Third Party Analysis of Manufactured Home Retrofit Tie Downs

Assessment & Analysis - State of Florida Residential Construction Mitigation Retrofit Program

Developed by FEMA, Mitigation Section, Technical Services Branch
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Rationale for Study

At the request of the State of Florida, the FEMA Mitigation Branch, Technical Services Division, performed an analysis of the retrofit tie down program. The retrofit program is funded through legislatively directed funds from the Florida Hurricane Catastrophe Fund. The tie down work entailed retrofitting existing manufactured homes to bring them closer to compliance with tie down regulations as promulgated by the Florida Department of Highway Safety and Motor Vehicles, Chapter 15C-1, amended March 31, 1999. Manufactured homes are constructed under the codes and standards promulgated by the United States Department of Housing and Urban Development (HUD). The standards for construction set by HUD are found in 24 CFR Part 3280. No state may change the standards set by HUD. The State of Florida has the most stringent installation standards for manufactured housing with respect to anchoring requirements.

Summary

The primary emphasis of the analysis was to determine how well structures in the program fared after impact by the 2004 hurricanes. The short answer to that question is: No structure in the sample for which retrofit tie down anchors were provided, appeared to be damaged due to anchor failure. This does not mean, however, that all structures survived. They did not.

Of the six manufactured home parks studied, only Emerald Lake, in Charlotte County experienced sustained winds at or above 1994 design load levels (See Table 6). Understandably, Emerald Lake also had the most damage of any park studied. A map is included at the back of this report indicating the locations of the parks studied and the estimated wind velocities experienced for each hurricane event. During the field study, attempts were made to determine age of all studied structures. This was not completely successful because many structures were not occupied by the original owner(s), or owners were not at home during the inspection. Additional sources of age information were researched, including the park records. This resulted in ages for all but one park, where the data was available. Age information is a valuable factor in determining vulnerability. Age in manufactured homes will determine the wind load design level for which the structure was constructed (See Wind Zone Discussion), installation date indicates the standards to which the structure was supposed to be anchored.

A substantial quantity of data was gathered by the field team, and that information is presently in the process of being collated and analyzed. Some casual observations were made by team members regarding various aspects of the tie down program.

1. In Emerald Lake, several retrofit straps were installed on original anchors. In at least one instance, the old anchor broke.
2. Several instances were noted in the field where original and some retrofit anchor straps were cut, ostensibly for access to utilities under the structure.
3. A large percentage (estimated to be approximately 90%) of original tie down straps were very loose or broken, with corrosion as the proximal cause.
4. A substantial proportion of retrofit straps were observed to be loose.

5. Only 4% to 5% of inspected homes were substantially damaged.
6. The sample consisted of very similar percentages of doublewide and singlewide manufactured homes with a slight advantage in numbers of singlewides (~ 43% vs. 57%)
7. In at least one instance, retrofit straps were installed on a structure with no apparent pier base pads. This structure appeared to have been substantially damaged by wind.
8. The majority of structures where attachments were removed by wind suffered damage due to direct attachment to the primary structure, in apparent violation of building codes.
    a. One notable exception was Starlight Ranch in Orange County. In this park, all observed additions were separate, stand-alone construction.
9. Many of the structures possessed additions or appurtenances that apparently limited access for either retrofit crew. These structures also restricted access by the inspection team.

Park	Peak Wind	Sustained Wind	Design Wind
Emerald Lake	149	119	110
Whispering Palms	113	87	100
Pinelake Gardens	109	84	100
Casa Loma	114	87	100
Starlight Ranch	109	83	100

Table 1. Wind Speeds and Design Level of Manufactured Homes in Parks Studied

Park	Original Tie Downs			
	Loose	Tight	Corroded	Broken
Emerald Lake	92%	8%	24%	20%
Whispering Palms	81%	19%	44%	25%
Pinelake Gardens	54%	46%	40%	37%
Casa Loma	46%	54%	31%	10%
Starlight Ranch	68%	32%	13%	10%
Average	68%	32%	27%	18%

Table 2. Condition of Original Tie Downs in Parks Studied

Park	Retrofit Tie Downs			
	Loose	Tight	Corroded	Broken
Emerald Lake	40%	60%	8%	7%
Whispering Palms	14%	86%	0%	0%
Pinelake Gardens	14%	86%	0%	0%
Casa Loma	12%	88%	0%	0%
Starlight Ranch	0%	100%	0%	0%
Average	10%	90%	1%	1%

Table 3. Condition of Retrofit Tie Downs in Parks Studied

Methodology

1. Survey of the efficacy of Manufactured Housing Anchor Program
   A. 6 Manufactured Home Parks were chosen for inspection.
   B. Based on wide geographic area in Florida—see location map at back of report.
   C. Park Sites chosen for peak and sustained winds during each of the 4 disasters

HOUSING PARK	MAX.PEAK WINDS (MPH)	MAX. SUSTAINED WINDS (MPH)	NUMBER OF RETROFITS	HURRICANE
Casa Loma	114	87	86	JEANNE
Colonial Pines	96	70	74	IVAN
Emerald Lake	149	119	141	CHARLEY
Pinelake Gardens	109	84	122	FRANCIS
Starlight Ranch	109	83	353	CHARLEY
Whispering Palms	113	87	249	JEANNE

Table 4. Summary Table Of Parks Chosen For Study

   D. Individual lot inspections were based on a 10% sample population of 1,025 retrofits installed for the selected Manufactured Home Parks. Contact calls were made giving homeowners advanced notice of inspections and highlighting any potential sites, problems, or comments. Homes chosen at randomly dispersed locations among given park.

HOUSING PARK	NUMBER OF RETROFITS	NUMBER SAMPLED	HURRICANE
Casa Loma	86	9	JEANNE
Colonial Pines	74	7	IVAN
Emerald Lake	141	14	CHARLEY
Pinelake Gardens	122	12	FRANCIS
Starlight Ranch	353	35	CHARLEY
Whispering Palms	249	25 TOTAL: 102	JEANNE

Table 5. Totals And Sample Size For Each Selected Park

   E. Inspections were based on Florida Administrative Code 15C-1 and data gathered was:

- Perimeter/Structural Measurements for each mobile home surveyed.
- Perimeter characteristics and magnitude dictate the number of tie downs/anchors required. Tie Down requirements for single vs. doublewide homes differ and were noted.

- Photo Documentation of each site (minimum 4 pictures, one of each exterior wall).
- Sketch drawing for each inspection site; locations of original and retrofit tie downs marked along with measurements (spacing) and condition of each one.
- Further photo documentation of proper and suspect installation examples, common findings, and anomalies (outliers).

2. Findings
   A. Installation in each home park.
      a. No observed failures of homes from improper tiedown installation or anchor malfunction.
      b. *All components observed were galvanized or on approved materials list.
      c. Some installation anomalies were noted in Punta Gorda (pictures 2 & 3).
      d. *<u>Few longitudinal Tie Downs</u> observed except in Colonial Pines, Navarre Beach – use of longitudinal bracing substituted in most cases.
      e. A significant amount of damage was caused by roof failure associated with the destruction of additions (carports, sunrooms, etc.), debris.
      f. Discussions with numerous homeowners indicated overwhelming approval of program and apparent increased overall structural stability after retrofit.

Figure 1. Lot # 155 Emerald Lake Punta Gorda 33950 Original auger and vertical strap with replaced **retrofit horizontal strap**. Vertical slightly loose. Overall good condition. Contrast with Photo 2, below.

Figure 2. Lot # 120 Emerald Lake Punta Gorda 33950
Retrofit galvanized strap replaced on original anchor auger (rusted and broken from ground)

Discussion

There were two primary, unexpected findings that deserve additional study.

1. A majority of original tie down straps and anchor swivels suffered from corrosion and many straps were found to be broken. As Table 2 indicates, up to 44% of the original tie downs studied in Whispering Palms Park were corroded. Up to 37% of the tie downs in Pinelake Gardens were broken. Emerald Lake may have lower percentages of corroded and/or broken tie downs catalogued because several of the most damaged units had been or were in the process of being removed and anchor ties had been cut or removed entirely in preparation.
    - Observation and photos indicate that corrosion is not an issue for the entire anchor mechanism. The corrosion observed appears to be strongly influenced by location along the anchor system, with the interface area between strap and anchor swivel suffering substantially, often 95% or more corrosive impacts compared to strapping two inches above broken areas and anchor below the swivel/attachment plate. It would appear that we are observing galvanic corrosion caused by a metal anchor being placed in an electrolyte (soil in this case) and dissimilar metals being joined at a stress point. The stress point occurring where the strap is rolled around the tensioning bolt on the anchor plate. Manufacturers of galvanized steel products warn about excessive bending of the steel and about bending the steel too quickly. Both of the above practices can lead to cracking of the zinc coating since the coating is less malleable then the steel substrate. Small cracks in the zinc coating are of less impact with a thicker coating, due to the fact that the zinc will mobilize to local areas to form a protective layer on the steel. Wide cracks, however might still suffer from corrosion.

Figure 3. Corrosion at Anchor Plate – Casa Loma

Unless significantly more sophisticated measurements are taken, it is only possible to speculate on the different causational modes for the corrosion observed in the field. In some cases, the soil may contain a higher admixture of saline components. Proximity to the ocean can significantly increase the salinity of rain falling on a location. This might result in a more saline soil with greater potential as an electrolyte. A second factor in corrosion of tie down straps is often related to the prior use of the site. A large number of manufactured housing parks occupy areas formerly devoted to agriculture, often citrus orchards. These old orchards were treated with fertilizers that increase the conductivity of the soil. This would increase the potential for corrosive activity at the joint between the strap and the anchor. It is important to

address the issue of corrosion due to the reduction in strength experienced by the strap, the tightening bolt and the anchor swivel plate. All of these experience reductions in strength, leading to potential breakage of strap, bolt or anchor. Straps are commonly the first item to break due to the difference in mass compared to the other components.

- It would appear that corrosion impacts were addressed in the new regulations implemented in 1999. One main change in the Florida update to its tie down regulations was an increase in zinc plating for the tie down straps. According to an official of the Bureau of Mobile Home and RV Construction, there had been various interpretations of HUD codes with both 0.15 and 0.30 ounces of zinc galvanizing per square foot of strap being applied. The standards for anchoring equipment are found in *24 CFR § 3280.306 (g) Anchoring equipment—weatherization. Anchoring equipment exposed to weathering shall have a resistance to weather deterioration at least equivalent to that provided by a coating of zinc on steel of not less than 0.30 ounces per square foot of surface coated, and in accordance with the following:*

  (1) Slit or cut edges of zinc-coated steel strapping do not need to be zinc coated.

  (2) Type 1, Finish B, Grade 1 steel strapping, 1–1/4 inches wide and 0.035 inches in thickness, certified by a registered professional engineer or architect as conforming with ASTM Standard Specification D3953–91, Standard Specification for Strapping, Flat Steel, and Seals.

  The tight radius required by the attachment mechanism may initiate premature failure of the strap by inducing tensional stress fractures within the protective zinc coating. Time will be required to determine how much the enhanced plating increases the lifespan of the anchor system. Present predictions are set at a thirty-year lifespan. It is considered important to document the impact corrosion has on the anchor plate and top of the anchor.

- Potential actions to prevent corrosion might be to place a non-conductive material in the connection. Use of ABS, nylon, ceramic or other non-conductive material between the strap and the anchor would break the connection. It might be prudent to seal the connection with a non-hardening sealer to prevent contamination bridging the gap between the strap and the anchor.
    i. Another potential for reduction in ground potential would be to place an insulating material between the frame and the clip or strap. Presently, a rotating clip is required between the frame and the strap. Reducing the connection conductivity between the frame and strap would reduce potential current paths.
    ii. There is some potential for use of a non-conductive material such as a Kevlar-reinforced fabric strap. This would remove the dissimilar metal connections presently involved in the anchor system.
- There is another potential anchoring method approved by the State of Florida. This is provided by Vector Dynamics. This system uses heavier materials and claims to

reduce or eliminate the need for lateral stability straps. Replacing straps with heavier metal brackets would reduce potential corrosion failure.

2. Field observations indicate that potentially up to 90% of all original tie down straps plus a significant percentage of retrofit straps were loose. Looseness varies by location, however any looseness of the tie down straps system removes a significant portion of the total system strength by allowing pier blocks to move much easier than if the system were properly tensioned. With loose vertical tie straps, the upper structure will be able to rotate upon wind loading of the side, placing additional rotational stress on piers and allowing flexure of the entire structural system. Should looseness be found under structures in a floodplain, this condition would be a significant threat during periods of flooding. If piers are subject to only gravity loading by a structure, without additional tensioning, lateral loading on the piers can lead to premature pier failure due to lateral translation.
    - One of the greatest potentials for loosening of the straps would appear to be settlement of the piers. Florida standards for placement of piers do not call for construction of footings. There also does not appear to be a specific compaction standard for placement of piers.
    - Tie down anchors are supposed to be sized according to soil probe tests during installation. Auger anchors are placed using motors and a significant proportion of these augers do not reach full placement depth. This reduces the resistance to pullout and changes the area of the cone of influence upon which pull-out resistance is calculated. The same test that indicates less resistance to pull-out should also strongly hint to a higher potential for settlement of the piers.
        - Pier settlement would be potentially reduced if one of several methods were used
            1. Placement of a larger non-corrosive grid plate beneath piers.
            2. Standard compaction values set by engineering analysis, perhaps calibrated to soil test probe measurements already mandated. With pier baseplate design predicated on the results.
            3. Use of footings for placement of manufactured housing in specific areas with known weak soils.
            4. Use of piers with a greater cross sectional area.
            5. Use of elastic-type anchor straps such as a Kevlar blend that would place similar overall downward pressure on piers, yet provide a degree of “give” that would maintain the foundation stability structure.

Wind Zone Discussion

A discussion of wind zones is appropriate in this study because of the potential impacts of hurricane force winds on a substantial portion of the manufactured housing stock in the State of Florida. Prior to 1974, there was no direct federal control or standard by which mobile homes were manufactured. Each state regulated construction standards within their jurisdiction. In 1974, congress designated HUD as the lead agency in the federal government to set standards for the construction of mobile homes. On June 15, 1976, new country-wide regulations were implemented with HUD taking full control of the manufacture of mobile homes. At this time,

the official term changed from mobile home to manufactured home. These standardized requirements were set as a primary standard, unlike most federal guidelines, which set a minimum performance level. (See CFR § 3282.11 in Appendix 1). Manufactured homes were constructed to the same standards nationwide until changes were implemented in 1994 in response to the devastation of Hurricane Andrew. At that time, three wind zones were defined. Type I wind zone homes are constructed to essentially the same wind load provisions as all previous manufactured homes to a fastest wind load rating of about 70 mph. Type II homes are designed to handle a fastest wind load of approximately 100 mph, while Type III homes are designed for a fastest wind speed load of 110 mph. The map in Figure 4 below indicates those zones in the State of Florida. The fastest wind speed rating differs from the Florida Building Code (FBC) in that the FBC uses the standards of ASCE 7-96. During the research for this report, a study performed for the Florida Manufactured Home Association was provided. It is included here to provide an engineered conversion from the HUD fastest mile rating to the Florida Building Code three-second gust rating. This provides a needed bridge to better understand how the two codes operate

The 1990 Census indicated 821,048 manufactured homes in Florida, the 2000 Census counted 849,304 manufactured homes. This would indicate a maximum number of 829,553 pre-1994 manufactured homes in the State of Florida. Additionally, the State of Florida did not implement their updated tie down standards of Florida Administrative Code 15C-1 until 1999. This would have left approximately 847,000 manufactured homes with lower anchoring standards and roughly 98 percent of those manufactured homes would not meet 1994 wind design standards. This is a huge vulnerability. It is understood that not all manufactured homes found in 1990 are still in service, however a majority are still being used. As was seen during the hurricanes of 2004, even older manufactured homes resisted damage when wind speeds remained below design levels. It was felt that a hidden vulnerability may exist, that of corroded, broken, cut or loosened original tie down straps. This was not part of the scope of this study, however the figures found to date appear significant. Most owners of manufactured homes are unaware of the foundations of their homes. Out of sight, out of mind is the operative term here. Unless a more detailed state-wide study is conducted, the true vulnerability of hundreds of thousands of homes in Florida is left to speculation and conjecture.

The primary cause of damage noted by the field team resulted from attached structures such as carports and additions that were not constructed to code. Many manufactured homes are sold with additions, such as screen rooms and carports. Some of these additions are designed to be attached to those manufactured homes. Unfortunately, a large percentage of these additions are not designed to be attached. This means that the manufactured home was not constructed with these additions in mind, especially from a wind resistance standpoint. This has become a gray area where local building departments often seem to fear to tread. However, this area was one of the most likely areas where weaknesses were shown during the hurricanes. Not only the primary structures suffered damage from poorly designed and constructed add-ons, neighboring structures and utilities suffered damage from debris that found its source in those same failed additions.

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Florida Codes and Manufactured Housing

Ever since HUD implemented their code for construction of manufactured homes as a preemptive rule that overrode local building codes, local codes officials seem to have had a difficult time determining where they stood with respect to manufactured housing. This has often led to a "hands off" stance. It was felt that the federal government controlled the construction, and, in the State of Florida, the Department of Motor Vehicles controlled the installation of those manufactured homes. Much of the addition and carport construction fell under the dollar amount that triggered the requirement for a building permit.

This lack of local oversight has led to increased vulnerability of manufactured homes to damage from tropical storms and high winds. During the 2004 Hurricanes, one of the largest contributors to damage was debris. Much of that debris was light aluminum from carports and substandard additions. In addition, many, if not most of the failed additions and carports were installed in violation to current codes. These structures were often attached to the manufactured housing with screws or other structural fastenings. When the attachment tore off in high winds, the attached sheet metal tore open the envelope of the manufactured home, damaging structural integrity and allowing entry of wind-driven rain into the walls and inner sections of those manufactured homes. Manufactured homes are constructed as a unit with the strength of each piece an integral and indispensable part of the whole. Damage one section and all will be diminished.

In the State of Florida, the Florida Administrative Code 15C-2.0072 (6) states: *(6) Structural additions, including, but not limited to add-a-rooms, roof-overs, porches and carports, when attached to an existing unit shall have provisions for piers or be blocked or otherwise supported under the existing unit so that all loads are transferred directly to the ground. This requirement shall not apply if the added structure is free standing and self-supporting with only the flashing attached or if the added unit is being designed to be married to the existing unit.* ***All additions shall be constructed in compliance with State and locally adopted building codes.*** (Emphasis added).

The preceding section covers setup by licensed dealers, manufacturers and installers, Remodeling and additions constructed after installation of the manufactured home are covered under FAC 15C-2.0081 (1) (a) *Additions, including, but not limited to add-a-rooms, roof-overs and porches shall be free standing and self-supporting with only the flashing attached to the main unit unless the added unit has been designed to be married to the existing unit.* ***All additions shall be constructed in compliance with State and locally adopted building codes.*** (Emphasis added)

If all manufactured homes had additions constructed in accordance with these regulations, damage would have been considerably less. Field inspections verified this fact. The field team reported that Starlight Ranch in Orange County complied with this standard and had far less damage than any of the other sites. In addition, many of the manufactured homes in other parks were obviously older than 1994, yet few of them suffered direct structural damage from winds

that was not attributable to failure of a carport or other attached structure. A second issue is with add-ons. Add-ons are defined in 24 CFR §3282 .7 (b) as *any structure (except a structure designed or produced as an integral part of a manufactured home) which, when attached to the basic manufactured home unit, increases the area, either living or storage, of the manufactured home.*

This year, HUD is completing a proposed manufactured home installation standard. This standard will consolidate information presently spread through the manufactured home construction and safety standards. These new rules will be found in 24 CFR Part 3280 and Part 3285. During the research for this study, it was noted that there may be some differences between HUD requirements and Florida Installation Codes. One of the largest differences noted is the requirement for vertical tie downs. Florida specifically requires three vertical ties on each longitudinal side of a manufactured home, one on each end, within twenty-four inches of the end and a center tie located equidistant between the two end ties. Diagonal ties, however are required to be placed no more than five feet, four inches apart. According to HUD 24CFR§3280.306 (g) noted above, there should be one vertical tie for each diagonal tie. According to Florida standards, vertical ties are set by manufacturer installation instructions and, since Florida diagonal tie standards are more stringent than other states, it is felt that the vertical tie requirement cannot equal their spacing since there are not enough points of attachment provided and Florida cannot dictate how many of those points there should be.

This returns to the fact that very few areas outside of the State of Florida have the potential for wind speeds Florida can experience, and no other state has as high a risk of damage. Florida is the only state in the continental US subject to only Type II and Type III wind speeds.

Observations on the Florida Retrofit Program

The Florida Manufactured Home Retrofit Tie Down Program has reduced vulnerability of many structures to wind damage. As a program, it helps to address an issue that should be brought to the public's attention. People have a right to know what they should do to help protect themselves and their property. At the present rate of installation of retrofits, it would take several years to address all non-compliant structures, even with a steady rate of normal attrition.

It was noticed during the field inspection, that numerous errors or omissions were apparently made during the original installation of some of the manufactured house units. Straps were placed inappropriately (Figure 5), homes were placed too low (Figure 6), and straps were cut after installation, apparently to allow access for work on utilities. If retrofit crews were to maintain a data sheet on each installation that could be entered into the Retrofit Program database, this would allow analysis of potential issues without additional survey work being required.

Figure 5. Note one tie hanger attached to a bolt, one tie is wrapped around chassis.

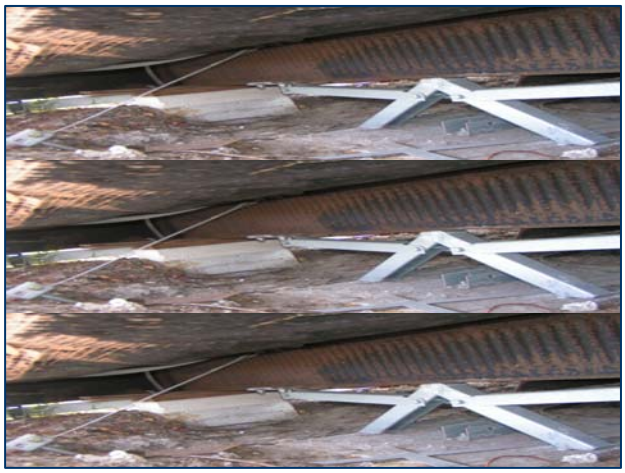


Figure 6. Piers are near minimum height, but dug into ground so that top had to be removed from longitudinal brace.

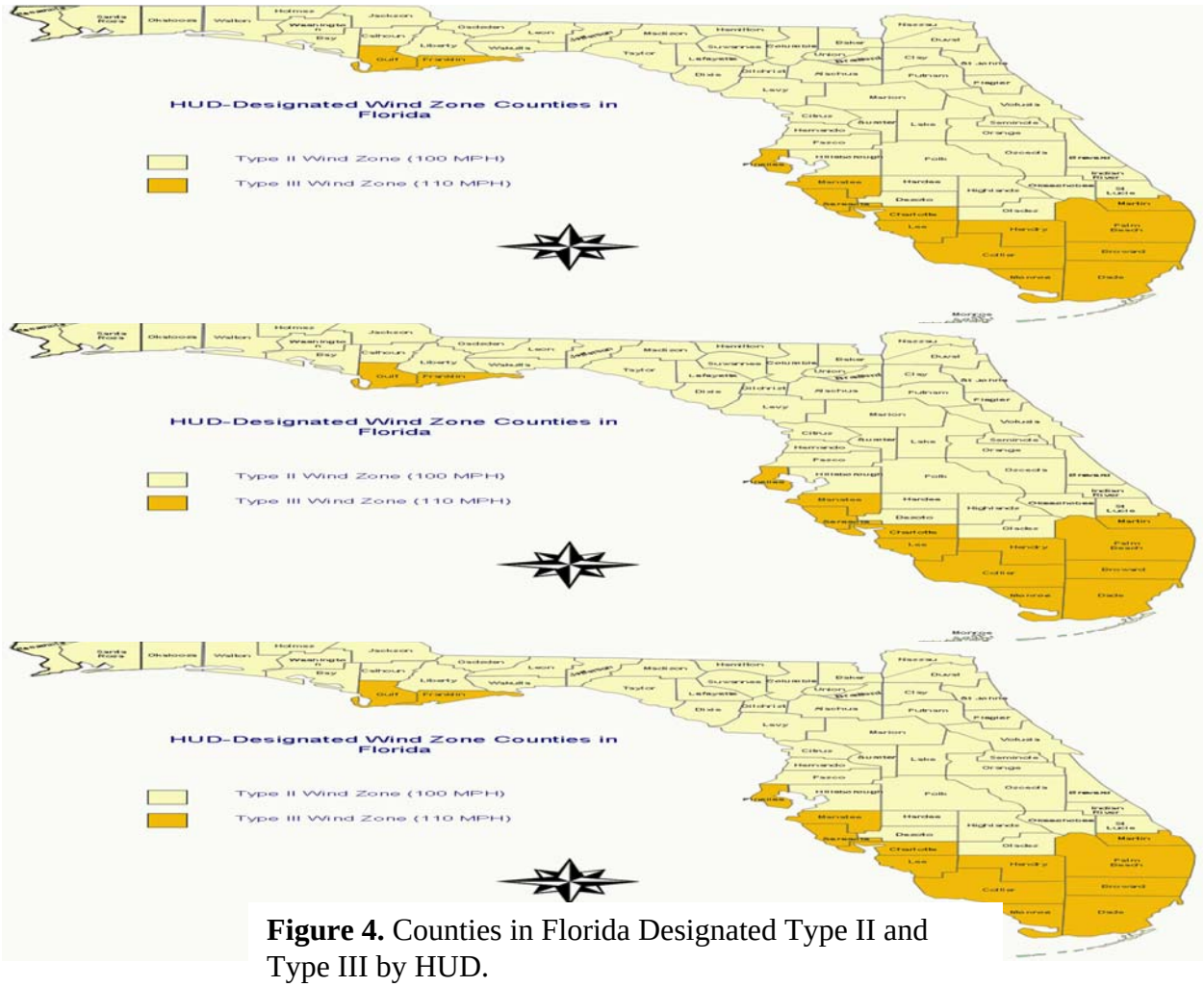


Figure 4. Counties in Florida Designated Type II and Type III by HUD.

Conclusions

Manufactured housing is a recognized and increasingly prevalent mode of providing inexpensive housing to people of low to middle income. In some cases, manufactured housing is being considered for more upscale housing by developers as a result of the increasing complexity of options available. Manufactured homes can be constructed with second stories, dormers, bay windows and other amenities previously the purview of stick-built homes According to statistics, over 8 million families are housed in manufactured housing nationwide. The median age of residents of manufactured housing is 52.6 years[1]. The State of Florida leads the nation in total manufactured housing households.

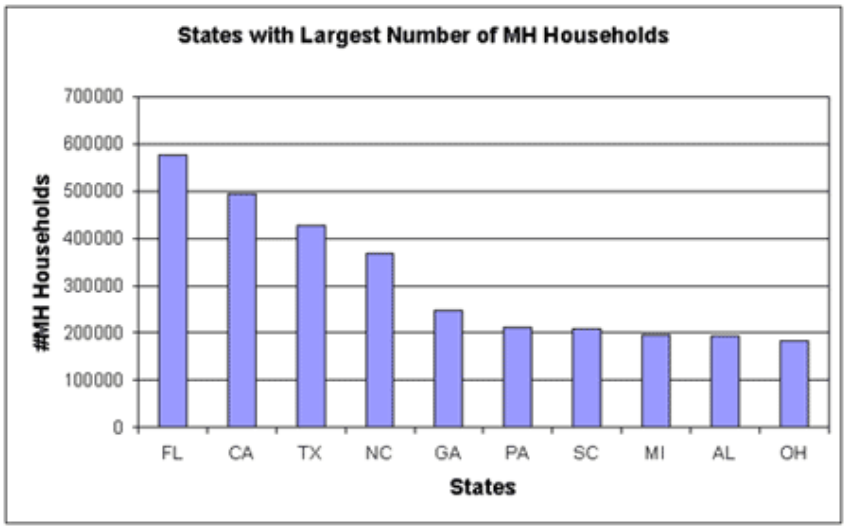


Figure 5. Chart 1 from the report "Manufactured Housing and its Impact on Seniors

We recognize that this affordability has allowed expanded private ownership of homes and has increased the ability of families to be independent. Congress addressed this very need with the Manufactured Housing Improvement Act of 2000 (PL 106-569). Notwithstanding this, it is important to remember that home ownership should not be a hazard.

The State of Florida has the largest number of manufactured homes {9.67% of all homes in the United States (US Census 2000)} and the highest number of manufactured homes owned by the elderly. This fact was considered by the report by Robert Wilden and recommendations were made in his report to bring manufactured housing parks into the care network for the elderly. This has some validity, since the elderly are tending to congregate in the parks through natural demographic and economic pressures. If, it is decided to incorporate care of the elderly into manufactured home parks, it becomes even more pressing to provide for safe, secure and sanitary accommodations. This requires that the structures they reside in provide a continuous load path

[1] Manufactured Housing And Its Impact on Seniors, by Robert W. Wilden, Wilden and Associates, LLC, February 2002 report prepared for: The Commission on Affordable Housing and Health Facility Needs for Seniors in the 21st Century

from roof to ground to prevent damage from high wind events. Increased safety from wind events will also assist in maintaining the psychological and physical stability of the residents.

The Florida Retrofit Tie Down Program is a promising start. There are, however some recommendations that might be considered to increase its effectiveness.

Recommendations

The following recommendations are considered suggestions as to how the Retrofit Program could be improved. When this analysis was first requested, the datasets available were queried and much useful information was not readily available. The first recommendations are designed to rectify that shortfall and to provide a source of useful information that could enhance overall safety for inhabitants of manufactured housing in the State of Florida.

1. The true vulnerability of manufactured home foundation/anchor systems in the State of Florida is unknown. A survey of non-retrofitted manufactured homes should be initiated to provide a statistically valid picture of the condition of wind anchoring systems in the State.
    a. As a prelude to this, and to provide a basic knowledge of age characteristics, each manufactured home park could provide information on age of manufacture and age of installation of all units in their park. This information should be placed in a state-wide database, to be maintained by the retrofit program.
        i. A partial database is available through registration information available from the Department of Motor Vehicles. Unfortunately, this database records only separate sections of manufactured homes, not housing units.
2. Basic information on the homes that had been retrofitted was not readily available. If the retrofit crews could be required to obtain information as to the age of each retrofit structure and, if possible, the date of installation in the mobile home park, this would be valuable for follow up.
3. Retrofit crews are a logical data gathering group. Forms could be completed as a part of each retrofit anchor system. A list of potential information to be gathered is attached as Appendix 2.
    a. Gathering of base information would also allow filtering of potential structures to determine if the retrofit anchoring would be cost effective.
        i. If the rim joist of a manufactured home has rot or termite damage, that structure would not be included in the program.
        ii. If it were determined that the number of anchors to be placed would not increase survivability of the structure by a pre-determined level, then that structure would not be included in the program. Manufactured housing design engineers might be a potential source for determination of characteristics that would make a retrofit non-cost effective.

The retrofit tie down program is designed to lower the vulnerability of older manufactured housing stock to wind damage. A major question remains, how much vulnerability truly exists? The data suggested above would allow more accurate modeling of potential impacts from high wind events. Knowing the age of manufactured homes allows better wind resistance parameters.

A more realistic model of vulnerability will assist emergency managers in allocation of finite resources such as shelters, response personnel and evacuation routes. It will also allow response agencies to better respond to disasters with adequate quantities of supplies. Much of this information would allow more realistic modeling by programs such as HAZUS. A program designed to allow trial runs of damage scenarios to better identify and quantify potential damage levels and areas of concern.

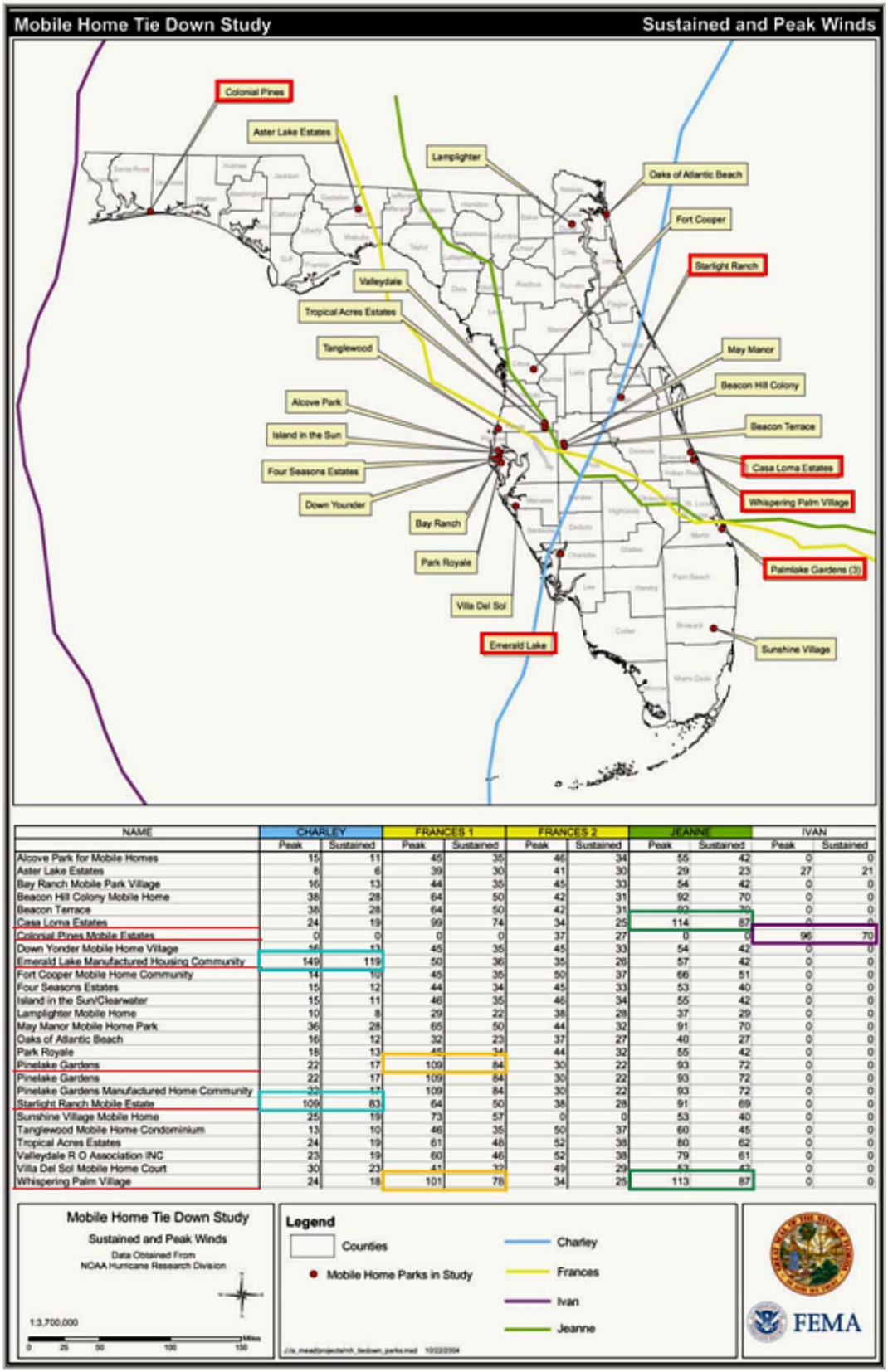
General Recommendations

These are recommendations that arose as a result of the survey, although they do not directly relate to the performance of the retrofit tie down program.

1. Commission a study of the condition of tie down anchors throughout the State of Florida. Initial findings during study of the retrofit parks indicate a great potential for corrosion and other weaknesses of the anchor systems of manufactured homes state-wide. As the 2004 Hurricanes showed, no section of Florida is immune to the strike of a potentially damaging hurricane.
2. Work with the US Census Bureau to update terminology. The Census still calls manufactured homes, "mobile homes". The term "mobile home" has come to be stigmatized as a low quality structure. Both the increase in quality due to federal standards and marketing necessity have led to the newer "manufactured home" term. Many owners of manufactured homes have been told they do not live in a mobile home. The majority of manufactured homes make one trip, from the factory to the final site for placement. The Census must update their terminology to allow better tracking. Comparison between Census figures and those of the Census-affiliated American Housing Survey (with data collected by trained survey teams) indicates that the present Census numbers for manufactured homes in the State of Florida may understate those numbers by up to 25 percent.
    a. A way to compensate for this shortfall, which can significantly impact shelter and evacuation population needs, would be to institute a requirement for manufactured home parks to report age of manufacture and age of installation of all units placed in their parks. To capture those homes set on private property, the county property tax offices should be queried on an annual basis.

    This data could reside in many appropriate places, however it is felt that the Retrofit Tie Down Program would be a very appropriate location for any such information, since they are tasked with reducing vulnerability by helping Florida residents make up for past inadequacies in anchoring. This Program would also be a logical location for storage of the results of any survey as proposed in general recommendation 1, above.

We are nowhere near having a technology or knowledge that would allow us to control storm events. We do, however, have the technology to look into potential future disasters and see the results. The better our knowledge of true vulnerabilities, the better we can plan and the more steps we can take to lower the risk to human life, safety and property.



NAME	CHARLEY		FRANCES 1		FRANCES 2		JEANNE		IVAN	
	Peak	Sustained	Peak	Sustained	Peak	Sustained	Peak	Sustained	Peak	Sustained
Alcove Park for Mobile Homes	15	11	45	35	46	34	55	42	0	0
Aster Lake Estates	8	6	39	30	41	30	29	23	27	21
Bay Ranch Mobile Park Village	16	13	44	35	45	33	54	42	0	0
Beacon Hill Colony Mobile Home	38	28	64	50	42	31	92	70	0	0
Beacon Terrace	38	28	64	50	42	31	92	70	0	0
Casa Loma Estates	24	19	99	74	34	25	114	87	0	0
Colonial Pines Mobile Estates	0	0	0	0	37	27	0	0	96	70
Down Yonder Mobile Home Village	16	13	45	35	45	33	54	42	0	0
Emerald Lake Manufactured Housing Community	149	119	50	36	35	26	57	42	0	0
Fort Cooper Mobile Home Community	14	10	45	35	50	37	66	51	0	0
Four Seasons Estates	15	12	44	34	45	33	53	40	0	0
Island in the Sun/Clearwater	15	11	46	35	46	34	55	42	0	0
Lamplighter Mobile Home	10	8	29	22	38	28	37	29	0	0
May Manor Mobile Home Park	36	28	65	50	44	32	91	70	0	0
Oaks of Atlantic Beach	16	12	32	23	37	27	40	27	0	0
Park Royale	18	13	45	34	44	32	55	42	0	0
Pinelake Gardens	22	17	109	84	30	22	93	72	0	0
Pinelake Gardens	22	17	109	84	30	22	93	72	0	0
Pinelake Gardens Manufactured Home Community	22	17	109	84	30	22	93	72	0	0
Starlight Ranch Mobile Estate	109	83	64	50	38	28	91	69	0	0
Sunshine Village Mobile Home	25	19	73	57	0	0	53	40	0	0
Tanglewood Mobile Home Condominium	13	10	46	35	50	37	60	45	0	0
Tropical Acres Estates	24	19	61	48	52	38	80	62	0	0
Valleydale R O Association INC	23	19	60	46	52	38	79	61	0	0
Villa Del Sol Mobile Home Court	30	23	41	32	49	29	53	42	0	0
Whispering Palm Village	24	18	101	78	34	25	113	87	0	0

Figure 6. Location map of Retrofit Tie Down sites in the State of Florida with estimated wind speeds from each of the 2004 Hurricanes to impact the State.

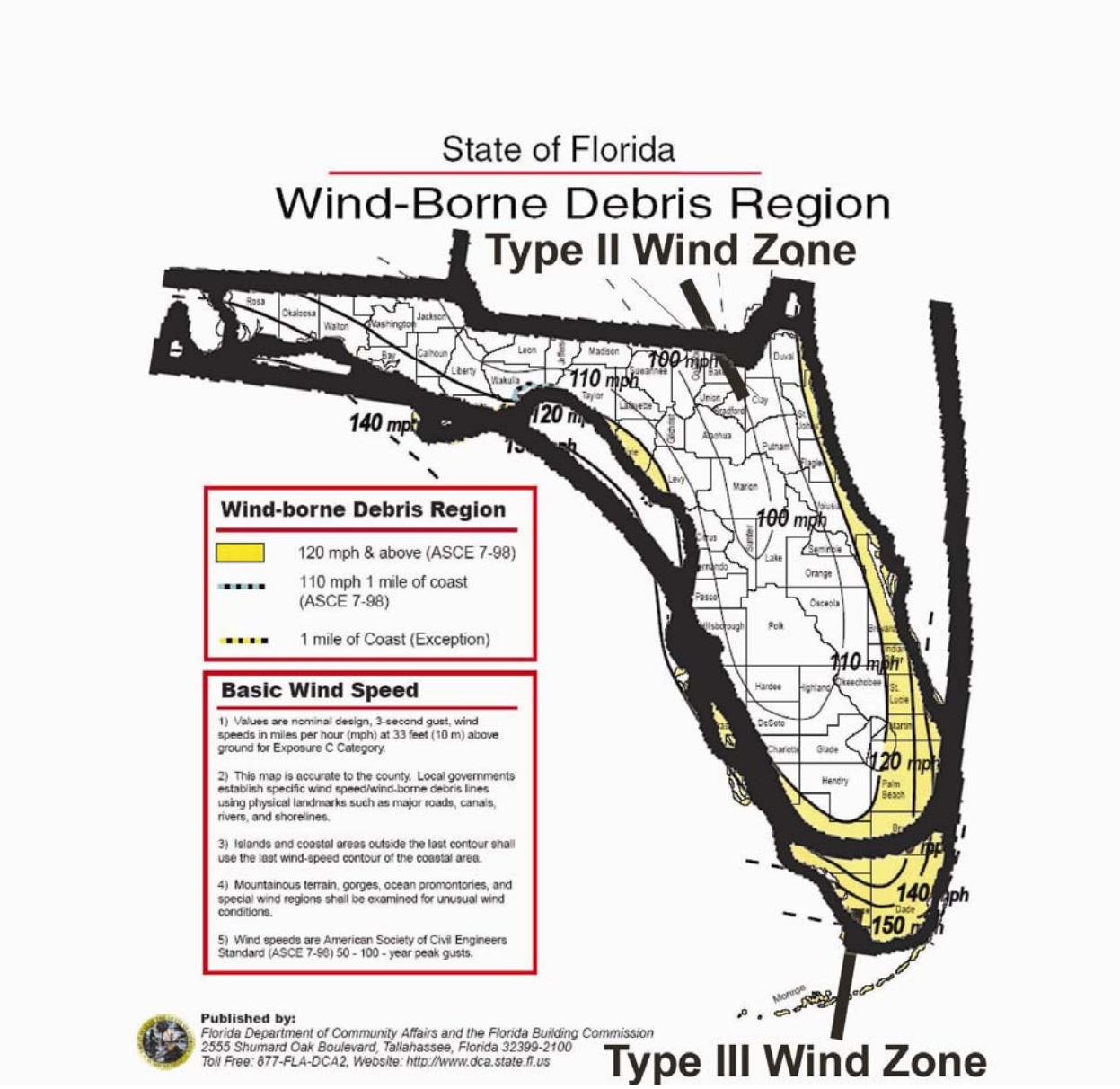


Figure 7. United States Department of Housing and Urban Development Basic Wind Zone Map overlaid on the ASCE 7-98 Wind-Borne Debris Region Map for Florida. Type II homes are rated for 100 mph winds, Type III homes are rated for 110 mph winds.

24 CFR **§ 3282.11 Preemption and reciprocity.**

(*a) No State manufactured home standard regarding manufactured home construction and safety which covers aspects of the manufactured home governed by the Federal standards shall be established or continue in effect with respect to manufactured homes subject to the Federal standards and these regulations unless it is identical to the Federal standards.*

(b) No State may require, as a condition of entry into or sale in the State, a manufactured home certified (by the application of the label required by §3282.362(c)(2)(i)) as in conformance with the Federal standards to be subject to State inspection to determine compliance with any standard covering any aspect of the manufactured home covered by the Federal standards. Nor may any State require that a State label be placed on the manufactured home certifying conformance to the Federal standard or an identical standard. Certain actions that States are permitted to take are set out in §3282.303.

(c) States may participate in the enforcement of the Federal standards enforcement program under these regulations either as SAAs or PIAs or both. These regulations establish the exclusive system for enforcement of the Federal standards. No State may establish or keep in effect through a building code enforcement system or otherwise, procedures or requirements which constitute systems for enforcement of the Federal standards or of identical State standards which are outside the system established in these regulations or which go beyond this system to require remedial actions which are not required by the Act and these regulations. A State may establish or continue in force consumer protections, such as warranty or warranty performance requirements, which respond to individual consumer complaints and so do not constitute systems of enforcement of the Federal standards, regardless of whether the State qualifies as an SAA or PIA.

(d) No State or locality may establish or enforce any rule or regulation or take any action that stands as an obstacle to the accomplishment and execution of the full purposes and objectives of Congress. The test of whether a State rule or action is valid or must give way is whether the State rule can be enforced or the action taken without impairing the Federal superintendence of the manufactured home industry as established by the Act.

		Wind Zone II (100mph)		**Wind Zone III (110mph)**	
Horizontal Load	**HUD**	**± 39 psf**		**± 47 psf**	
		Exp B (mph)	**Exp C (mph)**	**Exp B (mph)**	**Exp C (mph)**
	End Zone FBC	**133**	**121**	**146**	**132**
	Interior Zone FBC	**157**	**148**	**179**	**162**
Vertical Load	**HUD**	**- 27 psf**		**- 32 psf**	
		Exp B (mph)	**Exp C (mph)**	**Exp B (mph)**	**Exp C (mph)**
	End Zone FBC	**129**	**117**	**154**	**139**
	Interior Zone FBC	**152**	**138**	**189**	**172**
		Wind Zone II (100mph)		**Wind Zone III (110mph)**	
Horizontal Load	**HUD**	**± 39 psf**		**± 47 psf**	
		Exp B (mph)	**Exp C (mph)**	**Exp B (mph)**	**Exp C (mph)**
	End Zone FBC	**133**	**121**	**146**	**132**
	Interior Zone FBC	**157**	**148**	**179**	**162**
Vertical Load	**HUD**	**- 30 psf**		**- 36 psf**	
		Exp B (mph)	**Exp C (mph)**	**Exp B (mph)**	**Exp C (mph)**
	End Zone FBC	**136**	**123**	**163**	**148**
	Interior Zone FBC	**160**	**145**	**201**	**182**
		Wind Zone II (100mph)		**Wind Zone III (110mph)**	
Roof trusses:	**HUD**	**- 39 psf**		**- 47 psf**	
		Exp B (mph)	**Exp C (mph)**	**Exp B (mph)**	**Exp C (mph)**
	FBC	**120**	**101**	**131**	**119**
Roof coverings, sheathing, and fastening		**All other locations**			
	HUD	**- 39 psf**		**- 47**	
		Exp B (mph)	**Exp C (mph)**	**Exp B (mph)**	**Exp C (mph)**
	FBC (Zone 1)	**153**	**140**	**168**	**153**
	-	**Within 3' of ridge and eave at side wall**			
	HUD	**- 51 psf**		**- 62 psf**	
		Exp B (mph)	**Exp C (mph)**	**Exp B (mph)**	**Exp C (mph)**
	FBC (Zone 2)	**121**	**110**	**133**	**121**
	-	**Within 3' of gable end**			

	HUD	**- 73 psf**		**- 89 psf**	
		Exp B (mph)	**Exp C (mph)**	**Exp B (mph)**	**Exp C (mph)**
	FBC (Zone 3)	**145**	**131**	**159**	**145**
Wall framing:		**All other locations**			
	HUD	**± 38 psf**		**± 48 psf**	
		Exp B (mph)	**Exp C (mph)**	**Exp B (mph)**	**Exp C (mph)**
	FBC (Zone 4)	**145**	**126**	**156**	**142**
		Within 3' of building corners			
	HUD	**± 48 psf**		**± 58 psf**	
		Exp B (mph)	**Exp C (mph)**	**Exp B (mph)**	**Exp C (mph)**
	FBC (Zone 5)	**141**	**128**	**154**	**141**
Note:	Exp = Exposure to wind forces as defined in the Florida Building Code (FBC)				
	HUD = United States Department of Housing and Urban Development				
	psi = Pounds per square inch (measure of wind pressure)				
	Wind Zone = HUD designated zone for anticipated wind impact with fifty-year frequency of return				

Table 6. Conversion Chart from HUD Specifications to FBC Wind Speed Standards

Works Cited

AA—Aluminum Association, 900 19th Street NW., suite 300, Washington, DC 20006.

AAMA—American Architectural Manufacturers Association, 1540 East Dundee Road, Palatine, Illinois 60067

AFPA [previously (N)FPA]—American Forest and Paper Association, 1250 Connecticut Avenue, NW., Washington, DC 20036 [previously named (N)FPA-National Forest Products Association]

AGA—American Gas Association, 8501 East Pleasant Valley Road, Cleveland, Ohio 44131

AISC—American Institute of Steel Construction, One East Wacker Drive, Chicago, IL 60601

AISI—American Iron and Steel Institute, 1101 17th Street, NW., Washington, DC 20036

AITC—American Institute of Timber Construction, 11818 SE Mill Plain Blvd., suite 415, Vancouver, Washington 98684

ANSI—American National Standards Institute, 1430 Broadway, New York, New York 10018

APA—American Plywood Association, P.O. Box 11700, Tacoma, Washington 98411

ARI—Air Conditioning and Refrigeration Institute, 1501 Wilson Blvd., 6th Floor, Arlington, VA 22209–2403

ASCE—American Society of Civil Engineers, 345 East 47th Street, New York, New York 10017–2398

ASHRAE—American Society of Heating, Refrigeration and Air Conditioning Engineers, 1791 Tulle Circle, NE., Atlanta, Georgia 30329

ASME—American Society of Mechanical Engineers, 345 East 47th Street, New York, New York 10017

ASSE—American Society of Sanitary Engineering, P.O. Box 40362, Bay Village, Ohio 44140

ASTM—American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103

CISPI—Cast Iron Soil Pipe Institute, 5959 Shallowford Road, suite 419, Chattanooga, TN 37421

DOC—U.S. Department of Commerce, National Institute of Standards and Technology, Office of Engineering Standards, room A–166, Technical Building, Washington, DC 20234

FS—Federal Specifications, General Services Administration, Specifications Branch, room 6039, GSA Building, 7th and D Streets, SW., Washington, DC 20407

HPVA (previously HPMA)—Hardwood Plywood and Veneer Association, P.O. Box 2789, Reston, VA 22090 (previously named HPMA Hardwood Plywood Manufacturers Association)

HUD-FHA—Department of Housing and Urban Development, 451 Seventh Street, SW., Washington, DC 20410

HUD—USER Department of Housing and Urban Development, HUD User, P.O. Box 280, Germantown, MD 20874

IAPMO—International Association of Plumbing and Mechanical Officials, 20001 Walnut Drive South, Walnut, CA 91784–2825

IITRI—IIT Research Institute, 10 West 35th Street, Chicago, IL 60616

MIL—Military Specifications and Standards, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120

NFPA—National Fire Protection Association, Batterymarch Park, Quincy, MA 02269

NPA—National Particleboard Association, 18928 Premiere Court, Gaithersburg, MD 20879

NSF—National Sanitation Foundation, P.O. Box 1468, Ann Arbor, MI 48105

NWWDA—National Wood Window and Door Association, 1400 E. Toughy Avenue, suite G–54, Des Plaines, IL 60018

SAE—Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, Pennsylvania 15096

SJI—Steel Joist Institute, 1205 48th Avenue North, suite A, Myrtle Beach, SC 29577

TPI—Truss Plate Institute, 583 D'Onofrio Drive, suite 200, Madison, Wisconsin 53719

UL—Underwriters' Laboratories, Inc., 333 Pfingsten Road, Northbrook, Illinois 60062

Potential Criteria for Retrofit Tie down Project Data Collection

There are several points that might be explored during the placement of retrofit tie downs. Some of these could be used to filter the structure for suitability for inclusion in the program. This is a list of potential data to be considered for collection by retrofit crews and inclusion in a database to be kept by the Retrofit Program Office.

1. It is suggested that each studied structure be measured for dimensions of original manufactured house.
    a. Once dimensions are captured, calculations can be made to determine the number of tie downs that 15C1 would require for new installation. This value should be compared to the actual tie downs installed by the contractor.
    b. It is suggested that rough drawings of each structure be accomplished on graph paper to rough scale.
    c. Dimensions of additions, awnings and carports should be noted and placed on the rough drawings referenced to locations of tie downs and the main structure.
    d. Access points should be noted on the drawings.
    e. Elevation of frame members above ground should be taken at each end of all longitudinal frame members.
    f. Actual locations of tie downs should be recorded. This recordation should be on the drawing as well as on a table.
    g. Tie downs should be noted as: original, retrofit or undetermined.
        i. Condition of tie downs should be noted, i.e. good, rusty, cut, etc
    h. Tie downs should be classified as: vertical, horizontal or longitudinal.
    i. Frame connections of tie downs should be checked to ensure they meet specifications. Any discrepancies should be noted.
    j. Location of stabilizers should be noted along with orientation from vertical. If stabilizers are not present for retrofit tie downs, this fact should be noted.
2. Photos and GPS coordinates of each studied structure should be obtained. It is suggested that, as a minimum, photos be obtained of each side of the manufactured unit.
    a. At least one photo of a typical anchor of each type noted installed should be taken for each structure.
    b. Any discrepancies noted would be recorded and documented with photos.
3. Recordation should be done in a consistent manner, i.e. start recording at left front corner (front being the end of the manufactured home nearest the street) and progressing in a clockwise direction around the manufactured home to the starting point. All GPS points should be taken at the starting point, if possible. Any deviation of location for GPS data collection should be noted in the comments on the survey form.
4. It is suggested that each park be checked for location in a SFHA.
    a. Additionally, piers could be checked for plumb and proper blocking per 15C1. Unusual or significant aspects of piers or blocking should be documented, especially piers that are tilted or cracked, or non-existent base plates.
    b. Structures located in a SFHA are required to be double-stacked and cross-stacked. Any piers in a SFHA without this construction should be noted.
5. Physical Condition of the structure, including evidence of rot or insect damage should be noted.

	AHS	AHS Total	AHS	AHS	Census	Census Total	Census	Census	AHS % of Census	
Location	**Year**	**Housing**	**Mobile**	**Percent**	**Year**	**Housing**	**Mobile**	**Percent**	**Total**	**Mobile**
Tampa-St. Petersburg MSA = Hernando, Hillsborough, Pasco & Pinellas counties										
	1989	1,046,000	142,500	13.6%						
	1990	1,053,675	149,050	14.1%	1990	1,025,064	147,957	14.4%	102.8%	100.7%
	1991	1,061,350	155,600	14.7%	1991	1,036,956	148,104	14.3%	102.4%	105.1%
	1992	1,069,025	162,150	15.2%	1992	1,048,847	148,252	14.1%	101.9%	109.4%
	1993	1,076,700	168,700	15.7%	1993	1,060,739	148,399	14.0%	101.5%	113.7%
	1994	1,089,020	175,080	16.1%	1994	1,072,630	148,547	13.8%	101.5%	117.9%
	1995	1,101,340	181,460	16.5%	1995	1,084,522	148,694	13.7%	101.6%	122.0%
	1996	1,113,660	187,840	16.9%	1996	1,096,413	148,841	13.6%	101.6%	126.2%
	1997	1,125,980	194,220	17.2%	1997	1,108,305	148,989	13.4%	101.6%	130.4%
	1998	1,138,300	200,600	17.6%	1998	1,120,196	149,136	13.3%	101.6%	134.5%
	1999				1999	1,132,088	149,284	13.2%		
	2000				2000	1,143,979	149,431	13.1%		
	AHS	**AHS**	**AHS**	**AHS**	**Census**	**Census**	**Census**	**Census**	**AHS % of**	

		Total				Total			Census	
Location	**Year**	**Housing**	**Mobile**	**Percent**	**Year**	**Housing**	**Mobile**	**Percent**	**Total**	**Mobile**
Miami-Ft. Lauderdale CMSA = Broward & Miami-Dade counties										
	1986	1,405,900	33,200	2.4%						
	1987	1,429,950	36,650	2.6%						
	1988	1,454,000	40,100	2.8%						
	1989	1,478,050	43,550	2.9%						
	1990	1,502,100	47,000	3.1%	1990	1,399,948	47,096	3.4%	107.3%	99.8%
	1991	1,498,440	48,060	3.2%	1991	1,419,285	46,604	3.3%	105.6%	103.1%
	1992	1,494,780	49,120	3.3%	1992	1,438,623	46,111	3.2%	103.9%	106.5%
	1993	1,491,120	50,180	3.4%	1993	1,457,960	45,619	3.1%	102.3%	110.0%
	1994	1,487,460	51,240	3.4%	1994	1,477,297	45,126	3.1%	100.7%	113.5%
	1995	1,483,800	52,300	3.5%	1995	1,496,635	44,634	3.0%	99.1%	117.2%
	1996	1,505,929	52,400	3.5%	1996	1,515,972	44,142	2.9%	99.3%	118.7%
	1997	1,528,057	52,500	3.4%	1997	1,535,309	43,649	2.8%	99.5%	120.3%
	1998	1,550,186	52,600	3.4%	1998	1,554,646	43,157	2.8%	99.7%	121.9%
	1999	1,572,314	52,700	3.4%	1999	1,573,984	42,664	2.7%	99.9%	123.5%
	2000	1,594,443	52,800	3.3%	2000	1,593,321	42,172	2.6%	100.1%	125.2%
	2001	1,616,571	52,900	3.3%						
	2002	1,638,700	53,000	3.2%						