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HURRICANE LOSS REDUCTION FOR RESIDENCES AND MOBILE HOMES IN FLORIDA

A Research Project Funded by
The State of Florida Department of Community Affairs
Through Contract 01-RC-11-13-00-22-004

PRELIMINARY REPORT ON LOSS REDUCTION RETROFITS AND STRUCTURAL PERFORMANCE

DELIVERABLE #7

DUE BY MAY 1, 2001

PREPARED BY
THE INTERNATIONAL HURRICANE CENTER
FLORIDA INTERNATIONAL UNIVERSITY

PURPOSE

This report provides preliminary findings regarding alternatives for hurricane loss reduction measures that could be incorporated into the retrofitting of existing housing units, be they site-built or mobile homes, or as part of the design and construction or manufacturing of new units.

This preliminary report reflects the work of the International Hurricane Center (IHC) research team on the matter of *Loss Reduction retrofit and Structural Performance*, one of five research tracks under a project titled "Hurricane Loss Reduction for Residences and Mobile Homes in Florida"

The scope of the specific research track is as follows:

> *Loss Reduction Retrofits and Structural Performance: This research will identify and assess the effectiveness of various hurricane loss reduction measures that could be incorporated in the retrofitting of existing housing units, both conventionally site-built or manufactured, or even in their design and construction. The research will focus on:*
> *(a) Ways to retrofit existing housing units, both site-built and manufactured homes;*
> *(b) A review of research and testing related to loads, structural system performance and anchoring system performance for manufactured homes of different ages and types of construction,(c) Identification of potential retrofitting systems measures that may be effective in reducing the potential for damage from hurricanes;*
> *(d) Assessments of the mitigation effectiveness (damage reduction capability) of various, and retrofitting devices and techniques and their respective benefit-cost ratios;*
> *(e) The regulatory environment under which such loss reduction retrofitting may be allowed and recognized, and*
> *(f) Jurisdiction and authority regarding mitigation measures that may be incorporated during mobile home manufacturing/design processes.*

The link between hurricane loss reduction and structural performance is direct and clear. Design and construction or manufacturing are also directly linked to structural performance. The equation is clear. The design of housing units and their construction or manufacturing, but also installation in the case of mobile homes, play a critical role in the issue of hurricane loss reduction.

On the issue of hurricane loss one key question that often arises, mainly in the aftermath of a disaster, is: *what to do with existing housing stock that may not meet the higher standards for hurricane resistance?* Typical responses to this question usually point in the direction of retrofitting. The IHC research team working on this specific research track has already began the conceptual exploration of alternatives with regard to the existing stock of mobile homes.

Relative to these linked issues of hurricane loss, structural performance and retrofitting there is am important finding that has emerged from the work of the IHC research team. It has to do with the *in-situ* field retrofitting, and remodeling, of mobile homes that appears to be quite prevalent in numerous mobile home parks in Florida. It appears these post-installation modifications of mobile homes are primarily driven by two factors: (a) the desire to enlarge the dwelling, (b) aesthetics. Beyond the regulatory issues that arise from this activity, there is a much larger issue of hurricane vulnerability and the fact that these modifications are increasing the same from a structural performance point of view. (*Please See APPENDIX D*)

This report has been completed with contributions by the following members of the IHC research team: Jose Mitrani (FIU), Timothy Reinhold (Clemson University), Ronald Cook (UFL), Ricardo Alvarez (IHC), Jorge Remedios (FIU), Janaina Monteiro (IHC), Laura Tropeano (UFL), Dennis Altman (Clemson), Scott Robinett (Clemson) and John Lamb (Clemson)

This report has been prepared in compliance with the deliverable requirements of DCA Contract Number 01-RC-11-13-00-22-004 executed September 8, 2000 and modified through Amendment #1 executed January 18, 2001. This report specifically complies with deliverable #7 of said contract, due by May 1, 2001, which reads as follows:

> *By may 1, 2001, the Contractor shall submit both in hard-copy and electronic format a preliminary Report on the Loss Reduction Retrofits and Structural Performance. The report shall include research conducted on items a-f as referenced under this Scope of Work, section A, Part II Research, item 5.*

A WORK IN PROGRESS

This is a preliminary report. During the short time available since January 18, 2001 the IHC research team has conducted extensive search for, and review of, sources of information relative to loads, performance of structural systems and anchoring systems in manufactured homes of different ages and types. The team has also began to identify alternative for potential retrofitting of existing housing units, both site-built and manufactured homes. Issues of regulatory environment and of jurisdiction regarding the potential authorization of given retrofitting alternatives to mitigate the potential for damage from future hurricane impacts, are also being explored.

It must be emphasized however that conceptual findings addressing structural performance and potential retrofitting alternatives will need to undergo extensive analytical and physical testing, and field calibration, before their mitigation effectiveness can be properly assessed with regards to capabilities for hurricane loss reduction. Such testing is outside of the scope of this research effort. More importantly, the limited time left until the end of the current effort (June 30, 2001) will only allow the IHC research team to create a foundation for work on these outstanding, but critical issues, during the second year of this project.

It is also important to emphasize any specific findings or opinions contained in this report are preliminary in nature and must not be cited or referred to for purposes of supporting conclusions relative to structural performance or other matters.

This report also includes comments from the IHC research team regarding this research effort and future phases of work that may contribute to meeting the objectives of hurricane loss reduction that are central to the project.

Preliminary Report on Loss Reduction Retrofits and Structural Performance

OBJECTIVES

The objective of this study is to identify and to assess potential hurricane loss reduction measures that could be incorporated into the retrofitting of existing housing units. While the primary focus of the research is on manufactured homes, the study also considers retrofit measures for conventional site built homes.

GENERAL

Most of the research related to evaluating the condition of older manufactured homes or mobile home units has focused on degradation of the homes from moisture buildup in the walls and attic or ceiling spaces. Similarly, most of the research and demonstration projects for manufactured housing have generally dealt with improving the energy efficiency of the units. Little or no published work has been found that specifically investigates methods for improving the structural resistance of existing manufactured housing units. In some cases, the opportunity exists to transfer ideas and technologies developed for retrofitting conventional site built construction, where more research has been conducted, to manufactured housing. In other instances, the methods of construction, the size of members, and types of materials are so different that new approaches are needed.

Assessment of loss reduction measures will include, to the extent possible, the structural effectiveness of the mitigation measures as well as the cost of materials and construction for their implementation. Since the study is still in progress, the identification of potential measures and the assessment of these measures have not been completed. The following subsections of the executive summary provide a preliminary description of key findings based on research completed to date. These may be subject to change, and are contingent upon the results of research to be completed during the months of May and June 2001.

KEY FINDINGS

AGE AND STANDARDS ARE EXPECTED TO MAKE A DIFFERENCE

Manufactured housing built before June 15, 1976 was not subject to a consistent set of regulatory standards for construction and safety. Since June 15, 1976, The Department of Housing and Urban Development (HUD) has maintained and enforced the Manufactured Home Construction and Safety Standards (Part 3280) for manufactured housing. These standards preempt all state and local criteria. A major change in the HUD design requirements for wind resistance of manufactured housing was implemented and became effective on July 13, 1994. This change divided the country into three wind speed zones: one for 80 miles per hour (mph) or less, one for 81 to 100 mph and one for 101 to 110 mph. The wind speed zones were pegged to the basic fastest-mile wind speed contour map in the American Society of Civil Engineer's 1988 Standard *ASCE 7-88* [1]. The revised design standards required homes to be located in the two highest wind regions to be designed using *ASCE 7-88* wind loads. Although HUD recognized that homes built for the 80 mph zone would be designed for wind standards significantly lower than those specified for site-built or modular housing in moderate wind areas, it did not require changes in design wind loads for those areas [2].

The consensus of engineers and others involved in the manufactured housing industry is that homes built before June 15, 1976 are much more vulnerable than those built to the HUD standards adopted in 1976. While the change in design wind loads for high wind regions is directly attributed to the more than 10,000 manufactured homes that were damaged or destroyed during Hurricane Andrew (August 1992), those most familiar with the industry attribute the widespread damage during Andrew to manufacturing under the loose or non-existent standards used in the fabrication of units prior to 1976. Visits to fabricating plants building manufactured housing for the high wind zones revealed that units built to the new high-wind-zone requirements are in fact receiving a significant level of engineering attention and that load paths are being developed using metal strapping.

Based on those visits, it is possible that the structural resistance of wind rated manufactured units may, with one exception, be comparable to that of some site-built light-frame wood construction found in many high wind areas of the state. The exception has to do with resistance to windborne debris. Current manufactured housing design relies on achieving the necessary lateral wind load resistance using wood

sheathing material only on the ends and near the corners on the long side of units. Away from these areas, the exterior sheathing is typically comprised of fiberboard or insulating panels. These components do not provide the same level of protection from wind borne debris as the complete covering with wood sheathing found on most site-built homes in high wind areas.

The other major difference between the expected performance of high-wind rated manufactured housing and site-built light frame wood construction is in the anchorage of the homes. While site-built light frame wood construction is permanently attached to a foundation in the ground this is not the case for manufactured units. The statements made in the preceding paragraphs regarding improved structural integrity load paths, and engineering attention relate to the unit only. A major problem with the survivability of manufactured housing during high wind events has historically been, and still remains, its attachment to the ground. While anchors and anchorage of manufactured housing have improved somewhat in recent years, design of anchorage, straps, and soil-structure interaction problems remain a major hurdle. Even when properly designed and installed, engineers familiar with the situation still anticipate that significant lateral deformation will still occur in most cases before the required capacity is developed by the anchoring system. This is extremely detrimental to the structure of the unit itself, since it causes the structure to experience dynamic loading and load reversals that it is not designed for. Furthermore, field inspections indicate that anchor straps become slack over time and the materials are subject to corrosion and degradation. Consequently, the anchor capacity is expected to degrade over a period of months or years. In contrast, site-built homes that are properly secured to permanent foundations will develop the necessary resistance with very little deformation, and the foundations do not degrade significantly with time.

MODIFICATIONS MAY INCREASE VULNERABILITY

Inspections of mobile home parks in Florida have revealed widespread modification of the homes to add porches with roofs, additional rooms, and a variety of structures that are directly attached to the manufactured housing units. State regulators were very clear in discussions about retrofits that anything that is attached to a manufactured home must meet the HUD code requirements for the wind zone where the home is located. A review of the approved product list maintained by the Florida Department of Highway Safety and Motor Vehicles, Division of Motor Vehicles, Bureau of Mobile Homes and Recreational Vehicle Construction revealed that the only approved products that may be added relate to the anchorage of the units.

Most if not all of these additions are not approved products. They are installed without building permits being pulled, and without the corresponding, necessary and required inspections being performed. They fall into a gray area in the code enforcement arena and may well increase the vulnerability of the manufactured home to wind damage in a severe windstorm or hurricane.

CONFUSION CONCERNING REGULATORY RESPONSIBILITIES

HUD standards cover the initial design and construction of the manufactured unit. HUD has developed an inspection and certification process that results in the application of a HUD label to the home. In this label, the manufacturer certifies that the home meets the HUD standards in force on the date of construction of the unit. Regulation of the installation and subsequent modifications to the home are delegated to the state. The primary focus of the state regulations has been concerned with the initial setup and installation of the manufactured unit. If a unit becomes damaged and needs repairs, the general approach of the state regulators has been to require repair or replacement with materials or components that are equivalent to or better than the original materials, components and construction.

On the other hand, the addition of rooms, porches or other structures that are permanently attached to the ground fall under the jurisdiction of the local building department and building officials. At some point, it can be argued that the modifications may become of such magnitude that the entire structure including the manufactured housing unit has to conform to the local building code requirements. In fact, strictly speaking modifications to manufactured units are not allowed without the intervention of the local building department. As a minimum, modifications to the unit itself can be made only after a building permit is obtained, with the requirement that inspections be made pursuant to that permit. Furthermore any additions made must be independent of the unit and must comply with all local requirements including the local building codes in effect, not just a requirement that a permit be applied for and inspections performed.

In most cases, it is clear that repairs or modifications are being carried out without the knowledge or approval of the appropriate regulatory authority.

AGING AND DEGRADATION

In addition to the less stringent standards used for the design and construction of older manufactured housing units, it is clear that structural capacities and anchorage capacity decrease as the unit ages. Moisture buildup in wall and roof cavities in older units have

caused the materials and connections to lose strength. Similarly, inspection and testing of anchor components has revealed that the bending of the straps to make the attachments reduces the capacity of the straps, sometimes below the design values, and can result in loss of galvanizing that can lead to corrosion and further degradation of capacity over a period of time. Department of Community Affairs sponsored inspections have revealed widespread problems with anchorage including loose anchor straps, corroded or missing straps and a variety of other problems. This has resulted in the expenditure of several million dollars in each of the past two years on a program to retrofit the anchorage of manufactured housing units across the state.

BALANCING ANCHORAGE AND STRUCTURAL RESISTANCE CAPACITIES

For units built before the HUD standard was adopted in 1976, it may well be a toss up as to whether the structure of the home will come apart and blow away from the base or the anchorage will give way and the home becomes destroyed as it rolls or tumbles in the wind. For these older units, some level of anchorage is important but unless something is done to strengthen the superstructure, the net result in the next major hurricane may well be row upon row of tied down frames surrounded by the splintered debris from the walls and roofs of the homes. It was these images from Hurricane Andrew that led to the 1994 revisions in construction standards for manufactured homes in high wind areas.

For manufactured homes built between 1976 and 1994, and homes built after 1994 that are rated for the 80 mph zone, it is likely that the greatest initial increase in wind resistance can be achieved by improving the anchorage of the manufactured home, at least to the level of the latest anchorage requirements. Beyond that, the focus would then need to shift to strengthening the structure before additional benefit could be obtained by further improvements to the anchorage of the home. Striking a balance between retrofitting the structure and the anchorage will require the development of an inspection procedure to evaluate the current state of the structure, its connections and components.

Despite concerns about the debris impact resistance of the high-wind rated manufactured housing units built after 1994, the most cost effective means of improving the survivability of these homes and for reducing losses will likely come from further improvements to the anchorage of the homes.

MIXING OLDER HOMES WITH NEWER ONES INCREASES RISK OF DAMAGE TO NEW HOMES

HUD data indicates that in excess of 10,000 manufactured homes were damaged or destroyed by Hurricane Andrew. Current data on manufactured homes indicates that about 30 percent of the manufactured homes in Florida were built before the HUD code provisions were first implemented in 1976. An additional 50+ percent of the manufactured homes in Florida were built before HUD adopted the higher wind standards in 1994. Consequently, a large fraction of the existing stock of manufactured homes will be subject to substantial damage or destruction in another storm with wind speeds similar to those of Hurricane Andrew. The debris from the damaged or destroyed homes will become missiles that have the potential to substantially damage the newer more wind resistant manufactured housing units.

There are basically three possible approaches to reducing the vulnerability of the new more wind resistant manufactured homes to damage from wind borne debris. One is to change the design and construction of the homes to include a greater level of debris impact protection. A second is to modify the existing homes to improve their resistance to debris impact. The third is to reduce or remove potential missiles from the area around the home. This last approach could be accomplished by segregation of older and newer units within parks or limiting the types of units within a park.

RESEARCH NEEDS AND DIRECTIONS

Research into possible structural retrofits for older manufactured housing units has practically been nonexistent. Part of the reason for this has been the concern that even if methods were developed, they could not be implemented because the HUD code would not allow the retrofits. Discussions with federal and state regulators suggest otherwise. Basically, the federal regulations cover the initial design and construction of the home and the HUD sticker simply states that at the time the home was built, the manufacturer certifies that it was built to the standards in place at that time. Installation, modification and repairs are left to the state regulators. The Florida state regulators have indicated that retrofits are acceptable as long as they are equal to or better than the original construction. The exception is that they will not approve retrofits that are intended to change the classification of the wind resistance of the home so that it can be moved into an area that requires a higher wind speed rating.

Another reason that retrofit research has not been conducted is that the financial resources of the manufactured housing unit owners are limited and may not be sufficient to pay the cost of expensive retrofits. The challenge is develop inexpensive

yet effective retrofit measures and approaches that allow incremental improvements in wind resistance as funds become available.

It is clear that structural retrofits would benefit both the owners and occupants of the oldest homes, by reducing their risks and losses but may well also benefit the owners of near by homes built to higher standards because it will reduce the amount of wind borne debris impacting their homes. It is also clear that if nothing is done, the next time a strong hurricane strikes Florida there will be a large number of older manufactured homes damaged or destroyed once again, regardless of how well they are anchored.

Research is also needed on alternate anchoring systems, particularly for the newer wind rated homes where the structural resistance may well substantially exceed the performance of conventional anchorage systems. Furthermore, in order to establish better baseline data on the performance of current anchoring systems, a long term research program is needed that will periodically evaluate the real world performance of anchor systems that have been exposed to normal environmental variations such as soil saturation, loosening of the straps, and general environmental degradation.

OBJECTIVES

The objective of this study is to identify and to assess potential hurricane loss reduction measures that could be incorporated into the retrofitting of existing housing units. While the primary focus of the research is on manufactured homes, the study also considers retrofit measures for conventional site built homes.

Loss reduction measures appropriate for manufactured homes of different ages and types of construction will be identified. Assessments will consider the potential increase in structural performance, the practicality of the proposed retrofit and the costs associated with the retrofit. It is expected that the assessments will ultimately lay the foundation for conducting cost-benefit analyses of the various measures.

The research also addresses the existing regulatory environment under which such loss reduction retrofitting may be allowed and recognized.

METHODOLOGY

The identification of potential hurricane loss reduction measures is being conducted using internet searches, literature reviews, discussions with regulators, visits to manufacturers and site visits. The internet and literature searches have included a broad range of pertinent topics including vulnerability and cost-benefit analyses, structural resistance of light frame construction, assessments of the performance of housing in specific hurricanes, guidelines for wind resistant design, retrofitting of housing to improve wind resistance, retrofitting of manufactured housing, anchorage of manufactured housing, and wind loading on manufactured housing.

Two visits have been made to factories that produce manufactured housing units for high wind areas. Other visits are planned to factories that produce homes that are not rated for the higher wind zones.

Information on, ideas about, and testing of retrofits for conventional site-built homes are being carefully reviewed to determine what methods and ideas can be translated to retrofitting of manufactured housing. Energy retrofits that have been developed for manufactured housing are also being carefully reviewed to determine whether there is the possibility for retrofit solutions that may improve both the wind resistance and the energy efficiency of the existing homes.

A limited amount of data on the structural testing of complete manufactured housing units has been published in the literature. Much of this data has been generated by Goodman, first at Colorado State University and later at the University of Wyoming in conjunction with the Idaho National Engineering and Environmental Laboratory. Significantly more data is available about the performance of individual components and subsystems of manufactured housing units. This performance data will be compared with data on the performance of anchorage systems to assess the relative vulnerabilities of the structure and anchors for various ages of structures. It is anticipated that actual testing of older units will be needed in year two of this project to fill in gaps, particularly gaps in information on the structural performance of older homes.

RESEARCH TEAM

The project manager for the research effort is Ricardo Alvarez, Deputy Director of the International Hurricane Center at Florida International University. Ms. Janaina Monteiro, graduate research assistant at FIU is assisting Prof. Alvarez in this project. The structural performance and retrofitting research activity is being led and coordinated by Professor Jose D. Mitrani P.E. at Florida International University. He is being assisted at FIU by Jorge Remedios. Dr. Ron Cook P.E. at the University of Florida is principal investigator for a subcontract to assist in the identification and assessment of retrofit techniques. Ms. Laura Tropeano, a graduate research assistant at UF is assisting Dr. Cook with his subcontract activities. Dr. Tim Reinhold P.E. of Clemson University is assisting the project team as a consultant. Two Clemson University graduate students, Dennis Altman and Scott Robinett, and one Clemson University undergraduate student, John Lamb, are assisting Dr. Reinhold.

BACKGROUND

Historically, manufactured housing has not performed as well as conventional site built homes during Hurricanes and other types of severe wind storms. Even today, the tornado related death rates for people living in manufactured housing are significantly larger than those for people living in conventional site built homes. Thanks to the widespread evacuations of manufactured housing units during hurricanes, hurricane related death rates do not reflect the increased vulnerability of the manufactured housing units. Reactions to the increased death and injury rates for manufactured housing occupants and the more frequent instances of damage and destruction of manufactured housing than that observed for site built housing led to the enactment of federal regulations governing the construction and safety of manufactured housing.

The research shows that there are significantly different expectations concerning the performance of manufactured homes in wind storms based on the age of the homes and the standards used in their original construction. Before the enactment of the National Manufactured Housing Construction and Safety Standards act of 1974, manufactured housing was not subject to a consistent set of regulatory standards for construction and safety. Since June 15, 1976, the Department of Housing and Urban Development (HUD) has maintained and enforced the Manufactured Home Construction and Safety Standards (Part 3280) and these standards have preempted all state and local criteria. Generally, manufactured housing built before the HUD standards took effect are referred to as Mobile Homes and those built following the HUD standards are referred to as Manufactured Homes. Engineers and others involved in the manufactured housing industry clearly believe that homes built after the HUD standard went into effect are superior to those built before the standards were adopted.

Major changes in wind load requirements of the HUD standard were implemented and became effective on July 13, 1994. This change divided the country into three wind speed zones, one for 80 miles per hour (mph) or less, one for 81 to 100 mph and one for 101 to 110 mph. The wind speed zones were pegged to the basic fastest-mile wind speed contour map in the American Society of Civil Engineer's 1988 Standard *ASCE 7-88* [1]. Homes to be located in the two highest wind regions are required to be designed using *ASCE 7-88* wind loads. Although HUD recognized that homes built for the 80 mph zone would be designed for wind standards significantly lower than those specified for site-built or modular housing in moderate wind areas, it did not require changes in design wind loads for those areas [2].

These changes are attributed to the widespread partial and total destruction of manufactured homes that occurred when Hurricane Andrew struck South Florida (August 1992). HUD estimates that more than 10,000 manufactured homes were either damaged or destroyed by Hurricane Andrew [2]. According to the ASCE 7-88 map, no part of the state of Florida would fall into the low wind region. Consequently, once the rule went into effect, all manufactured housing units designed and built for installation in the state of Florida would have to be designed using ASCE 7-88 wind loads for the appropriate area where it was to be installed.

There are indications that the change to high wind construction standards for manufactured housing units may have been delayed in Florida until June 12, 1995. After HUD issued a final rule on the high wind standards in April 1994, the Florida Manufactured Housing Association together with some manufacturers filed a petition for judicial review of the rule. On June 12th , 1995 the 11th Circuit US Court of Appeals issued an opinion denying the petition and upholding the standards [2].

LITERATURE REVIEW

The literature review has been conducted using a variety of techniques, including library searches, Internet searches, industry contacts and government contacts.

LIBRARY SEARCH

Formal library searches were performed using the keyword search function of LUIS (Library User Information Service). The search locates books that have the keywords in their record. A search using the words “manufactured” and “housing” yielded 97 documents. A search for the word “hurricane” produced 471 documents. Of the 568 documents, four documents were found that pertained to manufactured housing and manufacturing procedures.

- *Council of State Administrative Agencies and U.S. Department of Housing and Urban Development,* Manufactured Home Consumer’s Guide*, February 1998.*
- *U.S Department of Housing and Urban Development, Office of Policy Development and Research,* Innovations at the Cutting Edge – New Ideas in Manufactured Housing*, August 1999.*
- *U.S Department of Housing and Urban Development, Office of Policy Development and Research,* Manufactured Home Installation Training Manual*, April 1999.*
- *U.S Department of Housing and Urban Development, Office of Policy Development and Research,* Manufactured Housing, A HUD USER Resource Guide*, November 1993.*

None of these documents had information on retrofit devices or procedures.

A periodical search was performed using the keyword search function of two subject indices, Engineering and Technology and General, Multidisciplinary, and Reference, and over 60 databases through LUIS. The search locates articles in periodicals and journals that have the keywords in either the record or the text of the article, depending on the database service through which the search is performed. Searches were performed using various combinations of the words “hurricane”, “manufactured”, “housing”, “wind” and “retrofit”. Of the articles returned through the search, three detailed ways to protect homes from wind damaged in hurricane conditions.

- Brown, Samuel J. and Perez, Victor. “Hurricane Retrofit.” *ASCE Civil Engineering*, May 1991, pp. 59-60.
- Tarricone, Paul. “The Winds of Change?” *ASCE Civil Engineering*, January 1994, pp. 42-45.
- “Huffing and Puffing Won’t Blow This House Down.” *Machine Design*, February 22, 2001, pp. 39.

Additional library searches have been conducted for wind engineering journals, wind engineering conference proceedings and publications from a number of research centers that have historically worked on wind engineering issues and structural issues related to manufactured housing construction and anchorage. Results of those searches are compiled in the attached bibliography. Papers and reports listed in the bibliography have been sub-divided into a number of categories depending on the major focus of the work. The categories include:

- Anchorage of Manufactured Housing
- Guidelines for Wind Resistant Design and Construction
- Retrofitting of Structures for Wind and Flood
- Structural Resistance
- Studies of Building Performance in Specific Hurricanes
- Vulnerability and Cost Benefit Analyses
- Wind Loads

Additional searches are still being conducted and copies of some of the reports and papers are still being procured.

The papers and reports identified and compiled to date indicate that the only research on the retrofit of manufactured housing has focused on either improving the anchorage of the home or on improving the energy efficiency of the home. The Pacific Northwest National Laboratory operated by Bonneville Power has conducted most of the research work on energy related retrofits. HUD has funded assessments of manufactured housing anchorage systems and work to improve the performance of these systems. The majority of the studies uncovered in the literature search have been conducted by either the National Institute of Standards and Technology or by the consulting firm of Wiss Janney Elstner Associates, Inc. Texas Tech University has also been involved in several studies of the performance of manufactured housing units in windstorms.

Investigations of the structural performance of structural components used in manufactured housing have been conducted by a number of organizations. Actual tests of complete units have been conducted by James Goodman, first at Colorado State University and more recently at the University of Wyoming in conjunction with the Idaho National Engineering and Environmental laboratory.

INTERNET SEARCH

Internet searches, using the search engine www.google.com, were performed with various keyword combinations. A search using the words “manufactured”, “housing”, and “hurricane” resulted in thousands of web pages. A general study of the resulting pages found that subject matter varied from manufactured homes for sale to news reports on how manufactured housing residents should prepare for a hurricane. In an attempt to streamline the results, another search was performed using the words “manufactured”, “housing”, and “retrofit”. The results were more specific regarding various ways of retrofitting manufactured housing, but primarily discussed ways to make them more energy efficient and did not provide information valuable to the structural retrofit research being studied. Additional searches were performed, but all yielded similar results. Although the searches did not provide information on the retrofit devices that are available, they did assist in becoming familiar with the agencies and organizations available to manufactured home owners such as the Manufactured Housing Institute (MHI), the Federation of Manufactured Home Owners (FMHO), and the Florida Manufactured Housing Association (FMHA). These industry contacts were instrumental in obtaining the government contacts that provided the list of state approved products. Phil Bergelt of the Department of Highway Safety and Motor Vehicles, Bureau of Mobile Homes and Recreational Vehicles provided the names of two companies, Tie Down Engineering and Oliver Technologies, that produce state approved retrofit and anchoring devices. A search of keywords located their web

pages, www.tiedown.com and www.olivertechnologies.com, respectively. Tie Down Engineering's web page provides a list of products that have been approved by the state for use in the manufactured housing industry. The web page also contains illustrations and a brief description of each product. Letters from the Department of Highway Safety and Motor Vehicles, Division of Motor Vehicles, Bureau of Mobile Homes approving specific products manufactured by Tie Down Engineering were also available on the web. Oliver Technologies' web page provided very little information about their products.

Searches of the MHI and HUD websites provided a valuable source of information on reports and studies related to various aspects of mobile home strength, wind resistance, testing, durability and economic assessments. A number of these references are included in the bibliography.

INDUSTRY CONTACTS

Several individuals associated with the manufactured housing industry were contacted. Frank Walters, Vice President Technical Activities for the Manufactured Housing Institute (MHI) suggested contacting Philip Bergelt, Program Manger with the Department of Highway Safety and Motor Vehicles, Division of Motor Vehicles, Bureau of Mobile Homes and Recreational Vehicle Construction. The Federation of Manufactured Home Owners (FMHO) recommended contacting the Florida Alliance for Safe Homes (FLASH) regarding their publication on manufactured housing safety. The publication briefly explains alternative anchoring methods as well as what should be done to prepare for a hurricane. Simpson Strong-Tie was contacted via e-mail regarding knowledge of the possibility of their products being used in the construction of manufactured housing. Aram Khachadourian provided the following response on March 6, 2001:

> "We have many products that are used in the manufactured housing industry. Some are installed in the field and some are installed in the factory. Examples of these products are MMLU hangers, MMLUI hangers, A35 framing anchors, LTB bridging, L angles, MP mending plates, PSCL sheathing clips, RCWB bracing, strap ties, RST-1, RST-2, RST-3 rafter ties, H8 hurricane ties, and H5 hurricane ties. Many manufactured homes are now supplied with porches. For these we offer post caps and deck brackets. At the foundation, MASB anchors are used to connect the sill and rim joist to the block foundation. Also A35F framing anchors can be used to connect the rim joist to the sill. Some of our products have piercing areas for power driven

nails. This allows quick installation by not forcing nails into specific holes but only into specific areas."

The aforementioned products can be found on the Simpson Strong-Tie website, www.strongtie.com.

GOVERNMENT CONTACTS

Curtis Blackman, Regional Administrator with the Bureau of Mobile Homes and Recreational Vehicle Construction suggested contacting David Cougher or Philip Bergelt on the state level regarding current retrofit devices. Philip Bergelt, Program Manager with the Department of Highway Safety and Motor Vehicles, Division of Motor Vehicles, Bureau of Mobile Homes and Recreational Vehicle Construction, explained that the State of Florida Department of Highway Safety and Motor Vehicles, Division of Motor Vehicles, Bureau of Mobile Homes and Recreational Vehicle Construction regulates all retrofit devices such that a manufactured home can not be retrofitted with a device that has not been approved by the state nor can a retrofit device be installed by a non-licensed agent. Each potential retrofit device must be tested to assure its strength. Once tested, the Bureau of Mobile Homes and Recreational Vehicle Construction evaluates the results of the tests and either approves or disapproves the product for use on manufactured homes in Florida. David Cougher, with the Department of Highway Safety and Motor Vehicles, Division of Motor Vehicles, Bureau of Mobile Homes and Recreational Vehicle Construction provided an approved product list and the testing specifications for such products. This information will be included as appendices in the final report.

SURVEY OF MANUFACTURED HOUSING PRODUCERS

The survey of manufactured housing producers includes information obtained through:

- Local manufacturers
- Factory tour

A list of contacts affiliated with the manufactured housing industry is provided in Appendix B.

LOCAL MANUFACTURERS

In talking with local manufacturers, it was found that they have little knowledge of current retrofit devices and procedures since their primary interest is new construction. However, if manufacturers want to implement new hurricane protection or retrofit existing homes, the products and procedures must conform to state and federal regulations, Department of Highway Safety and Motor Vehicles, Division of Motor Vehicles, Bureau of Mobile Homes and Recreational Vehicle Construction and U.S. Department of Housing and Urban Development (HUD), respectively. Thus,

manufacturers can only improve upon what has already been approved at the state and federal levels. Manufacturers can, however, implement hurricane protection indirectly through the quality of the homes they build.

FACTORY TOURS

A factory tour of Nobility Homes in Ocala, Florida, allowed observation of the manufacturing process and provided insight into the areas of most concern regarding retrofitting. The construction process begins when floor joists are laid on the steel frame. Plywood is overlaid on the floor joists and then the walls are framed. The studs are screwed into the floor system and secured with 20 gauge ties. The tie-down connecters are placed at 5' - 4" on center along the exterior length of the home. The roof system is assembled and then placed on the home. The studs around doorways are secured to the trusses with 20 gauge ties. Bent ties are used to connect the wall framing to the trusses. At this point, the home is structurally complete except for wood sheathing applied to create shear walls needed to prevent racking and to transfer the lateral wind loads on the superstructure down to the floor of the unit. It was discovered that manufacturers have been able to count on enough shear capacity from the interior finishes and fiberboard or insulating board exterior sheathing, so that they can limit the use of wood sheathing to the end walls and corner areas of the long walls while still meeting the ASCE 7-88 wind load requirements.

Ed Sims, Vice President of Engineering with Nobility Homes, who gave the tour, believes that the focus of retrofit efforts should be on homes manufactured before the more stringent wind standards were implemented after Hurricane Andrew, but more specifically on homes that were not built to HUD specifications. He explained that in his opinion the manufactured housing industry received bad press after Hurricane Andrew hit South Florida in August of 1992. Of the 85,000 residences – including individual homes, condominiums and apartments – that had to be replaced, only 4,500 of these were manufactured homes. Mr. Sims explained that when tallying the damage, recreational vehicles (RV's) and towable campers, that weren't anchored to the ground, were also considered manufactured housing. When assessing the damage to anchored homes, the majority of the homes that were destroyed, or greatly damaged, were older units that were built before HUD became the regulating agency of construction standards for the manufactured housing industry in 1974. Since Hurricane Andrew, construction standards have become increasingly stringent. Manufactured housing units today are built to withstand 100 mph wind in Wind Zone II and 110 mph winds in Wind Zone III as required by HUD. Mr. Sims believes that homes built after HUD began regulating construction, if anchored properly for existing soil conditions, should be able

to sufficiently withstand hurricane conditions. Pictures from the tour can be found in Appendix C.

A factory tour of Mascot Homes in Spartanburg, South Carolina was also conducted. Similar observations were made about the amount of strapping being used to build the high-wind rated manufactured housing units. It is clear that manufactured homes being built for installation in the higher wind regions are receiving a great deal of attention in developing load paths with metal strapping. Mascot Homes builds units for the upper end of the market and the units observed during the site visit were being fully sheathed with oriented strand board wood sheathing.

HISTORICAL AREAS OF WEAKNESS

One of the key areas where manufactured housing has experienced problems over the years is in the anchorage of the home. Post windstorm and post flood investigations have clearly shown that the typical anchorage of older manufactured homes is a clear weak link in the wind load resisting system. Investigations of damage to conventional site built light frame buildings sitting side by side with manufactured housing units has shown that the anchorage systems for manufactured homes provides significantly less resistance that that of permanent foundations.

Another area of vulnerability for manufactured housing units is caused by the attachment of appendages and structures to the unit when the unit has not been designed to carry the additional loads that may be induced by the attached structure. Inspections of mobile home parks in Florida have revealed widespread modification of the homes to add porches with roofs, additional rooms, and a variety of structures that are directly attached to the manufactured housing units. State regulators were very clear in discussions about retrofits that anything that is attached to a manufactured home must meet the HUD code requirements for the wind zone where the home is located. A review of the approved product list maintained by the Florida Department of Highway Safety and Motor Vehicles, Division of Motor Vehicles, Bureau of Mobile Homes and Recreational Vehicle Construction revealed that the only approved products that may be added relate to the anchorage of the units.

Most if not all of these additions are not approved products. They are installed without building permits being pulled, and without the corresponding, necessary and required inspections being performed. They fall into a gray area in the code enforcement arena and may well increase the vulnerability of the manufactured home to wind damage in a severe windstorm or hurricane.

The consensus of engineers and others involved in the manufactured housing industry is that homes built before June 15, 1976 are much more vulnerable than those built to the HUD standards adopted in 1976. While the change in design wind loads for high wind regions is directly attributed to the more than 10,000 manufactured homes that were damaged or destroyed during Hurricane Andrew (August 1992), those most familiar with the industry attribute the widespread damage during Andrew to manufacturing under the loose or non-existent standards used in the fabrication of units prior to 1976. Visits to fabricating plants building manufactured housing for the high wind zones revealed that units built to the new high-wind-zone requirements are in fact receiving a significant level of engineering attention and that load paths are being developed using metal strapping.

Based on those visits, it is possible that the structural resistance of wind rated manufactured units may, with one exception, be comparable to that of some site-built light-frame wood construction found in many high wind areas of the state. The exception has to do with resistance to windborne debris. Current manufactured housing design relies on achieving the necessary lateral wind load resistance using wood sheathing material only on the ends and near the corners on the long side of units. Away from these areas, the exterior sheathing is typically comprised of fiberboard or insulating panels. These components do not provide the same level of protection from wind borne debris as the complete covering with wood sheathing found on most site-built homes in high wind areas.

Another major difference between the expected performance of high-wind rated manufactured housing and site-built light frame wood construction is in the anchorage of the homes. While site-built light frame wood construction is permanently attached to a foundation in the ground this is not the case for manufactured units. The statements made in the preceding paragraphs regarding improved structural integrity load paths, and engineering attention relate to the unit only. A major problem with the survivability of manufactured housing during high wind events has historically been, and still remains, its attachment to the ground. While anchors and anchorage of manufactured housing have improved somewhat in recent years, design of anchorage, straps, and soil-structure interaction problems remain a major hurdle. Even when properly designed and installed, engineers familiar with the situation still anticipate that significant lateral deformation will still occur in most cases before the required capacity is developed by the anchoring system. This is extremely detrimental to the structure of the unit itself, since it causes the structure to experience dynamic loading and load reversals that it is not designed for. Furthermore, field inspections indicate that anchor straps become

slack over time and the materials are subject to corrosion and degradation. Consequently, the anchor capacity is expected to degrade over a period of months or years. In contrast, site-built homes that are properly secured to permanent foundations will develop the necessary resistance with very little deformation, and the foundations do not degrade significantly with time.

For units built before the HUD standard was adopted in 1976, it may well be a toss up as to whether the structure of the home will come apart and blow away from the base or the anchorage will give way and the home becomes destroyed as it rolls or tumbles in the wind. For these older units, some level of anchorage is important but unless something is done to strengthen the superstructure, the net result in the next major hurricane may well be row upon row of tied down frames surrounded by the splintered debris from the walls and roofs of the homes. It was these images from Hurricane Andrew that led to the 1994 revisions in construction standards for manufactured homes in high wind areas.

For manufactured homes built between 1976 and 1994, and homes built after 1994 that are rated for the 80 mph zone, it is likely that the greatest initial increase in wind resistance can be achieved by improving the anchorage of the manufactured home, at least to the level of the latest anchorage requirements. Beyond that, the focus would then need to shift to strengthening the structure before additional benefit could be obtained by further improvements to the anchorage of the home. Striking a balance between retrofitting the structure and the anchorage will require the development of an inspection procedure to evaluate the current state of the structure, its connections and components.

Despite concerns about the debris impact resistance of the high-wind rated manufactured housing units built after 1994, the most cost effective means of improving the survivability of these homes and for reducing losses will likely come from further improvements to the anchorage of the homes.

HUD data indicates that in excess of 10,000 manufactured homes were damaged or destroyed by Hurricane Andrew [2]. Current data on manufactured homes indicates that about 30 percent of the manufactured homes in Florida were built before the HUD code provisions were first implemented in 1976. An additional 50+ percent of the manufactured homes in Florida were built before HUD adopted the higher wind standards in 1994. Consequently, a large fraction of the existing stock of manufactured homes will be subject to substantial damage or destruction in another storm with wind speeds similar to those of Hurricane Andrew. The debris from the damaged or

destroyed homes will become missiles that have the potential to substantially damage other units including the newer more wind resistant manufactured housing units.

Interviews of mobile home park operators clearly indicated that they were concerned about the amount of debris that might be flying around their park when a major hurricane strikes the area. It is one of the reasons that they gave for wanting occupants of the homes to evacuate the area and were reluctant to consider construction of hurricane shelters within the park.

There are basically three possible approaches to reducing the vulnerability of the new more wind resistant manufactured homes to damage from wind borne debris. One is to change the design and construction of the homes to include a greater level of debris impact protection. A second is to modify the existing homes to improve their resistance to debris impact. The third is to reduce or remove potential missiles from the area around the home. This last approach could be accomplished by segregation of older and newer units within parks or limiting the types of units within a park.

EFFECTS OF AGING AND DEGRADATION

The anticipated life of a manufactured housing unit is 33 years [2]. In addition to the less stringent standards used for the design and construction of older manufactured housing units, it is clear that structural capacities and anchorage capacity decrease as the unit ages. Moisture buildup in wall and roof cavities of older units has caused the materials and connections to lose strength. Similarly, inspection and testing of anchor components has revealed that the bending of the straps to make the attachments reduces the capacity of the straps, sometimes below the design values, and can result in loss of galvanizing that can lead to corrosion and further degradation of capacity over a period of time. Department of Community Affairs sponsored inspections have revealed widespread problems with anchorage including loose anchor straps, corroded or missing straps and a variety of other problems. This has resulted in the expenditure of several million dollars in each of the past two years on a program to retrofit the anchorage of manufactured housing units across the state.

Some specific research programs dealing with the long-term performance of adhesives used in the assembly of manufactured housing units have been found in the literature. Apparently, this has been a major problem area that has received considerable attention from an industry working-group.

RETROFIT RESEARCH FOR MANUFACTURED HOMES

The only literature that has been found that deals with the retrofit of manufactured housing units has dealt with either the anchorage of the home or improving the energy efficiency of the home. Part of the reason for this has been the concern that even if methods were developed, they could not be implemented because the HUD code would not allow the retrofits. Discussions with federal and state regulators suggest otherwise. Basically, the federal regulations cover the initial design and construction of the home and the HUD sticker simply states that at the time the home was built, the manufacturer certifies that it was built to the standards in place at that time. Installation, modification and repairs are left to the state regulators. The Florida state regulators have indicated that retrofits are acceptable as long as they are equal to or better than the original construction. The exception is that they will not approve retrofits that are intended to change the classification of the wind resistance of the home so that it can be moved into an area that requires a higher wind speed rating.

Another reason that retrofit research has not been conducted is that the financial resources of the manufactured housing unit owners are limited and may not be sufficient to pay the cost of expensive retrofits. The challenge is to develop inexpensive yet effective retrofit measures and approaches that allow incremental improvements in wind resistance as funds become available.

Key areas where retrofit methods are needed include the anchorage of the units, the connections between walls and the roof and between the walls and the floor, possible strengthening of walls in older units that used small structural members, and the provision of ways to attach shutters or other devices to protect glazed openings.

RETROFIT RESEARCH FOR CONVENTIONAL SITE-BUILT HOMES

Considerably more research has been conducted to develop methods and ideas for retrofitting conventional site built homes to resist high winds and floods. The literature search turned up a number of specific reports on research projects aimed at developing retrofit techniques for conventional site-built homes. A number of guides are also available that provide information on ways to improve the wind resistance of conventional site-built construction. That information is currently being catalogued and it is anticipated that some of the ideas and information can be translated to manufactured housing applications.

REGULATORY ENVIRONMENT AND JURISDICTION

The *HUD Code* or *Federal Manufactured Home Construction and Safety Standards* controls the design and construction of new manufactured housing units. This is the only code that is mandated for national recognition. It took effect on June 15, 1976, and as such it has preemptive status with respect to manufactured homes over all state and local regulations. It was created in the *National Manufactured Home Construction and Safety Standards Act* of 1974, and incorporates by reference, standards from the following organizations:

- AA Aluminium Association
- AAMA American Architectural Manufacturers Association
- AFPA or NFPA American Forest and Paper Association
- AGA American Gas Association
- AISC American Institute of Steel Construction
- AISI American Iron and Steel Institute
- AITC American Institute of Timber Construction
- ANSI American National Standards Institute
- APA American Plywood Association
- ARI Air Conditioning and Refrigeration Institute
- ASCE American Society of Civil Engineers
- ASHRAE American Society of Heating, Refrigeration and Air Conditioning Engineers
- ASME American Society of Mechanical Engineers
- ASSE American Society of Sanitary Engineering
- ASTM American Society for Testing And Materials
- CISPI Cast Iron Soil Pipe Institute
- DOC U.S. Department of Commerce, National Institute of Standards and Technology, Office of Engineering Standards
- FS Federal Specifications, General Services Administration, Specifications Branch
- HPVA or HPMA Hardwood Plywood and Veneer Association
- HUD-FHA Department of Housing and Urban Development
- HUD-USER Department of Housing and Urban Development
- IAPMO International Association of Plumbing and Mechanical Officials
- IITRI IIT Research Institute
- MIL Military Specifications and Standards
- NFPA National Fire Protection Association

- NPA National Particleboard Association
- NSF National Sanitation Foundation
- NWWDA National Wood Window and Door Association
- SAE Society of Automotive Engineers
- SJI Steel Joist Institute
- TPI Truss Plate Institute
- UL Underwriters' Laboratories, Inc.

To ensure quality, the design and construction of the home is monitored by both HUD and its monitoring contractor, the National Conference of States on Building Codes and Standards (NCSBCS**).** HUD has entered into cooperative agreements with 36 State governments to conduct periodic checks of plan records and to respond to consumer complaints. These State governments each designate a State Administrative Agency (SAA). Manufactured Housing staff provides these functions in the other 14 States without SAAs. The HUD standards are published in the Code of Federal Regulations at 24 CFR 3280 and cover:

- Body and Frame Requirements
- Thermal Protection
- Plumbing
- Electrical
- HVAC
- Fire Safety
- Other aspects of the home

Design Approval Primary Inspection Agencies (DAPIAs) approve (for certification purpose only) the manufacturer's design, quality control program and quality assistance manual (set-up/homeowner's manual). DAPIAs can be either States or private organizations accepted by HUD.

Production Inspection Primary Inspection Agencies (IPIAs) approve (for certification purpose only) the manufacturer's plant facility and manufacturing process, as well as the performance of ongoing inspections of the manufacturing process in each manufacturing plant. They can be either States or private organizations accepted by HUD.

Florida's IPIAs, DAPIAs and SAAs are the following:

IPIA: Mr. Charles Smith

Program Manager
Bureau of Mobile Homes & RV
Division of Motor Vehicles
2900 Apalachee Parkway, Rm A129
Tallahassee, FL 32399-0640
850-488-8600
Fax: 850-488-7053
E-mail: mhrv@hsmv.state.fl.us

IPIA/DAPIA: Mr. Joseph V. Fletcher
Director
HUD Code Inspection Services
Hilborn, Werner, Carter & Associates, Inc.
1627 S. Myrtle Avenue
Clearwater, FL 33756-1131
727-584-8151
Fax: 727-587-0447
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SAA MR. EDWARD D. BROYLES, BUREAU CHIEF
Bureau of Mobile Homes & RV
Division of Motor Vehicles
2900 Apalachee Parkway, Room A-129
Tallahassee, FL 32399-0640
PH: 850-488-8600
FAX: 850-488-705
Email: MHRV@hsmv.state.fl.us
Designee: Chuck Smith, Program Manager

The State of Florida Department of Highway Safety and Motor Vehicles, Division of Motor Vehicles, Bureau of Mobile Homes and Recreational Vehicle Construction regulates all retrofit devices such that a manufactured home can not be retrofitted with a device that has not been approved by the state nor can a retrofit device be installed by a non-licensed agent. Each potential retrofit device must be manufactured and tested to assure its strength. Once tested, the Bureau of Mobile Homes and Recreational Vehicle Construction evaluates the results of the tests and either approves or disapproves the product for use on manufactured homes in Florida.

HUD standards cover the initial design and construction of the manufactured unit. HUD, through the SSAs, IPIAs, and DAPIAs has developed an inspection and certification process that results in the application of a HUD label to the home. In this label, the manufacturer certifies that the home meets the HUD standards in force on the date of construction of the unit. Regulation of the installation and subsequent modifications to the home are delegated to the state. The primary focus of the state regulations has been concerned with the initial setup and installation of the manufactured unit. If a unit becomes damaged and needs repairs, the general approach of the state regulators has been to require repair or replacement with materials or components that are equivalent to or better than the original materials, components and construction.

On the other hand, the addition of rooms, porches or other structures that are permanently attached to the ground fall under the jurisdiction of the local building department and building officials. At some point, it can be argued that the modifications may become of such magnitude that the entire structure including the manufactured housing unit has to conform to the local building code requirements. In fact, strictly speaking modifications to manufactured units are not allowed without the intervention of the local building department. As a minimum, modifications to the unit itself can be made only after a building permit is obtained, with the requirement that inspections be made pursuant to that permit. Furthermore any additions made must be independent of the unit and must comply with all local requirements including the local building codes in effect, not just a requirement that a permit be applied for and inspections performed.

In most cases, it is clear that repairs or modifications are being carried out without the knowledge or approval of the appropriate regulatory authority.

RESEARCH NEEDS AND DIRECTIONS

Research into possible structural retrofits for older manufactured housing units has practically been nonexistent. Yet, It is clear that structural retrofits could benefit both the owners and occupants of the oldest homes, by reducing their risks and losses, and the owners of newer homes built to higher standards because it will reduce the amount of wind borne debris impacting their homes. It is also clear that if nothing is done, the next time a strong hurricane strikes Florida there will be a large number of older manufactured homes damaged or destroyed once again, regardless of how well they are anchored.

Research is also needed on alternate anchoring systems, particularly for the newer wind rated homes where the structural resistance may well substantially exceed the

performance of conventional anchorage systems. Furthermore, in order to establish better baseline data on the performance of current anchoring systems, a long term research program is needed that will periodically evaluate the real world performance of anchor systems that have been exposed to normal environmental variations such as soil saturation, loosening of the straps, and general environmental degradation.

PROPOSED YEAR 2 RESEARCH

Proposed research activities for the 2001-2002 budget year will focus on several of the issues identified above. One will be the development of practical structural retrofits for older manufactured housing units. This will work on developing inspection and evaluation tools for assessing the condition of the older units and determining the most effective approaches to reducing the vulnerability of these homes. A second proposed effort will develop facilities and equipment necessary to conduct in-situ testing of both the structure and anchorage of manufactured housing units. Once the test facilities and equipment have been developed, a long-term testing program will be initiated to evaluate the performance of various systems commonly used to anchor manufactured housing units in Florida soils. These long term tests will be designed to evaluate the effects of soil saturation, corrosion of straps and anchors and the effects of settlement and loosening of the anchorage straps. A structural test program will also be developed that will evaluate the effectiveness of the proposed retrofit techniques.

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HUD USER's	Southwest Research Institute	Implementation of the Testing and Analisys Plan Development of Proposed Test Procedures for Possible Inclusion in the Federal Standards	Report	156
HUD USER's	School of Architecture. University of Illinois at Urbana-Champaign	Permanent Foundations Guide for Manufactured Housing	Report	N/A
HUD USER's	Southwest Research Institute	Transportation Research Volume II. Study of Recicled/Reusable Running Gear for Manufactured Housing as an Aid to Sitting	Report	N/A
HUD USER's	Wiss, Janney, Elstner Associates, Inc.	Roof Shingle Testing for the Department of Housing and Urban Development	Report	15
HUD USER's	Department of Civil Engineering at The University of Texas, Austin	Strength and behavior of Shear Walls used in Mobile Homes - Part II	Report	100
HUD USER's	Institute of Wood Research (MTU)	Durability of Structural Adhesives for use in the Manufacture of Mobile Homes. Final Test Report	Report	360
HUD USER's	Building and Fire Research Laboratory	Manufactured Homes - Probability of Failure and the need for better Windstorm Protection through Improved Anchoring Systems	Report	42
HUD USER's	USDA Forest Service / Forest Products Laboratory (Wisconsin)	Effect of Dynamic Loads on the Lateral Strength of Nail Connections for the Manufactured / Modular Housing Industry	Report	32
HUD USER's	Department of Civil Engineering at The University of Texas, Austin	Strength and behavior of Typical Connections used in Mobile Homes	Report	154
HUD USER's	Boston Redevelopment Authority. Research Department	Tax Constraint and Fiscal Policy: After the Property Tax Volume II - Analytic Tools and Techniques	Report	330
HUD USER's	NAHB Research Foundation, Inc.	Structural Performance of Scissors-Type Roof Trusses used in Manufactured Housing	Report	34
HUD USER's	Southwest Research Institute	Transportation Research Volume I. Permanent Perimeter Foundations for Manufactured Housing	Report	359
HUD USER's	Technology-Economics, Inc.	Economic Benefit-Cost and Risk Analisys of Results of Mobile Home Safety Research: Transportation Safety and Durability Analysis	Report	143
HUD USER's	Center for Building Technology-National Engineering Laboratory-National Bureau of Standards	The Measurement of Wind Loads on a Full-Scale Mobile Home	Report	121
HUD USER's	Southwest Research Institute	Design-Engineering Analysis Package Cost/Benefit Analysis	Report	38
HUD USER's	NAHB National Research Center	Structural Tests of a Ceiling Diaphragm Construction for Manufactured Housing	Report	26

HUD USER's	Southwest Research Institute	Development of a Proposed Test and Analysis Plan	Report	52
HUD USER's	Southwest Research Institute	Re-Draft of Federal "Mobile Home Construction and Safety Standards"	Report	20
HUD USER's	Wiss, Janney, Elstner Associates, Inc.	Testing of Soil, Anchors and Straping	Report	14
HUD USER's	NAHB National Research Center, Inc.	Manufactured HousingShearwall Tests using ASTM Methods E72 and E564	Report	53
HUD USER's	Wiss, Janney, Elstner Associates, Inc.	Full-Scale Laboratory Testing of Manufactured Housing Lateral Load Restraint Devices for U.S. Department of Housing and Urban Development	Report	N/A
HUD USER's	Southwest Research Institute	Development and Correlations of Mobile Home Stiffness Field Test Methodology. Mobile Home on-site Durability Research	Report	60
HUD USER's	NAHB Research Center, Inc.	Comparison of Methods for Wind Uplift Load Testing of Roof Trusses for Manufactured Housing. Final Report	Report	N/A
HUD USER's	Southwest Research Institute	Evaluation of Dynamic Load Factors on Two Manufactured Home Transportable Sections due to Road Transport Excitation	Report	136
HUD USER's	Southwest Research Institute	Manual for Designers, IPIA's and DAPIA's Relative to Mobile Home Durability	Report	44
HUD USER's	Wiss, Janney, Elstner Associates, Inc.	Laboratory Testing of Soil Anchors for U.S Department of Housing and Urban Development	Report	N/A
HUD USER's	Institute of Wood Research (MTU)	Design Engineering Analysis of Adhesive Joints in Typical Single and Double Wide Mobile Homes	Report	74
HUD USER's	NAHB Research Center, Inc.	Residential Structural Design Guide: 2000 Edition	Guide	N/A
Hunker Down Systems	Hunker Down Systems	Hunker Down Systems Details	http://www.hunkerdown.com/	N/A
Idaho National Engineering and Environmental Laboratory (INEEL)	Research Team of INEEL, Vof WY, EPM, Inc. and MHI	Full-Scale Structural Testing of a Single-Wide Manufactured Home-Oakwood Model 1320: 14ft. X 62 ft. Test Report	Booklet	37
IHC	Jorge Remedios	Regulatory Environnment	Personal Notes	7
Illinois Legislature	Illinois Legislature	Illinois Compiled Statutes. Health Facilities. Mobile Home Park Act. 210 ILCS 115/	http://www.legis.state.il.us/ilcs/ch210/ch210act115.htm	12
Illinois Legislature	Illinois Legislature	Illinois Compiled Statutes. Property. Mobile Home Landlord and Tenant Rights Act. 765 ILCS 745/	http://www.legis.state.il.us/ilcs/ch765/ch765act745.htm	10

Illinois Legislature	Illinois Legislature	Illinois Compiled Statutes. Health Facilities. Illinois Mobile Home Tiedown Act. 210 ILCS 120/	http://www.legis.state.il.us/ilcs/ch210/ch210act120.htm	2
INEEL	William D.Richins, J.M.Lacy, T.K.Larson, T.E.Rahl, J.R.Goodman, R.J.Schmidt, B.D.Koerner and A.K.Pandey	Full-Scale Structural Testing of a Single-Wide Manufactured Home	Technical Report	7
INEEL	Brian D.Koerner, Richard J.Schmidt, James R.Goodman and William D.Richins	Lateral Load Testing and Analysis of Manufactured Homes	Technical Report	8
INEEL	William D.Richins, T.K.Larson, J.R.Goodman, R.J.Schmidt and A.K.Pandey	Improved Design of Manufactured Homes for Hazardous Winds	Technical Report	7
INEEL	William D.Richins, T.K.Larson, T.E.Rahl, D.G.Pollock and V.Yadama	Testing of Wood Joints for High Winds	Technical Report	8
Institute for Research in Construction (IRC)	Canada's Construction Technology Centre	National Guide of Sustainable Municipal Infrastructure: Innovations and Best Practices	http://www.nrc.ca/irc/irccontents.html	N/A
Insulated Dry Roof System	Insulated Dry Roof System	Product Application	http://www.dryroof.com/applications.html	2
Jacobsen Homes	Jacobsen Homes	Jacobsen Homes Family Model Center	http://www.jachomes.com/faflpl.html	10
Kathy Bayes Insurance Agency	Kathy Bayes Insurance Agency	Mobile Home Quote Request	http://www.insurance4texas.com/mobilehome.htm	4
Manufactured Homeowners Network	Manufactured Homeowners Network	Analysis of the Conversion of Wheels & Axles owned by Homeowners	http://maxpages.com/mobilehomes/running_gear	4
Manufactured Housing Global Network	Sure Safe Industries, Inc.	Design Built Foundations	http://www.suresafe.com/	N/A

Manufactured Housing Global Network	Manufactured Housing Global Network	Free Classifieds Manufactured Housing Finance	http://www.manufactured-housing.net/	8
Manufactured Housing Institute (MHI)	Manufactured Housing Institute (MHI)	Summary of State Laws and Court Decisions Regarding the Zoning, Placement and Tax Treatment of Manufactured Housing	http://www.mfghome.org/DR_state_laws_map.html	22
Manufactured Housing Publications	Manufactured Housing Institute (MHI)	MHI Bookstore: Books and Brochures	http://www.mfghome.org/cgi-local/SoftCart.exe/online-store/scstore/BS_booklets.html?E+scstore	7
Manufactured Housing Publications	Manufactured Housing Institute (MHI)	MHI Bookstore: Reports and Surveys	http://www.mfghome.org/cgi-local/SoftCart.exe/online-store/scstore/BS_reports.html?E+scstore	5
Manufactured Housing Resources	George Porter	What's a Ridge Beam Support Column?	http://www.mfdhousing.com/george_porter/ridge.shtml	3
Manufactured Housing Resources	George Porter	Mother Nature Doesn't Listen	http://www.mfdhousing.com/george_porter/mother.shtml	2
Manufactured Housing Resources	George Porter	Safety is All in Your Head	http://www.mfdhousing.com/george_porter/safety.shtml	3

Manufactured Housing Resources	George Porter	The HUD Code goes to the Ground	http://www.mfdhousing.com/george_porter/code.shtml	3
Manufactured Housing Resources	George Porter	Every Duct has a Bill	http://www.mfdhousing.com/george_porter/bill.shtml	3
Manufactured Housing State Administrative Agencies	Industry Associations Index	State Administrative Agencies	http://www.mobilehome.com/saa/index.shtml	N/A
Manufacturer Housing Associations	Manufacturer Housing Associations	Mobile Home.Net / Home Sale Advertising	http://www.mobilehome.net/associations.htm	N/A
Manufacturing Housing Industry (MHI): Government Affairs	www.hudclips.org	Database: Code of Federal Regulations '97 (from Document 3280.1 through Document 3280.815)	http://www.access.gpo.gov/nara/cfr/cfr-table-search.html	N/A
MDC Public School	Spillis Candela & Partners	Enhanced Hurricane Protection Areas (EHPA) Design Criteria	Booklet	
MHI	MHI: Media Center, Press Released	Manufactured Home Industry Meets Consumer Demand	http://www.mfghome.org/press_releases/071999.htm	2
MHI	MHI: Technical Resources (Research Directory)	Program Background	http://www.mfghome.org/TR_DirectoryofMHResearch/ProgBkgrnd.html	10

MHI	MHI: Boostore (Booklets and Brochures)	Bookstore Code - OSHA	http://www.mfghome.org/cgi-local/SoftCart.exe/online-store/scstore/BS_booklets.html?E+scstore#BR008	N/A
MHI	MHI: Boostore (Reports and Surveys)	Minimize Damage from Disasters and Save Lives	http://www.mfghome.org/cgi-local/SoftCart.exe/online-store/scstore/BS_reports.html?E+scstore	N/A
MHI	MHI: Technical Resources (Addresses and Telephone Numbers)	Addresses and Telephone Numbers of Organizations for Purchase of Research Publications	N/A	N/A
MHI	Directory MHI-Completed by HUD	Manufactured Home Research Completed by HUD	http://www.mfghome.org/TR_DirectoryofMHResearch/	14
MHI	MHI: Consumer Center-Fast Facts	Fast Facts: Little Known Facts about Manufactural Housing	http://www.mfghome.org/fast_facts.html	1
MHI	MHI:Technical Resources:Regulations, Reports and Studies	Directory of Manufactured Home Research September 2000	http://www.mfghome.org/TR_DirectoryofMHResearch/index.html	40
MHI / HUD	MHI Consumer Center	Housing & Urban Development (HUD) - The HUD Code	http://www.mfghome.org/CC_hud.html	4

MHI / Texas Tech. University	Institute for Disaster Research, Texas Tech. University	Research Publications/ Texas Tech University	http://www.mfghome.org/TR_DirectoryofMHResearch/TexasTechPubs.html	1
MH-Quote	MH-Quote	Extended Service Contracts for New Manufactured Homes	http://www.mh-quote.com/Insurance/NewPurchase.asp	2
Modern Mobile Homes	Modern Mobile Homes	Modern Mobile Homes and Manufactured Housing	http://www.no1dealer.com/modern.htm	4
Moore Emergency Management-Killer Tornadoes	Emergency Management & Communications-The City of Moore, Oklahoma	Killer Tornadoes 1996-Present: Yearly US Tornado Statistical Information	http://www.smileamerica.com/emermgt/killr96.htm	4
MSN Home Advisor	HomeAdvisor.com	Best-Priced Loan Guaranteed	http://www.homeadvisor.msn.com/	N/A
MSN Home Advisor	HomeAdvisor.com (Insurance Center)	Hazard Insurance: Preparing for a disaster	http://www.homeadvisor.msn.com/insurance/disaster.asp	N/A
MSN Home Advisor	HomeAdvisor.com	Advisor Guides: When Disaster Strikes	http://homeadvisor.msn.com/improve/guides/whendisasterstrikes.asp	5

MSN Home Advisor	HomeAdvisor.com	Advisor Checklists:Make Your Home Safe and Secure	http://homeadvisor.msn.com/improve/checklists/makeyourhomesafe.asp	N/A
MSN Home Advisor	HomeAdvisor.com	Homeowner's Handbook	http://www.homeadvisor.msn.com/improve/checklists/makeyourhomesafe.asp	N/A
National Comission on Manufactured Housing	National Comission on Manufactured Housing	Manufactured Housing	http://www.mobilehomesfl.com/WhatIsManufacturedHousing.html	9
Nebraska Emergency Management Agency (NEMA)	NEMA	Tornado Facts	http://www.nebema.org/tornadofacts.html	5
Nebraska Natural Resources Commission	Nebraska Natural Resources Commission (Rules Governing Flood Plain Management)	Title 258. Minimum Standards for Flood Plain Management Programs	http://www.nrc.state.ne.us/floodplain/flood/minstd.html	7
NOAA	NOAA	The Saffir-Simpson Hurricane Scale	http://www.nhc.noaa.gov/aboutsshs.html	N/A
Novel Tools	Novel Tools	Structural Engineering Software	http://www.noveltools.com/	4
NRC - IRC Home. Canadian Building Digest	W.R. Schriever	CBD-188. Wind Forces on Mobile Homes	http://www.nrc.ca/irc/cbd/cbd188e.html	7
NRC-CNRC	Institute for Research in Construction (IRC)	IRC Publications Catalog for Structural and Fire Safety. Manual for Screening of Buildings for Seismic Investigation. Designing for Fire Safety. Structural Fire Protection	http://www.nrc.ca/irc/catalogue	N/A

Online Sunshine	The 2000 Florida Statutes	Chapter 723 Mobile Home Park Lot Tenancies	http://www.leg.state.fl.us/Welcome/index.cfm	N/A
Oregon State Archives. Administrative Rules	Department of Consumer and Business Services, Building Codes Division	Division 500. Manufactured Dwellings. General Rules	http://arcweb.sos.state.or.us/rules/OARS_900/OAR_918/918_500.html	26
Pacific Nothwest Library	Pacific Nothwest Library	Publication Guide: Energy-Efficient Manufactured Housing	http://mfdhousing.com/pnnl/index.html	1
Palm Beach Post & FEMA	Palm Beach Post & FEMA	Prepare your Mobile Home	http://www.gopbi.com/weather/special/storm/getready/mobilehome.html	N/A
Partnership for Advancing Technologies in Housing (PATH)	PATH	Products & Technologies: PATH Technology Inventory (Index-Subject List)	http://www.nahbrc.org/toolbase/pandt/tech/index.html	N/A
Partnership for Advancing Technologies in Housing (PATH)	PATH	Products & Technologies: PATH Technology Inventory (Subject List)	http://www.nahbrc.org/toolbase/pandt/tech/subject.html	N/A
Partnership for Advancing Technologies in Housing (PATH)	PATH	Products & Technologies: PATH Technology Inventory (Foundations)	http://www.nahbrc.org/toolbase/pandt/tech/foundsub.html	N/A
Partnership for Advancing Technologies in Housing (PATH)	PATH	Products & Technologies: PATH Technology Inventory (Exterior Walls)	http://www.nahbrc.org/toolbase/pandt/tech/extsub.html	N/A

Partnership for Advancing Technologies in Housing (PATH)	PATH	Products & Technologies: PATH Technology Inventory (Roofs)	http://www.nahbrc.org/toolbase/pandt/tech/roofsub.html	N/A
Partnership for Advancing Technologies in Housing (PATH)	PATH	Products & Technologies: PATH Technology Inventory (Interior Partitions, Ceilings and Floors)	http://www.nahbrc.org/toolbase/pandt/tech/interiorsub.html	N/A
Partnership for Advancing Technologies in Housing (PATH)	PATH	Products & Technologies: PATH Technology Inventory (Doors and Windows)	http://www.nahbrc.org/toolbase/pandt/tech/doorssub.html	N/A
Partnership for Advancing Technologies in Housing (PATH)	PATH	Products & Technologies: PATH Technology Inventory (Whole-House Systems)	http://www.nahbrc.org/toolbase/pandt/tech/wholesub.html	N/A
PATH	PATH	Manufactured Housing Disaster-Resistant Pier Systems	http://www.nahbrc.org/toolbase/pandt/tech/abstracts/foundab8.html	4
PATH	PATH	Manufactured Housing Ground Anchor Systems	http://www.nahbrc.org/toolbase/pandt/tech/abstracts/foundab4.html	3
PFGMH	Permanent Foundations Guide	Permanent Foundations Guide for Manufactured Housing	http://www.huduser.org/publications/destech/permfound.html	1

Public Campaign hereby bestows upon U.S. Senators R. Shelby and Jeff Sessions and U.S. Representative Bob Aderholt	Public Campaign US Senator Richard Shelby and Jeff Sessions and US. Representative Bob Aderholt	The Golden Leash Award	http://www.publicampaign.org/	5
Purdue University	Timothy Whalen	Wind Engineering	http://bridge.ecn.purdue.edu/~whalen/wind_eng.html	3
Quality Manufactured Homes	Quality Manufactured Homes	Quality Manufactured Homes and RV's Online	http://www.qmh.com/	2
Redman Homes Construction	Redman Homes Construction, Inc.	Redman Homes Quality Construction	http://www.redmanhomes-nw.com/	N/A
Redman Homes, Inc.	Redman Homes, Inc.	Featured Model Homes	http://www.redmanhomes-nw.com/models.htm	2
San Jose Business Journal / Silicon Valley	Dorothy Stonley	Factory-Built Homes Make Comeback	http://sanjose.bcentral.com/sanjose/stories/1998/02/16/focus1.html	5
Silicon Valley/ San Jose Business Journal	Silicon Valley/ San Jose Business Journal	Two-Story Mobile Homes on Market	http://sanjose.bcentral.com/sanjose/stories/1997/10/27/daily10.html	2
Skyline Corporation	Skyline Corporation	Skyline Manufactured Housing	http://www.skylinecorp.com/	4
South Carolina Legislature	South Carolina Legislature	A Bill to Amend Chapter 29 (Uniform Standards Code for Manufactured Housing), Title 40, Code of Laws of South Carolina, 1976, Relating to the Business of Manufactured Housing	Booklet	39

South Carolina Legislature	South Carolina Legislature	2001-2002 Bill 43: Manufactured Housing Board, licensure and regulation of Mobile Home Industry. A Bill to Amend Chapter 29 (Uniform Standards Code for Manufactured Housing), Title 40, Code of Laws of South Carolina, 1976, Relating to the Business of Manufactured Housing	http://www.lpitr.state.sc.us/bills/43.htm	31
State of Colorado	State of Colorado	Manufactured Housing (Includes Mobile and Stationary Housing)	http://www.state.co.us/gov_dir/oed/industry/housing.html	N/A
Statewide Mobile Homes	Statewide Mobile Homes	Selling and Transporting Mobile Homes all over the State of Maine	http://statewide_trans.tripod.com/	4
Sun One	Rob Haneisen and Mark Hollis	State works to improve mobile home installations	http://www.sunone.com/news/articles/12-15-99y.shtml	4
SWIRL / Twister	Warner Bros. & Universal Pictures	Tornado Safety Information	http://movies.warnerbros.com/twister/cmp/safety.html	N/A
SWIRL / Twister	Warner Bros. & Universal Pictures	Tornado Intensity Scale	http://www.batmanforever.com/twister/cmp/intensity.html	N/A
Technology Inventory	Technology Inventory: Results from the field	Solar Water Heaters	http://nahbrc.org/toolbase/pandt/tech/abstracts/plumbab5.html	3
The Augusta Chronicle Online	Metro@Augusta- The Augusta Chronicle Online	Augusta, Georgia: Metro@Augusta: Tornadoes Strike Area on 05/08/98	http://www.augustachronicle.com/stories/050898/met_tornado.shtml	5

The Canadian Connection	P.J.Wade (Realty Times)	Manufactured Housing: Building in a Building	http://realtytimes.com/rtnews/rtpages/20001031_cabuilding.htm	3
The Cato Journal Vol.16 No.1	Louis De Alessi	Error and Bias in Benefit-Cost Analysis: HUD's Case for the Wind Rule	http://www.cato.org/pubs/journal/cj16n1-8.html	15
The Manufactured Housing Global Network	The Manufactured Housing Global Network of Manufactured Home Communities	1997 The Decade 1995-2005 Statistical Data Summary	http://mfdhousing.com/gfa/statdata.shtml	1
Tim's Manufactured Home	Tim's Manufactured Home	Models	Booklet	17
Tornadoes Saferoom Resource Library	Tornadoes Saferoom Resource Library	Tornadoes Saferoom for Mobile Homes and Manufactured Homes and Others	http://www.tornadosaferoom.com/info.htm	4
Torro Website	The Tornado and Storm Organisation	Tornadoes and Storm Research Organisation	http://www.torro.org.uk/	4
University of Colorado	Jon K.Ayscue. The Johns Hopkins University and Natural Hazards Research and Applications Information Center. Institute of Behavioral Science, University of Colorado	Hurricane Damage to Residential Structures: Risk and Mitigation	http://www.colorado.edu/hazards/wp/wp94/wp94.html	47
US Census Bureau	US Census Bureau	American Housing Brief- American Housing Survey 1997	http://www.census.gov/hhes/www/housing/ahs/hsgprof.html	5
US Department of Housing	Florida State Office	Florida State Office-Miami	http://www.hud.gov/local/fso/localhud.html	3
Village of Blue Mounds, Wisconsin	Police Department Village of Blue Mounds, Wisconsin	Tornado Safety Rules	http://userpages.chorus.net/bluemnds/police.html	2

Web	Jennifer Davis of Peoria Journal Star, Peoria, Illinois, USA	Not the mobile homes of yore	http://www.mhoai.org/NewsClips/Yore.htm	3
Web	M.W.Schofield, Assessor	Manufactured Homes Transactions	http://www.co.clark.nv.us/ASSESSOR/MobileHm.htm	N/A
Web	Mobile Home Doctor	Mobile Home Doctor Cures Mobile Home Problems	http://www.mobilehomedoctor.com	N/A
Web	Queen's Printer, Victoria, British Columbia, Canada	Manufactured Home Tax Act [RSBC 1996] Chapter 281 (unofficial version)	http://bbs.qp.gov.bc.ca/bcstats/96281_01.htm	4
Web	ABAG	Impacts of Earthquakes on Buildings from Shaken Awake!	http://www.abag.ca.gov/bayarea/eqmaps/shelpop/bldg.html	4
Web	Moving Mobile Home (01/18/2001)	Moving Your Mobile Home	http://www.hanscom.af.mil/jppso/mmh.htm	11
Web	Chuck Doswell	Tornadoes: Some Hard Realities	http://webserv.chatsystems.com/~doswell/Tornado_essay.html	17
Web	Chuck Doswell	Tornado-Resistant Construction, Tornado Safety and Reconstruction after Disasters	http://cordell-ok.net/~doswell/Tornado_construction.html	N/A

Web	Janet Wickell	Differences between Modular Homes and Manufactured Homes	http://vacationhomes.about.com/realstate/vacationhomes/library/weekly/a~041100.htm	5
Web	Janet Wickell	How to Tell if a Home is Manufactured	http://vacationhomes.about.com/realstate/vacationhomes/c/ht/01/01/how_tell_difference_ma3/10/01	4
Web	Tom Sporney	Building Quality in Manufactured Homes. Home Repair - 07/29/99	http://homerepair.about.com/homegarden/homerepair/library/weekly/a~072999.htm	5
Web	Tom Sporney	Manufactured Housing. Net Links	http://homerepair.about.com/homegarden/homerepair/cs/manufactrdhousing/index.htm	3
Web	Eagle Point	Structural Wind Analysis	http://www.eaglepoint.com/structural/wind.htm	4

World Homes	World Homes	Mobile Modular Housing for Emergency Use and Disaster Relief	http://www.net-magic.net/worldhomes/faq.htm	4
Yakima Valley News (Online Newspaper)	Yakima Valley News (Online Newspaper)	Mobile Home and Recreational Vehicle Parks (Chapter 16.12)	http://www.yakvalnews.com/t16/ch16.12.html	14

APPENDIX B

List of Contacts Affiliated with the Manufactured Housing Industry

Kinder Mobile Homes
4020 South Pine Avenue
Ocala, Florida 34480
(352) 622 - 2460

Ann Sawyer
Palm Harbor Village
5200 South Pine Avenue
Ocala, Florida 34480
(352) 690 - 3040

Jeff George
Jacobsen Homes
6160 South Pine Avenue
Ocala, Florida 34480
(352) 629 - 3001

Michelle Smith
Dave Carter Mobile Homes
3530 Southwest 7th Street
Ocala, Florida
(352) 732 - 3317

Fleetwood Mobile Homes
931 Northwest 27th Avenue
Ocala, Florida
(352) 840 - 0066

Ed Sims, VP of engineering
Nobility Mobile Homes Corporate Office
3741 Southwest 7th Street
Ocala, Florida
(352) 732 - 6110

Skyline Mobile Homes
1230 Southwest 10th Street
Ocala, Florida
(352) 629 - 7571

Curtis Blackman
Bureau of Mobile Homes & Recreational Vehicle Construction (Regional Office)
4033 East Fowler Avenue
Tampa, Florida 33617
(813) 975 - 6570

Philip R. Bergelt, Program Manager
Department of Highway Safety and Motor Vehicles, Division of Motor Vehicles,
Bureau of Mobile Homes and Recreational Vehicle Construction
Neil Kirkman Building
2900 Apalachee Parkway
Tallahassee, Florida 32399-0500
(850) 488 - 8600

David Cougher
Department of Highway Safety and Motor Vehicles, Division of Motor Vehicles,
Bureau of Mobile Homes and Recreational Vehicle Construction
Kirkman Building
2900 Apalachee Parkway
Tallahassee, Florida 32399-0500
(850) 488 - 8600

Frank Walters, VP Technical Activities
Manufactured Housing Institute
1745 Jefferson Davis Highway
Arlington, Virginia 22202
(703) 558 - 0400

Federation of Manufactured Home Owners
4410 Northwest 67th Court
Coconut Creek, Florida 33073
(727) 530 - 7539

Beth Loftis
Florida Manufactured Housing Association
2958 WELLINGTON CIRCLE NORTH, SUITE 100
Tallahassee, Florida 32308-6686
(850) 907 - 9111

APPENDIX C

Photographs from Nobility Homes Factory Tour

Tie-down connector attached to floor framing.

Tie-down connectors at 5’-4” on center.

20 gauge ties securing studs to floor frame.

20 gauge strap ties securing studs at door opening and
20 gauge bent ties connecting stud walls to roof joists.

Shear wall strap connector on interior wall of home.

Strap-tie connecting interior wall to primary structural beam.

APPENDIX D

IN-SITU MODIFICATIONS TO MOBILE HOMES

FINDING FROM FIELD VISITS TO MOBILE HOME PARKS

Members of the IHC research team have visited numerous mobile home parks in Miami-Dade and Broward counties. Visits to mobile home parks in Pinellas and Hillsborough counties are planned for May 2-4, 2001.

The main objectives of these visits are to document, by way of digital photography, instances of:

(a) Structural or architectural modifications to mobile homes performed in-situ.

(b) Various anchoring devices in use.

An important initial finding from these visits is the prevalence of in-situ modifications of mobile homes. Clearly the majority of units in the mobile home parks visited show modifications, of various types, that are structurally attached to the original unit.

Two important issues arise from these prevailing field modifications of mobile homes:

1. Since state statues do not allow field additions to mobile homes that are structurally connected to the same, questions about compliance with regulations need to be answered.

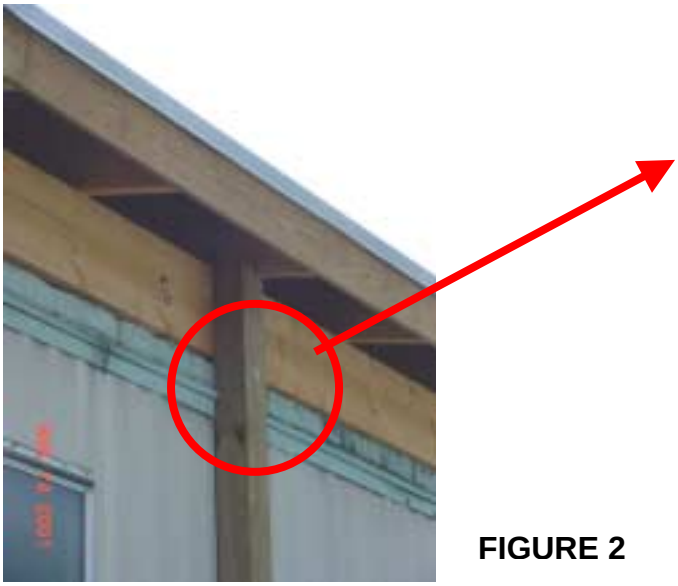
2. More important perhaps, as this goes to the issue of structural performance, is the need to explore how these field modifications are affecting the overall structural performance of the housing unit and its potential for hurricane loss.

Following is a series of photographs, with commentary, showing one specific individual instance of field modification as an example of what is mentioned above.

Numerous other examples have been documented already. Several case studies, based on this documentation, will be included in the final report for this project. Also, the complete collection of photographs and comments will be displayed in the IHC's web page and supported via an interface to the web-enabled TerraFly tool being used in this research effort.

FIGURE 1

Example of a single-wide mobile home in the process of undergoing in-situ modification. The wood columns supporting the roof over the mobile home have been attached to the manufactured dwelling at various points.



Structural attachment of additions to mobile homes, in-situ, is forbidden by statute unless the addition and its connection to the existing mobile home have been specifically designed, and approved by pertinent authority, to perform as a unit.
IHC field research is showing that this is not the case for most if not all of the in-situ modifications that have been observed.

FIGURE 2

FIGURE 3

Another view of the same unit being modified in-situ. Notice how the skirt has been removed in places to allow for the wood columns to be connected to the understructure of the mobile home.

Notice the manufactured unit in the background also undergoing similar modification.

FIGURE 4

The same units two weeks later (notice the date on the picture). Aluminum siding has been installed on the addition, as well as a raised floor on a wood structure.

Interior view of the addition. The interior framing suggest possible future installation of windows. Notice the lack of lateral bracing on the roof structure. The columns shown have been attached to the original mobile home.

FIGURE 5