appropriation under section 215.555(7)(c) from the Florida Hurricane Catastrophe Fund to the Department of Community Affairs for the purposes set forth in this section.

(2)(a) Seven million dollars in funds provided in subsection (1) shall be used for programs to improve the wind resistance of residences and mobile homes, including loans, subsidies, grants, demonstration projects, and direct assistance; cooperative programs with local governments and the Federal Government; and other efforts to prevent or reduce losses or reduce the cost of rebuilding after a disaster.

(b) Three million dollars in funds provided in subsection (1) shall be used to retrofit existing facilities used as public hurricane shelters. The department must prioritize the use of these funds for projects included in the September 1, 2000, version of the Shelter Retrofit Report prepared in accordance with s. 252.385(3), and each annual report thereafter. The department must give funding priority to projects in regional planning council regions that have shelter deficits and to projects that maximize use of state funds.

(3) Forty percent of the total appropriation in paragraph (2)(a) shall be used to inspect and improve tie-downs for mobile homes. Within 30 days after the effective date of that appropriation, the department shall contract with a public higher educational institution in this state which has previous experience in administering the programs set forth in this subsection to serve as the administrative entity and fiscal agent pursuant to s. 216.346 for the purpose of administering the programs set forth in this subsection in

accordance with established policy and procedures. The administrative entity working with the advisory council set up under subsection (5) shall develop a list of mobile home parks and counties that may be eligible to participate in the tie-down program.

(4) Of moneys provided to the Department of Community Affairs in paragraph (2)(a), 10 percent shall be allocated to a Type I Center within the State University System dedicated to hurricane research. The Type I Center shall develop a preliminary work plan approved by the advisory council set forth in subsection (5) to eliminate the state and local barriers to upgrading existing mobile homes and communities, research and develop a program for the recycling of existing older mobile homes, and support programs of research and development relating to hurricane loss reduction devices and techniques for site-built residences. The State University System also shall consult with the Department of Community Affairs and assist the department with the report required under subsection (7).

(5) Except for the program set forth in subsection (3), the Department of Community Affairs shall develop the programs set forth in this section in consultation with an advisory council consisting of a representative designated by the Department of Insurance, a representative designated by the Florida Home Builders Association, a representative designated by the Florida Insurance Council, a representative designated by the Federation of Manufactured Home Owners, a representative designated by the Florida Association of Counties, and a representative designated by the Florida Manufactured Housing Association.

(6) Moneys provided to the Department of Community Affairs under this section are intended to supplement other funding sources of the Department of Community Affairs and may not supplant other funding sources of the Department of Community Affairs.

(7) On January 1st of each year, the Department of Community Affairs shall provide a full report and accounting of activities under this section and an evaluation of such activities to the Speaker of the House of Representatives, the President of the Senate, and the Majority and Minority Leaders of the House of Representatives and the Senate.

(8) This section is repealed June 30, 2006.

History.--s. 2, ch. 99-305; s. 1, ch. 2000-140; s. 1, ch. 2001-227.

THE IHRC PROJECT RESEARCH TEAM

In keeping with the comprehensive agenda of the research topics for this project, the IHRC organized a multidisciplinary team of researchers, assistants and support staff from within the IHRC and five academic institutions.

All together a total of forty-nine individuals were involved in this project representing such disciplines as (a) architecture, (b) construction management, (c) civil engineering, (d) sociology and anthropology, and others.

In addition to their specific disciplines members of the IHRC research team possessed a wealth of practical expertise in the fields of (a) emergency management, (b) vulnerability assessment, (c) hazard mitigation, (d) hurricane damage assessment, (e) structural testing, (f) construction management, (g) analytical survey methodology, (h) statistical analysis, (i) project management, and others.

The 49 members of the research team are listed below:

Principal Investigator: Ricardo Alvarez FIU/IHRC

Project Manager: Carolyn Anderson FIU/IHRC

Principal Researchers:

Syed Ahmed	FIU	Construction Management
Ronald Baier	FIU	Construction Management
Amaury Caballero	FIU	Construction Management
Jaime Canaves	FIU	Architecture
Jason Chandler	FIU	Architecture
Nicole Dash	UNT	Sociology
Jack Dye	FIU	Construction Management
Eugene Farmer	FIU	Construction Management
Hugh Gladwin	FIU	IPOR
T. Trent Green	USF	Architecture
Martha Gutierrez	FIU	HPDRC
Walter G. Peacock	TA&MU	Landscape Architecture & Urban Planning
Edgar Polo	FIU	HCET

Principal Researchers (cont'd....):

Alex Ratensky	USF	Architecture
Alfredo Ravinet	FIU	HCET
Timothy Reinhold	Clemson	Civil Engineering
James Rivers	FIU	IHRC
Stephen Schreiber	USF	Architecture
Kang Yen	FIU	Construction Management

Research Assistants:

Christien Acosta	FIU	Construction Management
Josue Cruz	FIU	Architecture
Michael DeLoach	Clemson	Civil Engineering
Carlos Escuti	FIU	Architecture
Ernesto Iona	FIU	Electrical Engineering
Laura Lake	USF	Architecture
Kevin Nickorick	USF	Architecture
Mauricio Medina	FIU	Construction Management
Mary Phillips	Clemson	Civil Engineering
Scott Robinett	Clemson	Civil Engineering
Swapnali Salunkhe	USF	Architecture
George Torrente	FIU	Architecture
Zuzana Hlavacova	FIU	International Relations

Undergraduate Students:

Victor Campos	FIU	Architecture
Brian Dick	Clemson	Civil Engineering
Cos Gardner	Clemson	Civil Engineering
Kyle Hardee	Clemson	Civil Engineering
Jon Lamb	Clemson	Civil Engineering
Brie Losego	FIU	Architecture
Ryan Losego	FIU	Architecture

Support Staff:

Antonio Moreno De Ayala	FIU	Facilities Management
Kyle Campbell	USF	FCCDR

Support Staff (cont'd....):

Maria Cano	FIU	IHRC
Scott Caput	FIU	IHRC
Regnier Jurado	FIU	IHRC
Ana Rouco	FIU	IHRC
Patricia Ruiz	FIU	Facilities Management
Jennifer Sandford	USF	FCCDR

THE WORK PLAN AND TIMELINES

To address the purpose of this research project, as stated in the language of the Bill Williams Residential Safety and preparedness Act, the IHRC and DCA, after consultation with an ad-hoc sub-committee of the Hurricane Loss Mitigation Advisory Council, agreed on a set of three research tracks. Included below is the text of a document submitted by the IHRC to DCA containing the work plan and timelines. The Work Plan guided all research work during the 2002/2003 year covered under the Final Report.

MEMORANDUM

TO : Keith Delhomme – RCMP
FROM: Ricardo A. Alvarez – IHC/FIU
REF : Research Agenda
DATE : July 12, 2002

Based on the results of a telephone conference on June 5, 2002, and a meeting of Ricardo A. Alvarez, representing the International Hurricane Research Center (IHRC) at Florida International University (FIU), with Mr. Robert S. Cohen, Mr. Don Hazelton of the RCMP Advisory Council, and Ms. Lori Killinger on June 18, 2002 the IHC proposes the following research work for the year starting on July 1, 2002 and ending on June 30, 2003 under the Hurricane Loss Reduction Project:

(1) Eliminating State and Local Barriers to Upgrading Existing Mobile Homes and Communities

Work under this research topic will emphasize the collection of data from actual case studies that should help illustrate the various types of barriers encountered, the result of the process and which will also assist in evaluating potential remedies or solutions for the elimination of such barriers.

- (a) Work will build upon research conducted during the year 2001-2002 in Broward, Hillsborough, Miami-Dade, Pinellas and Polk counties.
- (b) The specific geographical areas where research data will be collected, including specific counties or municipalities, will be identified in consultation with a subcommittee designated by the Advisory Council to include Mr. Robert S. Cohen, Mr. Don Hazelton and Ms. Lori Killinger or their designees.

- (c) The specific area or areas to be included in the 2002-2003 research cycle will depend on priorities set by DCA, other research objectives required by DCA and budgeting constraints.
- (d) In addition work under this research track will also look into potential remedies to correct some of the contributors to given barriers. For example: during the current year knowledge gaps have been detected among public agency staff responsible for informing the public. The IHC will work in two areas, Hillsborough- Pinellas-Polk and Miami-Dade-Broward, to design and test an educational program to correct said knowledge gaps.

(2) Development of a Replacement Program for Existing Older Mobile Homes

Work will concentrate on the completion of specific work initiated during the 2001-2002 cycle that requires more time and a much more comprehensive analysis due to the complexity of issues. Specifically this effort will focus on:

- (a) Funding alternatives for a proposed older mobile home replacement program could be funded;
- (b) Resolution of critically complex social issues that have been identified through research during 2001-2002, and
- (c) How would potential stakeholders in an eventual older mobile home replacement program react or contribute to the same.
- (d) Time and motion and cost study for the actual replacement of at least one unit to further verify the findings resulting from work during 2001-2002. This will take the form of a practical exercise to verify all of the technical and regulatory steps involved in the removal and disposal of a mobile home.

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

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

3.1 Continuation of Structural Testing on at Least Five of the Areas Listed Below:

- (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 various roof covering materials, and
- (c) Performance of roof to wall connections.
- (d) 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;
- (e) 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;
- (f) 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.
- (g) 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.

- (h) Development of prototype loss-reduction devices for roof covering. This may involve devices to reinforce the edge of shingle roofing along the gable end. Test will focus on cost-effectiveness of such prototype devices as well as on installation methods.

3.2 Evaluation of Effectiveness of Hurricane Loss Reduction Program

IHC 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 IHC 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 by financial institutions and insurers to create incentives for the adoption of energy efficient building methods.

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

Work Elements

The IHRC/FIU proposes to complete the following specific elements of work:

1. Eliminating state and local barriers to upgrading existing mobile homes and communities
2. Research and develop a program of recycling of existing older mobile homes
3. Programs of research and development relating to hurricane loss reduction devices and techniques for site-built residences
4. Project Progress Reports
5. Assisting DCA in drafting the Annual Report to the Florida Legislature

Guiding Criteria and Objectives

Work to be conducted by the IHRC/FIU will abide by the following guiding criteria:

1. The IHRC/FIU will emphasize assessing the scope of the issue by identifying those factors, ranging from the physical and structural to the social and regulatory, that may contribute to or influence the incidence of hurricane damage to site-built residences and manufactured housing in Florida.
2. The IHRC/FIU will build upon the findings and recommendations that resulted from work completed for this project during the fiscal year that ended June 30, 2002.
3. The IHRC/FIU will continue to work on specific areas initiated during the first year of this project that are critical to enhancing our assessment of the scope of the issue as it relates to the three specific research tracks approved by the State Legislature.

The main objectives of the work proposed by the IHRC/FIU are:

1. To meet the requirements established by the Act related tot the development of hurricane loss reduction devices and techniques and credible data on potential loss reduction

2. To understand the issues and the factors that may influence the same, that may act as barriers or incentives to hurricane loss mitigation;
3. To identify specific issues arising from work under this project that are relevant to the mission and objectives of DCA and other interested parties, including homeowners and regulators having jurisdiction over housing-related matter;
4. To identify potential policy alternatives that may be considered by state policy-makers that address issues of hurricane loss reduction for the housing stock in Florida.

Timelines

Main timelines for this project are:

1. September 20, 2002; submit detailed work plan and milestones chart to FL DCA
2. September 18, 2002; initiate research work related to program evaluation
3. September 20, 2002; complete organizational/contractual phase including (a) subcontracting with researchers/consultants outside FIU, (b) hiring/retaining graduate students affiliated with FIU faculty
4. October 15, 2002; submit Quarterly Report
5. October 23, 2002; working meeting of research team
6. November 30, 2002; submit draft of Annual Report to the Florida Legislature
7. January 10, 2003; working meeting of research team
8. January 15, 2003; submit Quarterly Report
9. April 4, 2003, working meeting of research team
10. April 15, 2003; submit Quarterly Report
11. June 30, 2003; complete draft of final report and distribute for review and discussion to all members of IHC/FIU research team
12. July 30, 2003; submit final report including key findings and recommendations to DCA

Hurricane Loss Reduction Project Milestones Chart

	July	August	September	October	November	December	January	February	March	April	May	June	July
	1 15 31	1 15 31	1 15 30	1 15 31	1 15 30	1 15 31	1 15 31	1 15 28	1 15 30	1 15 30	1 15 30	1 15 30	1 15 31
Overall Work Plan													
IHC Proposal & Preliminary Work Plan	█												
Organizational & Contractual Phase													
Reporting Requirement 1: Work Plan and Milestones Chart	█	█	█	█	█								
Test Space Identification			█	█	█	█							
Reporting Requirement: Annual Report to Legislature				█	█	█	█						
Test Space Contractual Phase				█	█	█							
Test Space Set-up					█	█	█	█					
Reporting Requirement 2, 4, & 5: Submit Quarterly Report													
Reporting Requirement 6: Final Report													█
Working Meeting				█				█			█		
Advisory Council Meetings					█			█			█		
Research Tracks													
1). Eliminating Barriers													
Identification of Case Study Sites				█	█	█							
Assessment of Existing Up-grading Problems				█	█	█	█	█					
Re-platting Case Study							█	█	█	█	█	█	█
Analysis of Regulatory Environment							█	█	█	█	█	█	█
Mobile Home Parks Case Studies							█	█	█	█	█	█	█
Mobile Home Residents Interview and Surveying Instruments							█	█	█	█	█	█	█
Case Study Graphics and Visuals										█	█	█	█
Assessment of Current and Forecast Distribution of Manufactured Housing in Florida				█	█	█							
Case Study Jurisdictions Identification/Selection					█	█							
Document Regulatory Requirements by Case Study Jurisdiction						█	█	█	█				
Statewide Survey of Building Officials							█	█	█	█			
Qualitative Interviewing of Building Officials in Case Study Jurisdictions								█	█	█	█		
Educational and Outreach Materials/Initiative										█	█	█	█
Data Analysis/Findings/Recommendations/Report											█	█	█

