Traffic Signs Research Study for Miami-Dade County

Final Report

Miami-Dade County Metropolitan Planning Organization (MPO)

Center for Urban Transportation Research
University of South Florida

Traffic Signs Research Study for Miami-Dade County

Final Report

Prepared for

Miami-Dade County

Metropolitan Planning Organization (MPO)

Prepared by

Pei-Sung Lin, Ph.D., P.E. PTOE

Aldo Fabregas

Center for Urban Transportation Research

University of South Florida

May 14, 2007

DISCLAIMER

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Miami-Dade County MPO.

ACKNOWLEDGMENT

The research team wishes to thank the Miami-Dade County MPO project manager, Jesus Guerra, for his full support and assistance on this research project. We also would like show our gratitude to Debora Rivera and Gary Ogle of FDOT; Muhammed Hasan, Joaquín Urréchaga, and Joan Shen of Miami-Dade Public Works; and Jeannie Cann from FDOT District 6. We are grateful to Nucor Steel Marion, Inc. representatives Rick Mauer and Steve Conway, Traffic & Parking Control (TAPCO) Inside Sales/V-Loc Sales Manager Bryan J. Everard, and Municipal Signs for their valuable input and cooperation in this study. The project team also gives thanks to Dr. Gray Mullins, professor of the Department of Civil and Environmental Engineering at the University of South Florida, for his comprehensive recommendations and to Mark Richmond of Sarasota County Public Works for providing input on the traffic sign installation process in Sarasota County, Florida.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

BACKGROUND

The years 2004 and 2005 were very active regarding hurricane activity in the Atlantic basin. Miami-Dade County experienced damages due to hurricanes Katrina and Wilma within a time span of barely two months. A significant proportion of street signs failed when these two hurricanes impacted Miami-Dade County and its surrounding communities. A traffic sign is considered as failed if it is leaning by more than 15 degrees from its vertical axis. Most of the street signs failed at their foundations, as shown in Figure A. This fact raised the need to find effective alternatives to secure traffic signs and reduce the number of damaged signs during moderate hurricanes. By improving the wind force withstanding capability of street signs, the costs associated with their repair and/or replacement are considerably reduced and the county's valuable resources can be concentrated towards other aspects of the recovery process.

Figure A: Stop signs damaged in Miami-Dade County during Hurricane Wilma

Currently, the installation process for a standard street sign can be performed by one crew member in less than 30 minutes. The goal of this study is to evaluate a set of feasible alternatives for improving withstanding capabilities of the street signs without making the installation process more difficult.

EXISTING METHODOLOGIES

The AASHTO 2001 standards are the most suitable design standards to evaluate support structures, especially those located in hurricane prone regions of the United States. This is because the wind loads used in the AASHTO 2001 standards included hurricane wind effects. For the evaluation of existing foundations, the methodologies suggested in AASTHO 2001 were applied.

The Florida Department of Transportation (FDOT) standard index and Miami-Dade County design standards were also reviewed in this study. Miami-Dade County standards suggest the use of soil plates in the installation of street signs in case of weak soil.

The AASHTO-AGC-ARTBA guide to small support hardware was also reviewed. This guide provides specifications for concrete foundations and for direct burial installation of street signs. The AASHTO guide is expected to change in the near future in order to incorporate the upgrades listed in the AASHTO 2001 standards.

POTENTIAL ALTERNATIVES

Based on the literature review of existing methodologies and the practices suggested for the installation and support for traffic signs, four major alternatives are proposed in this study in addition to the baseline alternative of taking no action: (1) increase installation depth, (2) use soil plates, (3) use concrete foundations, and (4) use third party hardware (drive anchors). The alternatives were evaluated in terms of the ultimate wind load the sign support is capable of withstanding before the soil foundation fails. The analysis was performed using different soil characteristics of both clay and sand, which are the most general soil types. Combinations of alternatives such as increasing installation depth and concrete foundations yielded the best results. The results of the evaluation of different alternatives are shown in Figure B for sand and in Figure C for clay.

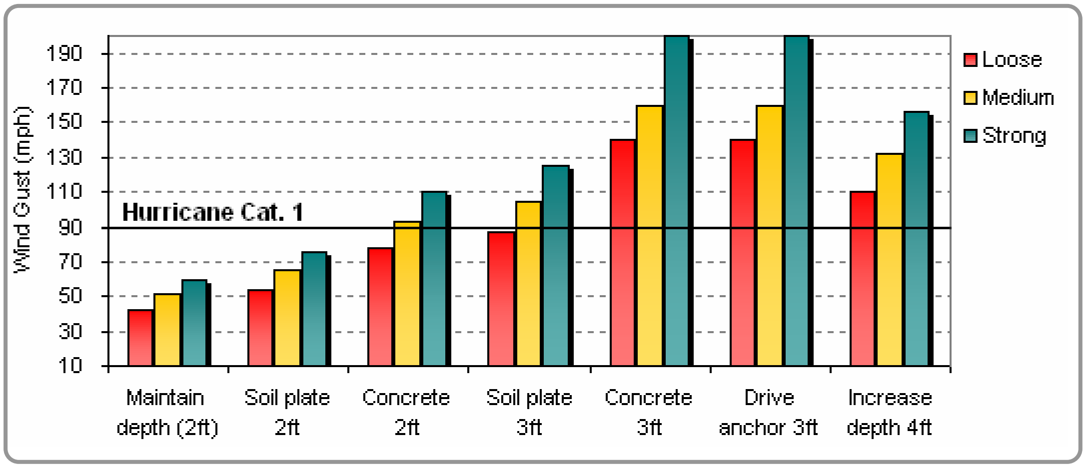


Figure B: Ultimate wind load resistance for improvement alternatives in sand

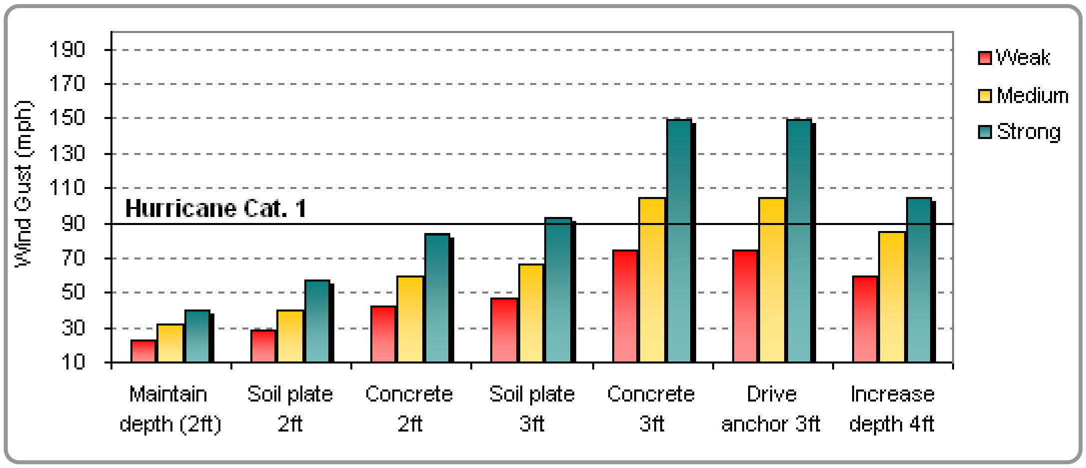


Figure C: Ultimate wind load resistance for improvement alternatives in clay

CONCLUSIONS AND RECOMMENDATIONS

This study covered the evaluation of proposed major actions that can be taken to improve the hurricane-withstanding capabilities of Miami-Dade County's traffic signs. A primary obstacle to an adequate sign installation is the presence of buried utilities (wires, cables, water mains etc.) within the right-of-way. In Florida, buried utilities can be found 30 inches below the surface, which has led Miami-Dade County to install traffic signs at a depth of 24 inches (2 ft.). In general, the soil at that depth is not strong enough to provide adequate support to the signposts during a major tropical storm. The following recommendations are intended to improve the withstanding capabilities of street signs as well as provide directions for further analysis:

- For the embedment depth of 2 ft., the top two alternatives from the four major proposed options are drive anchors and concrete foundations. Drive anchors provide withstanding capabilities equivalent to those of concrete foundations. Concrete foundations were consistently ranked at the top of the studied options in terms of ultimate wind resistance for all soil types. Therefore, drive anchors can be used in all types of soils with similar results to those of concrete foundation. The main advantage of drive anchors is that the installation time is significantly less than what is required to cast a concrete foundation for a street sign. The installation time for a sign with drive anchor is approximately 25 minutes, whereas it takes around 60 minutes for a sign with concrete foundation. It is important to note that if the foundation depth is greater than 2 ft., then the selected two alternatives can perform even better.

- The most likely events for Miami-Dade County during any particular year are 0 hurricanes or, at most, 1 hurricane of Category 1. The combination of these two scenarios accounts for 90 percent of the possible cases for any year. If an improvement alternative for traffic signs on hurricane-withstanding capabilities is designed based on the above-mentioned scenarios, then it will reasonably reduce the number of failed signs during a hurricane.

- By promoting the use of regulations such as those in the Utility Accommodation Manual where utilities cannot be located within 3 ft. of the right-of-way, the problem of installation depth might be overcome for new developments.

- The results obtained from this study might be improved by performing physical testing of the proposed alternatives. Custom formulas or spreadsheets can be obtained for different soils and different sign support designs to allow for a better assessment of the performance of the alternatives for improving the wind resistance capability.

1. INTRODUCTION

The years 2004 and 2005 were very active regarding hurricane activity in the Atlantic basin. Weather reports from the National Hurricane Center showed six intense hurricanes in 2004 and seven in 2005 [1]. In 2005, Miami-Dade County experienced damages from two of those hurricanes, Katrina and Wilma, within a time span of barely two months. The recovery cost was estimated over $5 million for the Miami-Dade County Public Works Department [2]. The recovery process included activities such as resetting or repairing traffic signals, traffic signs, streetlights, trees, guardrails and sidewalks. A large proportion of street signs failed when hurricanes Katrina and Wilma impacted Miami-Dade County and its vicinity, as can be observed in Figure 1. This study focuses on the formulation of alternatives to reduce the number of damaged signs during moderate tropical storms. By improving the withstanding capability of street signs, the associated costs are reduced and the available resources can be concentrated in other aspects of the recovery process.

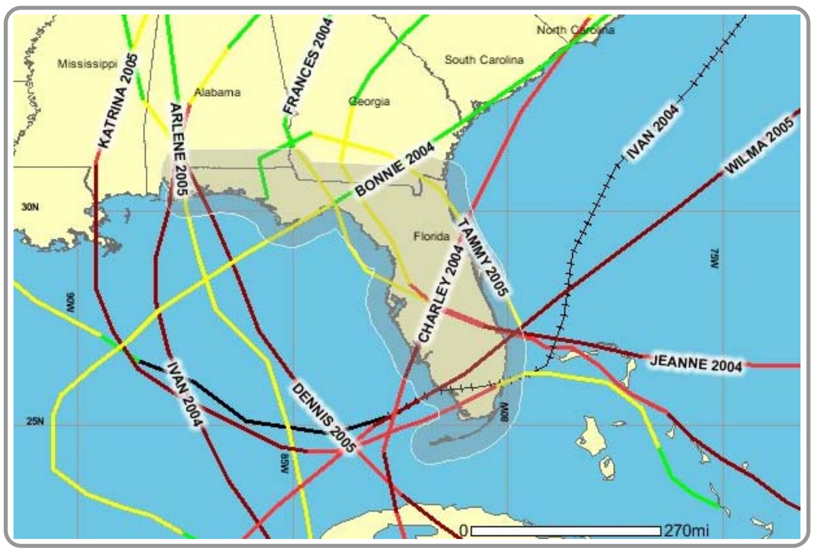


Figure 1: Hurricanes in the 2004-2005 season

This project included the following tasks: literature review, brainstorming session formulation of actions, performance analysis, cost effectiveness analysis, and final recommendations. The review of the current design standards for supports for street signs led to the application of the Standard Specifications for Structural Supports for Luminaries and Traffic Signals 2001 [3]. A brainstorming session was held with Miami-Dade County Metropolitan Planning Organization (MPO), the Florida Department of Transportation (FDOT), the Miami-Dade County Public Works Department, and the research team at the Center for Urban Transportation Research (CUTR) at the University of South Florida (USF) to discuss the problem and formulate a list of actions to be evaluated. These actions included increasing embedded depth, using concrete foundations, using soil plates, and combinations. The performance of each action was assessed by calculating the ultimate wind force the traffic sign can withstand. A cost analysis was also performed to generate a ranking of actions by effectiveness. The results obtained in this report can be further improved by collecting appropriate information on the number of damaged signs in the upcoming hurricane seasons.

2. PROBLEM DESCRIPTION

The most common traffic sign type in Miami-Dade County is the single-pole roadside stop sign. After the 2005 hurricane season, a large number of these street signs failed and had to be reinstalled by the Miami-Dade County Public Works Department. A sign is considered failed if it is leaning by more than 15 degrees from the vertical axis. A significant proportion of the signs in the county failed at their foundations, as shown in Figure 2. No structural failures for traffic signs were reported; therefore, the recovery of the signs consisted of reinstalling the displaced sign.

The failure of signs at the foundation was primarily due to the soil characteristics and embedded depth of the sign post. Installation depth is a restrictive factor in Florida, where buried utilities can be encountered at 30 inches below the surface. To keep a safe depth from buried utilities, the signpost cannot be installed deeper than 24 inches from the surface. This distance was also set to bypass the process of obtaining clearance from Sunshine State One Call of Florida (SSOCF), which may take up to 72 hours or more. This is especially restrictive due to the large number of signs in metropolitan areas such as in the case of Miami-Dade. Under extreme conditions, such as those after a hurricane strike, obtaining a clearance would significantly delay the recovery process.

Figure 2: Stop signs damaged in Miami-Dade County during Hurricane Wilma

During the recovery process, stop signs are the first level of priority, followed by school signs. In general, the repair and recovery of signage is delayed until the majority of stop signs are repaired. The locations with damaged signs become known by means of surveys of affected zones or reports of failed signs from the general public. The problem caused by downed stop signs can be partly alleviated during an emergency by drawing permanent stop markings on the pavement. Thus, after a hurricane, County crews that inventory downed signage can clear debris from the pavement markings, providing a temporary traffic control sign. Currently, the installation process for a standard street sign can be performed by one crew member in approximately 20 minutes. This is particularly important when a large number of signs need to be retrofitted. Given the problem background, the goal is to find a set of feasible alternatives for improving withstanding capabilities of the street signs without making the installation process too complex.

3. LITERATURE REVIEW

The literature review was divided into three major topics: highway design standards, regulations regarding the placement of utilities and traffic signs, and additional work related to structural supports for highway signs.

3.1 Highway Signs Design Standards

There are several regulations involved in the design and installation of highway signs. In this section, an overview of different designs standards is provided. The objective of this section is to gain insight in recommended design practices and installation procedures.

3.1.1 Historical Background

According to Fouad and Calvert [4], the first wind map for the United States was published in 1968. That wind map was included later in the first wind load standard by the American National Standards Institute (ANSI) in 1972. The map was used in most existing standards including the AASHTO Standard Specifications for Structural Supports for Luminaries and Traffic Signals [3] until 1996. In that year, the American Society of Civil Engineers (ASCE) published "ASCE 7-95 Minimum Design Loads for Buildings and Other Structures," introducing major modifications to the existing wind loading criteria [5]. The AASHTO standard specifications were upgraded with the new wind map in 2001 [3]. The upgraded versions of the wind loading criteria included refinement of wind speed contours in hurricane regions and the addition of a wind directionality factor. The majority of the signs currently in place throughout the country were designed using standards based on prior wind loading criteria. This has created nationwide initiatives to evaluate existing sign structures and to adopt the updated AASHTO standard specifications for new projects.

3.1.2 Design Standard Specifications for Hurricane Winds

AASHTO standard specifications [3] consider provisions for hurricane winds using an updated version of the wind map. The new wind map presented in Figure 3 includes special considerations for coastal regions that have increased likelihood of hurricane activity. Hurricanes are considered in the design phase when calculating the wind loading factors. The wind pressure (P_z) is computed with the following expressions:

$$P_z = 0.613 K_z G V^2 I_r C_d \qquad (Pa)$$
$$P_z = 0.00256 K_z G V^2 I_r C_d \qquad (psf)$$

Where,

V: Design wind speed at 10 m. (32.8 ft.)
C_d: Drag coefficient
G: Gust effect factor
K_z: Height and exposure factor
I_r: Wind importance factor

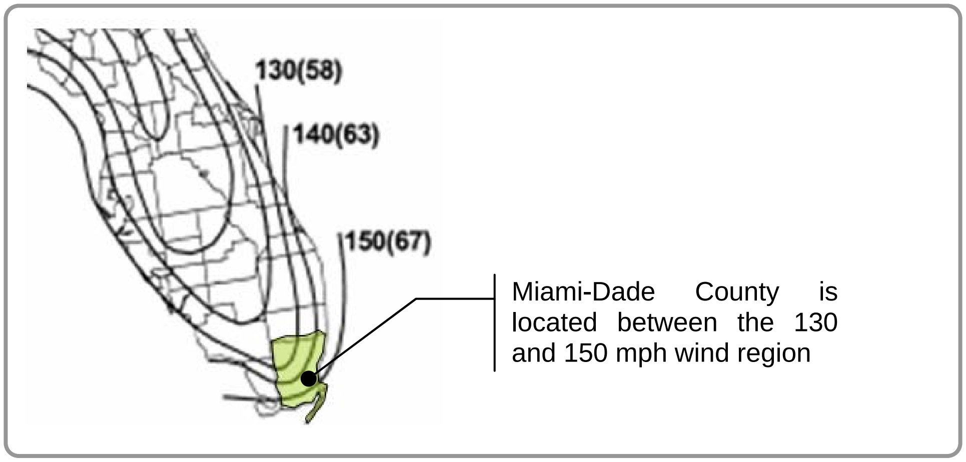


Figure 3: ASCE 7-02 wind map

The design wind speed is generally associated with a 50-year mean recurrence interval. The drag coefficient accounts for the effect of geometry on the wind pressure. The gust effect factor corrects the wind pressure to account for the interaction of the wind and the structure. The height and exposure factor account for the effect for signs above 10 meters (32.8 ft.). The wind importance factor converts wind pressures associated with a 50-year mean recurrence interval to wind pressures associated with different intervals of recurrence. Additional details about the wind loading criteria for design can be found in Appendix A.

3.1.3 Florida Design Standards

In Florida, the FDOT Standard Index is the reference document for the design of traffic signs. The applicable standard indices are 11860 through 11865 from reference [6]. From Standard Index 11860, the design profile that resembles most of the Miami-Dade case corresponds to sign identification number 65, as shown in Figure 4.

Sign Identification Number	SIGN			TYPE OF SIGN BRACKET			
				WIND ZONE			
	PROFILE	- SIZE	SQ. FT.	60	70	80	90
55		30 x 24	5.0	2- I	2- I	2- I	2- I
56		36 x 48	5.6	2- II	2- II	2- II	2- II
64		24 x 48	8.0	2- II	2- II	2- II	2- II
65		12 x 36 30 x 30	8.2	1 - I 2- I	1 - I 2- I	1 - I 2- I	1 - I 2- I

Figure 4: Column size, column height and column footing from FDOT Standard Index 11860

According to the same FDOT Standard Index, Miami-Dade County is located in Wind Zone 4, whose corresponding wind speed is 90 mph. The corresponding upgraded wind speed in the updated AASHTO specifications [3] is 150 mph (3-second gust), which includes provisions for hurricane winds.

Standard Index 11865 deals with the installation of flanged driven posts. The designs presented in the standards are applicable to all locations within Florida. Standard Index 11865 recommends a minimum embedment depth of 3 ft. (36 in.), as can be observed in Figure 5. It also states that the maximum height to the bottom of the sign should be 14 ft. and that the total area for all the signs mounted on a single post should not exceed 25 square ft.

For sign installation, the FDOT Standard Index suggests several ways to proceed. One option is to set the posts in pre-formed holes at the specified depth and use backfill material or bagged concrete. In the case of flanged steel posts, these can be driven in the ground at the specified depth.

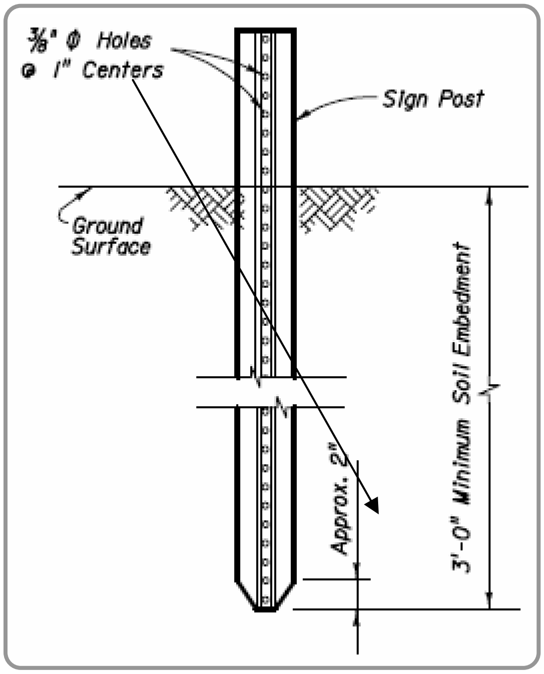


Figure 5: Steel flanged channel post details from FDOT Standard Index 11865

3.1.4 Miami-Dade County Design Standards

Section 168 of the Dade County design standards [7] deals with the design, fabrication, assembly, installation, and maintenance of street signs. Section detail R 18.1 establishes that the installation depth is 24 inches. The use of soil plates is suggested for installations in soil with loose fill as shown in Figure 6. A typical stop sign is presented in Figure 7 .

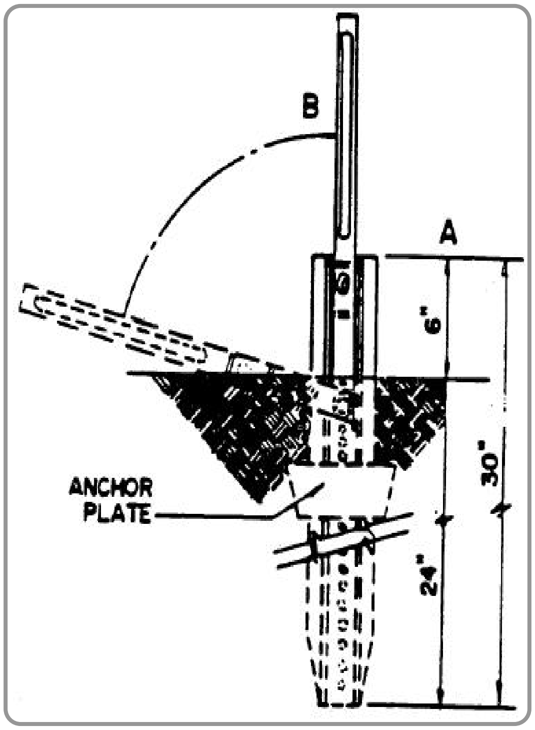


Figure 6: Typical installation for street sign posts established in Miami-Dade County design standards

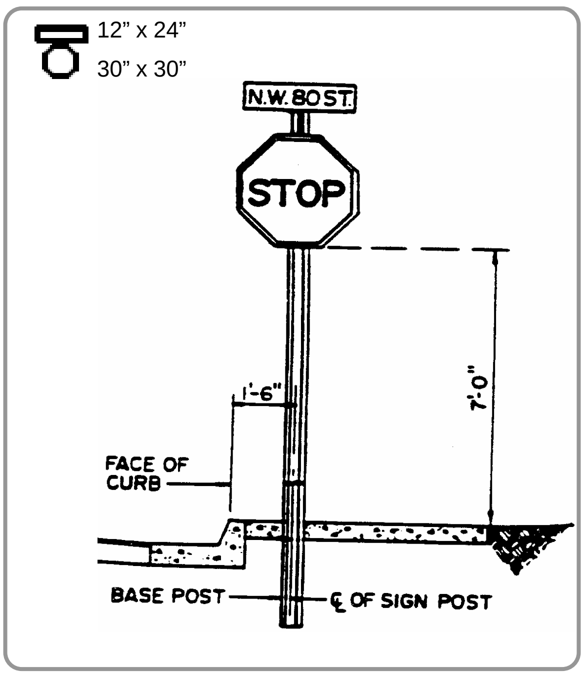


Figure 7: Typical stop sign in Miami-Dade County

3.2 Regulations Regarding Utility Accommodations

The Accommodation Manual of Florida (UAM) [8] suggests that, for transportation facilities, parallel underground installations require a minimum vertical clearance of 36 inches below the top of the pavement and 30 inches below the unpaved ground. The UAM also establishes that new parallel underground utilities should not be within 3 ft. of the right-of-way to allow space for above-ground facilities. It also establishes that, in cases where no other location exists to place an underground facility, placement within 3 ft. of the right-of-way may be acceptable. On the other hand, the Manual on Uniform Traffic Control Devices (MUTCD) 2003 [9] established the minimum lateral offset distance for traffic signs to be 2 ft., as can be observed in Figure 10. It is observed that promoting these two regulations may help to overcome some of the installation issues for new land developments. This may allow the process to be expedited or in certain cases avoid requests of horizontal clearance from Sunshine State One Call of Florida (SSOCOF).

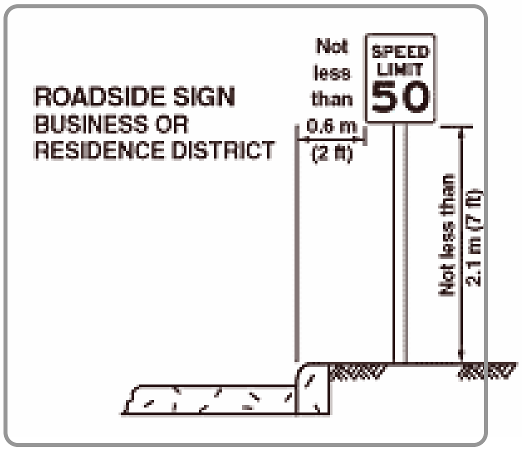


Figure 8: Minimum lateral offset for traffic signs (MUTCD 2003)

SSOCOF serves as a notification system between excavators and utility companies to prevent damage to underground infrastructure. SSOCOF is not responsible for physically locating and marking underground facilities or for keeping a database of the exact location of underground facilities. Moreover, Florida Statute 556.105 [10] dictates that only the horizontal location of underground facilities should be provided since the depth of a utility is variable for reasons such as soil characteristics and grade.

3.3 Additional Documentation Related to Structural Supports for Traffic Signs

The goals of this section are to find common practices on the adoption of the updated AASTHO standard specifications [3] and to compile information on the design practices of traffic signs capable of withstanding hurricane winds.

The Virginia Department of Transportation (VDOT) sponsored a study by Cole, Jason et al. [11] in which the researchers presented a managerial overview of the process of recovery of overhead signs and streetlights after a hurricane. One of their objectives was to develop a model for evaluating sign-strengthening alternatives through characterization of hurricane impacts. In their work, the authors compared their estimates of hurricane wind speeds with those presented by the 1994 AASHTO standards. Their estimates of wind speeds were consistent with the wind speeds adopted later in AASHTO 2001 [3].

Fouad and Calvert [12] presented a comparison between AASHTO 1994 and 2001 standards for traffic signals in Alabama. For the coastal areas of Alabama, the wind speed for a 25-year mean recurrence interval changed by 75 percent. Previously, the wind design speed was 80 mph, and with the adoption of the 2001 version of the AASHTO standard specifications, the wind design speed was 140 mph. The implication in the design of poles for traffic signals was an increase of 52 percent in their weight. The authors presented an example in which the weight of a traffic light pole increased from 580 pounds to 882 pounds. Since Miami-Dade County is located between the 140-150 mph wind regions, similar results to those of Alabama might be expected.

More recently, White [13] presented the hurricane scale and corresponding design wind speeds applicable to AASHTO 2001 wind loading equations (Table 1). The author also presented a comparison between the current AASHTO standards and the Saffir-Simpson scale, noting that the standards take into consideration hurricane winds of up to Category 3. A countywide wind speed map for Florida was also presented. In that map, the basic wind speed for Miami-Dade County was 150 mph.

Table 1: Saffir-Simpson Hurricane scale and corresponding design wind speeds

Saffir-Simpson Hurricane Scale					
Category	1	2	3	4	5
Sustained winds (mph), 60 sec.(weather service)	74-95	96-110	111-130	131-155	>155
3-sec. gust (mph) (used in design)	90-119	120-139	140-164	165-194	>194

Table 2: AASHTO 2001 Design wind speed, structure type and Saffir-Simpson scale

AASHTO 2001 Design Code			
3-Second Gust Design Wind Speed			**Design Importance Factor and Structure Types**
150 mph (Cat 3)	130 mph (Cat 2)	110 mph (Cat 1)	1.00 importance factor, 50-year recurrence interval, high mast light poles, overhead sign structures, mast arms
134 mph (Cat 2)	116 mph (Cat 1)	98 mph (Cat 1)	0.80 importance factor, 25-year recurrence interval, strain poles, aluminum light poles
110 mph (Cat 1)	96 mph (Cat 1)	81 mph (Tropical Storm)	0.54 importance factor, 10-year recurrence interval, single and multiple column ground signs

Ahlborn et al. [14] performed a comprehensive study for selecting the most beneficial design for overhead sign supports. Their work consisted of a multi-state survey to assess the state of the practice of the design of overhead sign supports and compliance with the 2001 AASHTO standards. It also included a detailed analysis of selected overhead sign designs. In the survey, each state was asked about the date it would begin the adoption of the 2001 AASHTO standards. For Florida, the response was within five years. The year in which the survey was applied was 2002; therefore, the expected timeline for starting the adoption of the 2001 AASHTO standard is 2007. (The FDOT structures manual for year 2007 [15] presents a classification table by county in which Miami-Dade basic design wind speed is 150 mph in accordance with the current wind loading criteria.)

The AASHTO Guide to Small Sign Support Hardware [16] is a comprehensive reference document for street signs. The AASTHO guide provides specifications for breakaway support systems for single and multipost signs. The Franklin Eze-Erect sign support system is currently used by Miami-Dade County for most street signs. The recommended installation according to the AASHTO guide for this type of support system is provided in Appendix B.

4. DATA COLLECTION

Data collection was divided into hurricane activity and soil information. The hurricane activity was used to calculate the probability of hurricane winds in Miami-Dade County. The soil information was necessary to assess the performance of the proposed improvements under the different scenarios present in Miami-Dade.

4.1 Hurricane Activity

A review was conducted of hurricane activity in the 2004-2005 hurricane season, hurricane probability calculation for the southeast region of Florida, and data related to hurricanes affecting Miami-Dade County directly in the last 100 years.

4.1.1 Hurricane Activity in Miami-Dade County in 2005

Two major hurricanes hit Miami-Dade County in the 2005 hurricane season, Katrina and Wilma. According to the National Hurricane Center [17], tropical storm Katrina reached its hurricane status less than two hours before its center made landfall on Florida between Broward and Miami-Dade counties. At the moment of its landfall, Hurricane Katrina presented maximum sustained winds of 81 mph; landfall occurred during the evening of August 25, 2005, and continued through Florida on August 26, 2005. Hurricane Katrina spent about six hours over land, primarily over the Everglades. Official surface measurements of wind speeds at selected locations are presented in Table 3.

Although Hurricane Wilma did not pass through Miami-Dade County, its winds had the effect of a Category 1 hurricane. Hurricane Wilma occurred two months after Hurricane Katrina. Based on a report published by the National Hurricane Center [18], the maximum sustained winds of Hurricane Wilma at landfall were 121 mph (Category 3) on October 24. Wilma traversed the Florida Peninsula in only 4.5 hours, but the extent of damages was greater than its predecessor, Hurricane Katrina. Surface observations of wind speeds at selected locations are presented in Table 3.

Table 3: Official observed wind speeds during Hurricane Katrina at selected locations in Miami-Dade County

	Hurricane Katrina			Hurricane Wilma		
Location	**Date**	**Sustained Speed (mph)**	**Gusts (mph)**	**Date**	**Sustained Speed (mph)**	**Gusts (mph)**
WFO Miami	26/01:15		87	24/12:10	66	104
West Kendall	26/01:37	49	76	24/11:52	58	83
Miami	26/01:24	48	78	24/12:25	67	92
Opa-Locka	25/22:29	45	66	24/13:16	85	105
Key West	26/15:27	61	74	24/06:16	71	83

4.1.2 Hurricane Probabilities for Miami-Dade County

The history of hurricanes traversing Miami-Dade County was obtained from the National Hurricane Center [19]. A summary of the information is presented in Figure 13. Additional details and trajectory maps are provided in Appendix C. It can be observed that the period between years 1940 and 1960 was very active followed by a less active period with a lower hurricane count in spite of Hurricane Andrew in 1992 (Category 4).

A Poisson distribution was assumed to estimate the yearly probability of hurricanes affecting Miami-Dade County. The probability of at least one hurricane hitting Miami-Dade County was estimated to be 16.6 percent whereas the probability of exactly one hurricane is 15 percent. Therefore, the most likely scenario for Miami-Dade County for any particular year is 0 hurricanes or 1 hurricane, at most, according to Figure 10. The probability of having a year with 0 hurricanes is 83 percent. The probabilities for a hurricane to be category 1, 2, 3 or 4 are 37, 21, 26 and 16 percent, respectively, based on the information presented in Figure 9. Therefore, for the most likely scenario for Miami-Dade the probabilities of occurrence of hurricanes category 1, 2 3, and 4 or more are 5.6 (once every 10 years), 3.2 (once every 30 years), 4 (once every 25 years), and 2.4 percent (once every 40 years), respectively. Additional information of hurricane probabilities for Florida is provided in the work of Gray and Williams [20]. Additional details for the south Florida region are provided in Appendix D.

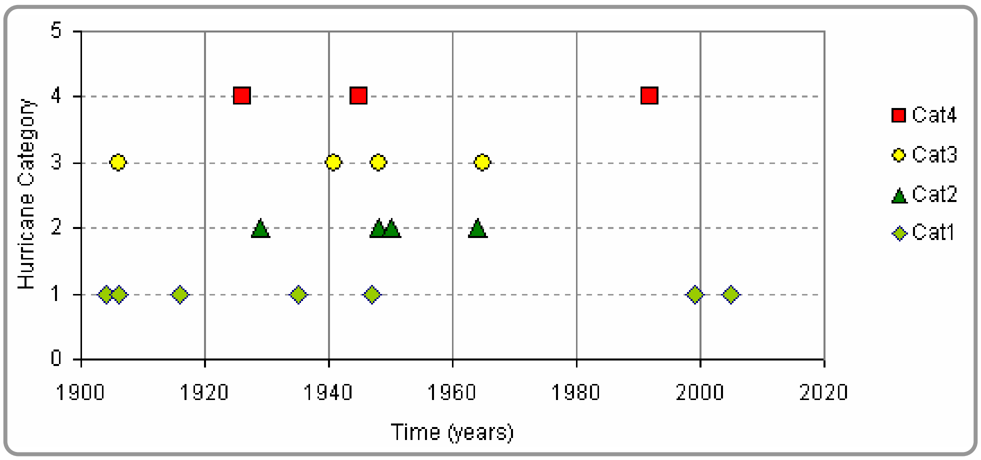


Figure 9: History of hurricane occurrences in Miami-Dade County

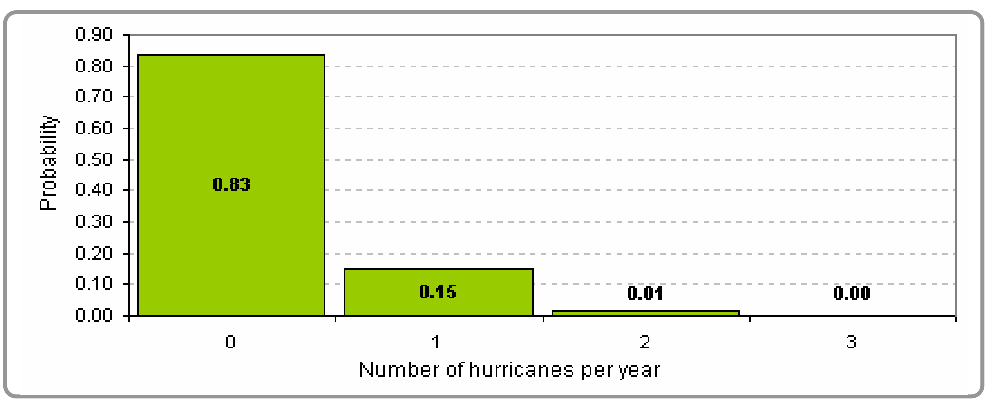


Figure 10: Proposed probability distribution for the number of hurricanes per year in Miami-Dade County

4.1.3 Soil Properties

Soil plays an important role in determining the embedment depth and ultimate wind resistance of traffic signs, especially in the case of direct burial posts. Using GIS data from the U.S. Department of Agriculture [21], soil distribution can be determined for most of the Miami-Dade region. The soils were classified using the Unified Soil Classification System (USCS) [22]. The group names and their descriptions are presented in Table 4. The engineering properties of the soils can be found in Appendix E.

Table 4: Group symbol and description for soil types in the USCS system

Group symbol	Description
GW	Well-graded gravel, fine to coarse gravel
GP	Poorly graded gravel
GM	Silty gravel
GC	Clayed gravel
SW	Well graded sand, fine to coarse sand
SP	Poorly-graded sand
SM	Silty sand
SC	Clayed sand
ML	Silt
CL	Slay
OL	Organic silt, organic clay
MH	Silt of high plasticity, elastic silt
CH	Slay of high plasticity, fat clay
OH	Organic clay, organic silt
PT	Peat

The map in Figure 11 shows the distribution of sands in the Miami-Dade County region. The map contains a summary of the dominant types of soil types for layers located at less than 3 ft. It can be seen that sands are frequently encountered at the northern part of the county. Clays are more frequent at the southern regions and also is the common soil type in the Everglades. Also, Limestone is commonly encountered close to the surface. This is a special case in which, for the installation of a street sign, a hole can be drilled in the rock at less than 2 ft. and the signpost driven into the rock. A concrete backfill can be used to fix the post at its location.

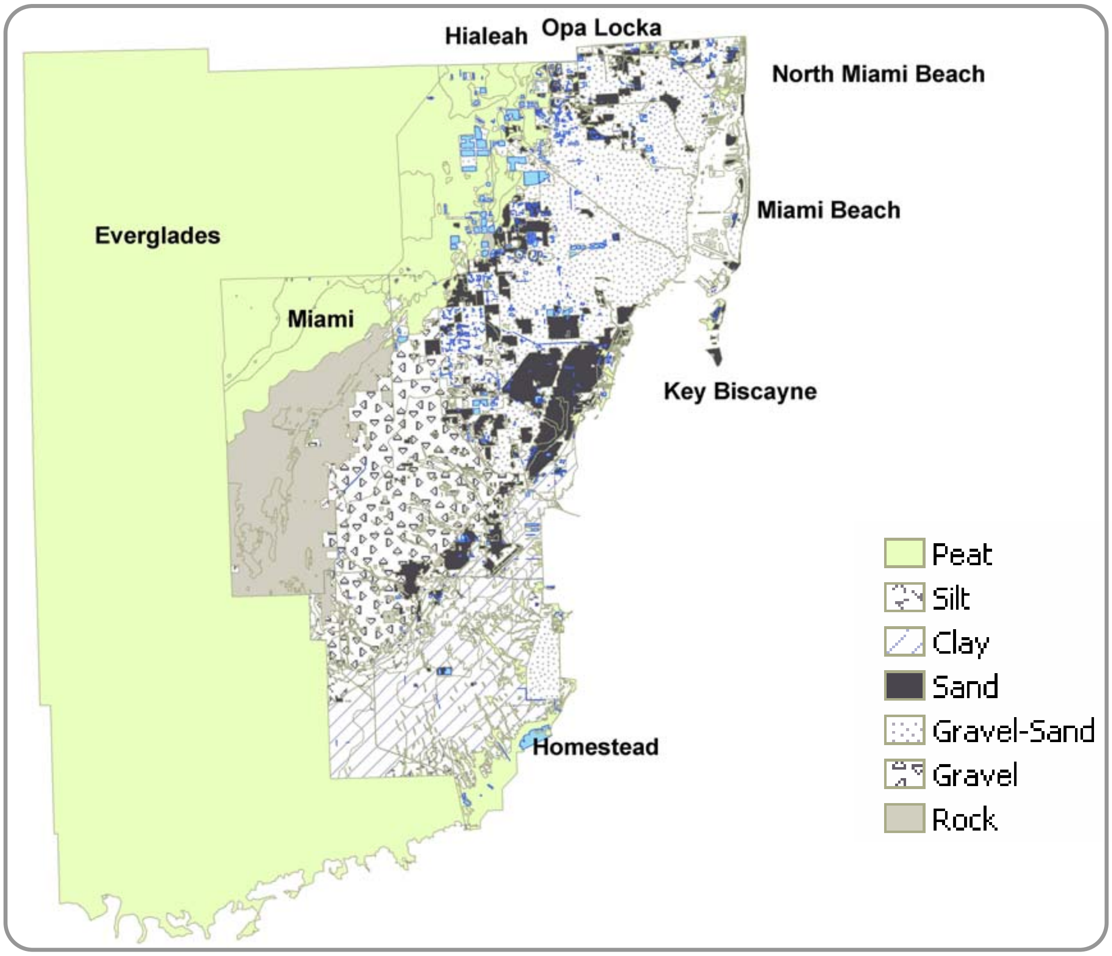


Figure 11: Map of soil distribution in Miami-Dade County

5. ANALYSIS OF CURRENT INSTALLATION METHOD

The analysis of the current installation method was based on stop signs since they constitute the majority of the signs in Miami-Dade County. The analysis was performed using the typical stop sign provided in the County design standards. Different types of soils were used in the analysis, according to the soil map presented in Section 4. The embedment length depends heavily on the soil type; therefore, the analysis was performed for a range of soil parameters rather than for a specific class of soil. It is important to note that the soil information provided is just an approximation and a site specific survey is required for a more accurate assessment of the performance of the signs. Two main types of soils were used for the analysis: clays and sands.

The ultimate load for clay was calculated based on the method suggested in the AASHTO standard specifications [3] in section 13, "Embedment of Lightly Loaded and Small Posts and Poles." It is important to note that the method proposed by AASHTO uses a chart (nomograph) that has a minimum value for the embedment depth of 4 ft. The actual formulation for the embedment depth in AASHTO was based on the Structural Engineering Handbook [23], which presents a closed-form expression for the calculation of the ultimate load in the case of small poles and posts. For signs installed in sand, the method of Broms presented in reference [24] and also suggested by AASHTO [3] was used.

The AASHTO 2001 standard specifications account for up to Category 3 hurricane winds. Figure 12 presents observed gusts from hurricanes Katrina and Wilma, AASHTO design wind speed, and wind speed for the different hurricane categories.

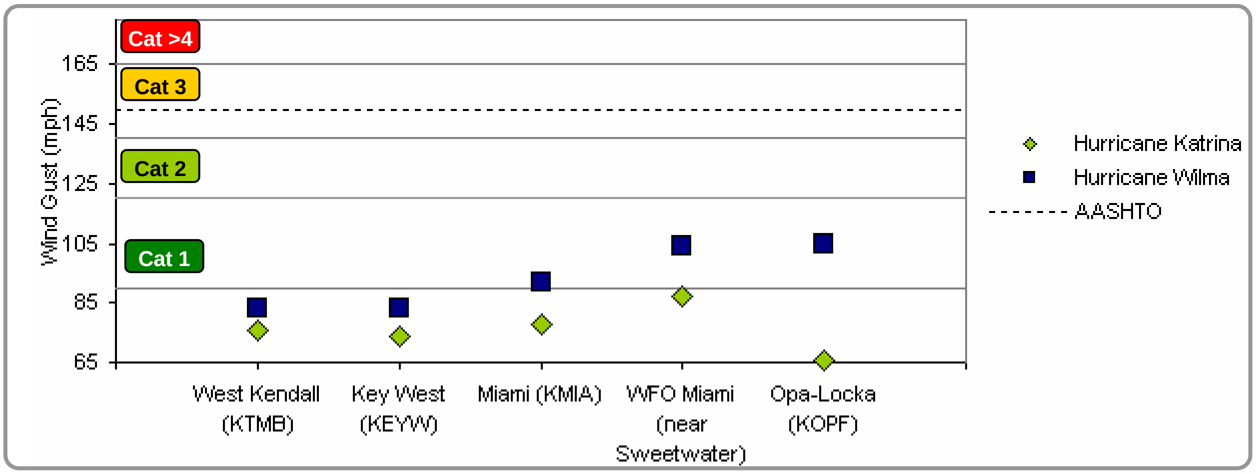


Figure 12: Hurricane scale in 3 second gusts, hurricane wind speeds from 2005 season, and AASHTO 2001 design wind speed for Miami-Dade County.

A customized chart equivalent to those presented in AASHTO [3] was generated for the street sign under consideration. The ultimate load was converted to 3-second gust in order to establish the hurricane category that the improved sign support may withstand. Figure 13 shows the ultimate wind load resistance for signs installed in sand and the peak gusts registered during hurricanes Katrina and Wilma.

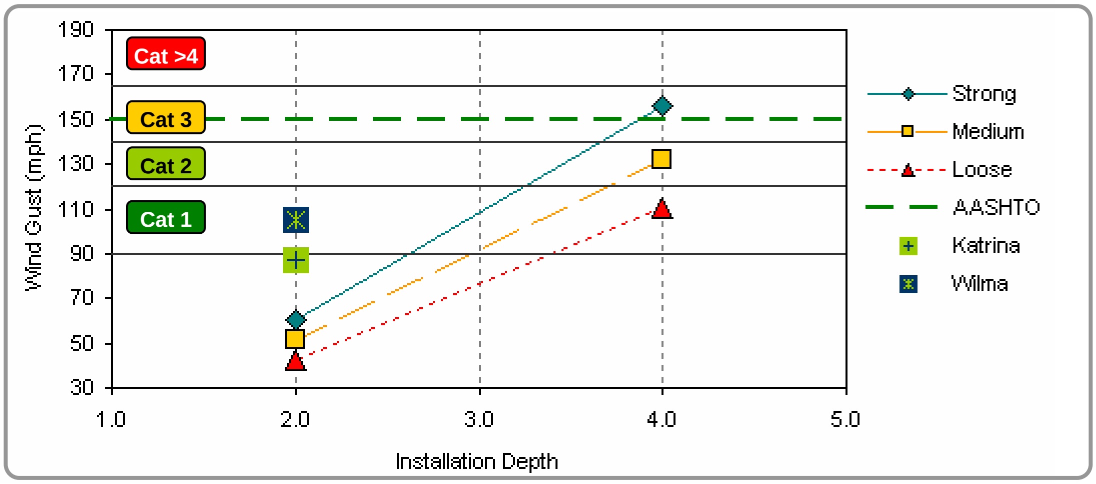


Figure 13: Current design analysis for sands

It can be observed that, in strong soil, an installation depth of 2 ft. is not capable of withstanding Category 1 hurricane wind forces. The graph also shows that, at 4 ft. in strong soil, the AASHTO requirements are met. Figure 14 shows the analysis of the current design for clays. It can be observed that, for clays, the installation depth itself is not enough to meet the AASHTO requirements.

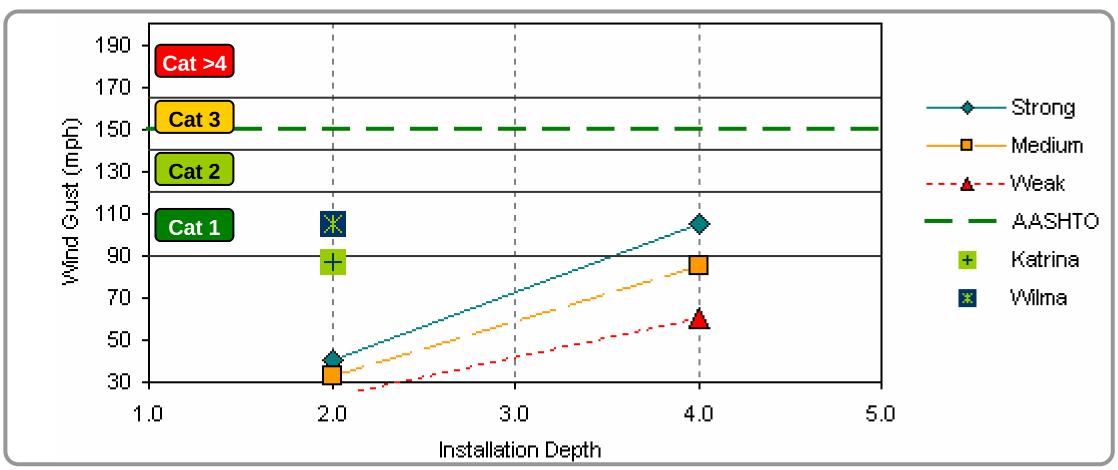


Figure 14: Current design analysis for clays

AASTHO standards are always a good benchmark or guide to set state or county standards. AASHTO documents are peer reviewed and contain up-to-date knowledge on the design practices for the different elements comprising the transportation infrastructure. For the case under study, AASHTO suggests 150 mph design wind speed. The suggested wind speed can be achieved by improving the foundation of the sign.

6. PROPOSED ALTERNATIVES

Based on the literature review and the practices, four alternatives are proposed in addition to the baseline alternative of taking no action: (1) increase installation depth, (2) use soil plates, (3) use concrete foundations, and (4) use third party hardware.

6.1 Increase Installation Depth

This alternative consists of enlarging the buried section of the u-channel post (basepost), as shown in Figure 15. It requires horizontal clearance from utility companies and involves pulling out the sign, disassembling the base post, assembling a new base post, and reinstalling the sign. It takes about 55 minutes to install with material cost at $12.

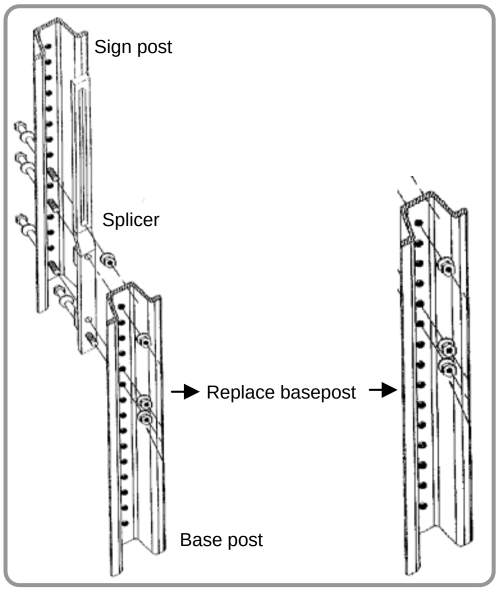


Figure 15: Increase installation depth

6.2 Use Soil Plates

Soil plates are recommended by several manufacturers for weak soils. Soil plates increase the soil reaction by adding more area to the buried section of the post. A trapezoidal shape was chosen for the soil plate to facilitate the driving of the post into the ground. Implementing the soil plate for a new sign does not significantly increase installation time. However, for sign retrofitting, the addition of soil plates requires pulling out the sign, attaching a soil plate, and reinstalling the sign. If the installation depth is increased, the upgrading procedure includes disassembly of the base post and attachment the new base post to the sign. The installation time for a soil plate is estimated to be 45 minutes. If the depth is also increased, this process will take 65 minutes. The cost of a trapezoidal soil plate is estimated to be $5.25. If the installation depth is increased, the cost of materials is estimated to be $17.25.

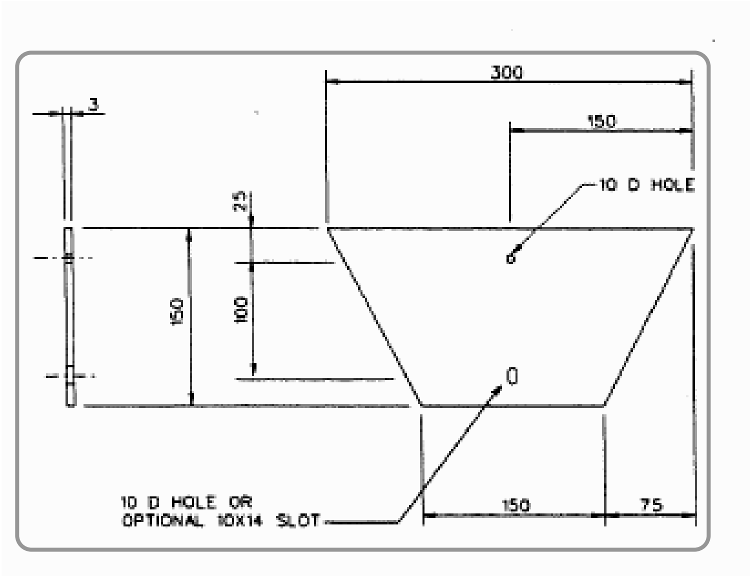


Figure 16: Trapezoidal soil plate PLS02 recommended by AASHTO (distance in mm)

6.3 Use Concrete Foundations

The width of the embedded section also affects the performance of the sign when facing wind forces. This factor can be modified by using concrete in the installation of the sign support. The installation time will be significantly affected by this alternative. Concrete footing is considered in the FDOT Standard Index, but it is optional for steel posts. A suggested concrete footing is presented in the AASHTO Guide to Small Sign Support Hardware [16] and is shown in Figure 17.

Using a 1-ft. diameter concrete foundation and keeping the installation depth at 2 ft. requires 1.3 cubic ft. of concrete. Increasing the foundation depth to 3 ft. while keeping a diameter of 1 ft. will require 1.9 cubic ft. of concrete. The foundation recommended in Figure 17 will require 5.5 cubic ft of concrete. The installation time is estimated to be 60 minutes for the concrete base. Once the concrete base and the driving sleeve are installed, it is recommended that the concrete cure for one day. The post driving is then performed, which consists only of removing the sign from its original location and driving it into the concrete foundation. This operation is estimated to take 25 minutes. The cost of the driving sleeve is assumed to be $8. The cost of concrete is estimated to be $4.5 per cubic foot.

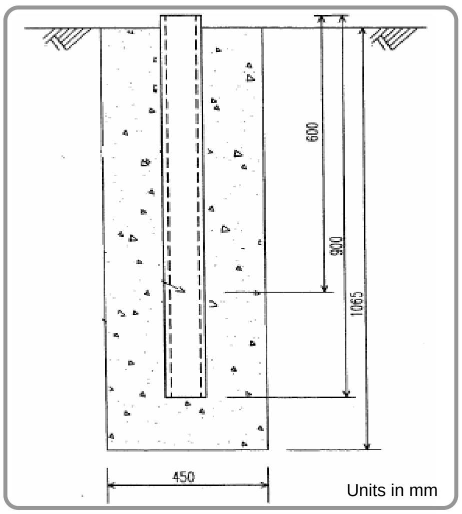


Figure 17: Concrete footing suggested by AASHTO (distance in mm)

6.4 Use Third Party Hardware

Based on a study performed by the New Jersey DOT [25], the use of anchoring devices was included among the solution alternatives. The authors of the study compared the effectiveness of drive anchors with concrete foundations for fence posts. The comparison was performed by physical testing and finite element models and the tests were carried out in strong soil type. The anchor drive is shown in Figure 18. The installation times for these devices are estimated at 30 minutes. The cost of the drive anchor is estimated to be $8.05.

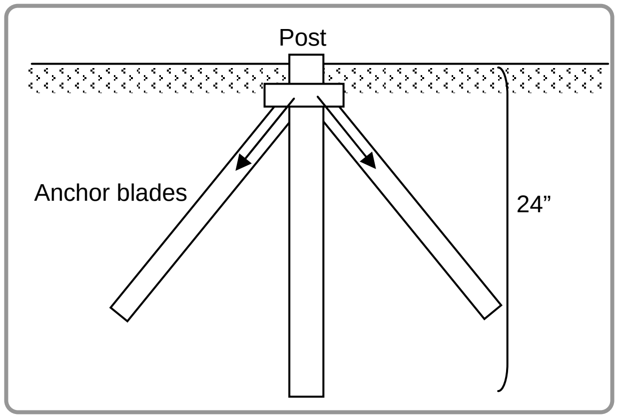


Figure 18: Use drive anchor

7. EVALUATION OF ALTERNATIVES

The evaluation of alternatives stage consists of calculating the ultimate wind force a traffic sign can withstand and ranking them by a cost effectiveness criterion.

7.1 Calculation of the Ultimate Load for the Alternatives

The performance of the traffic signs was assessed by calculating the ultimate load − the amount of wind force the sign can resist before the soil fails (short pile). If the foundation is capable of resisting wind loads meeting AASHTO recommended design wind speed it is possible that the post or any other element may fail. For the current u-channels posts in Miami-Dade it needs to be verified that the minimum yield stress is greater then 520 MPa in order to meet AASHTO suggested wind load criteria for the south Florida region.

7.1.1 Increase of Installation Depth

For this improvement alternative, the installation depth ranged between 2 ft. (current installation) and 5 ft. For sand, an installation depth of 4 ft. will enable the signs to resist up to Category 2 hurricane winds, as can be observed in Figure 19. For clay, increasing the installation depth to 4 ft. is not as effective. Only for stronger clays will this improvement work effectively, as can be observed in Figure 20.

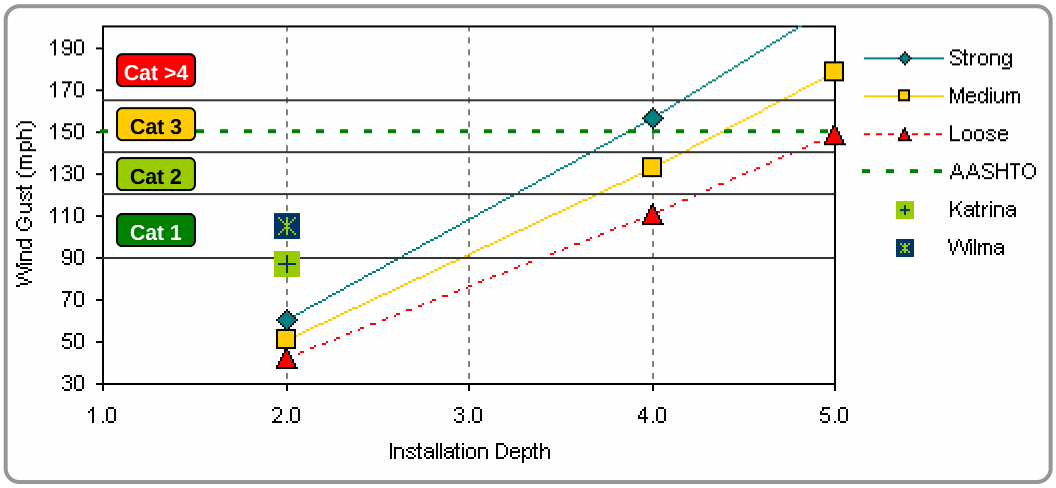


Figure 19: Performance of stop signs in sand when installation depth is increased

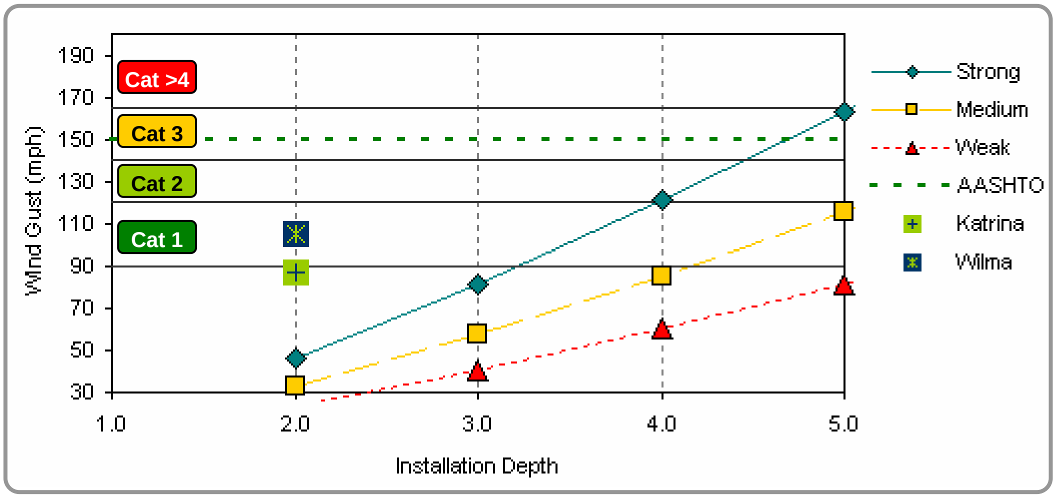


Figure 20: Performance of stop signs in clay when installation depth is increased

7.1.2 Soil Plates

Soil plates are used to increase the soil reaction by widening the lateral section of the post. Soil plates offer a certain degree of improvement, especially when the installation depth is restrictive. Figure 21 shows the estimated performance of a traffic sign with a trapezoidal soil plate in sand. For medium soil, the use of plates helps to get closer to the required standards. For weak soil, plates will restrain the sign from leaning during a tropical storm and minor hurricane wind. A similar chart for clay is presented in Figure 22

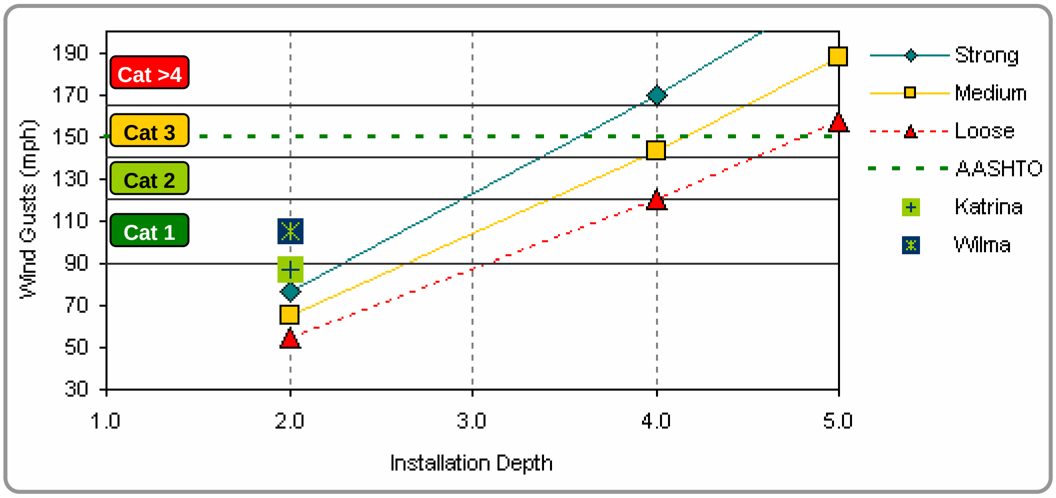


Figure 21: Performance of support system for stop signs in sand using soil plates

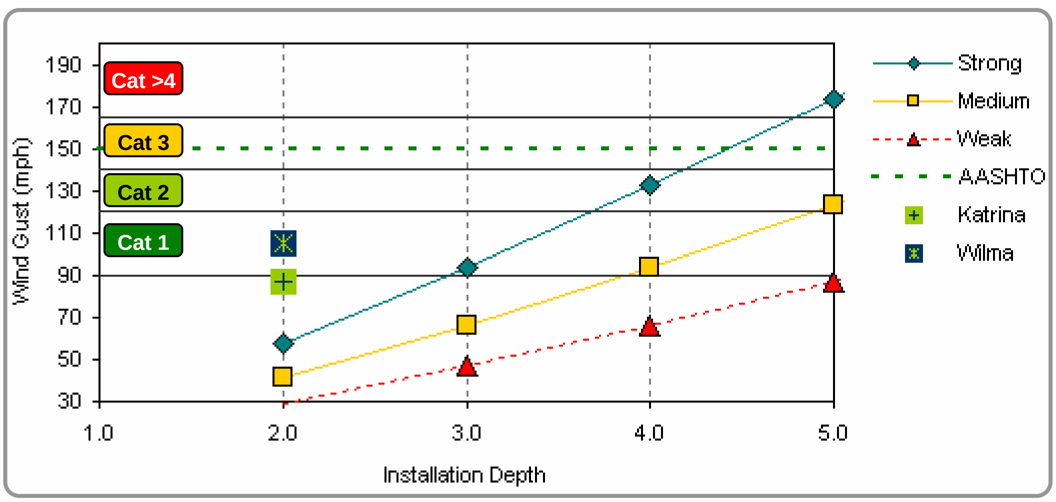


Figure 22: Performance of support system for stop signs in clay using soil plates

7.1.3 Concrete Foundation

The concrete foundations were assumed to be 1 ft in diameter. The depth varied from 2 ft. to 4 ft. in. to make appropriate comparisons with the other proposed improvements.

Concrete foundation gives the best performance in ultimate wind load at expense of installation time. At 2 ft concrete foundations in sand may be able to resist a category one hurricane as shown in Figure 23. The estimated performance of the signs installed in clay can be observe in Figure 24.

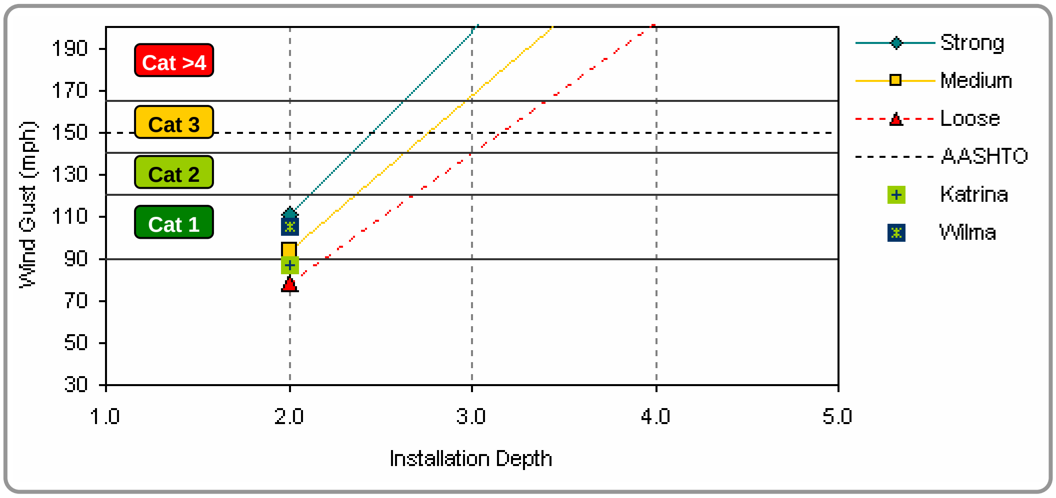


Figure 23: Performance of stop signs in sand using 1 ft concrete foundation

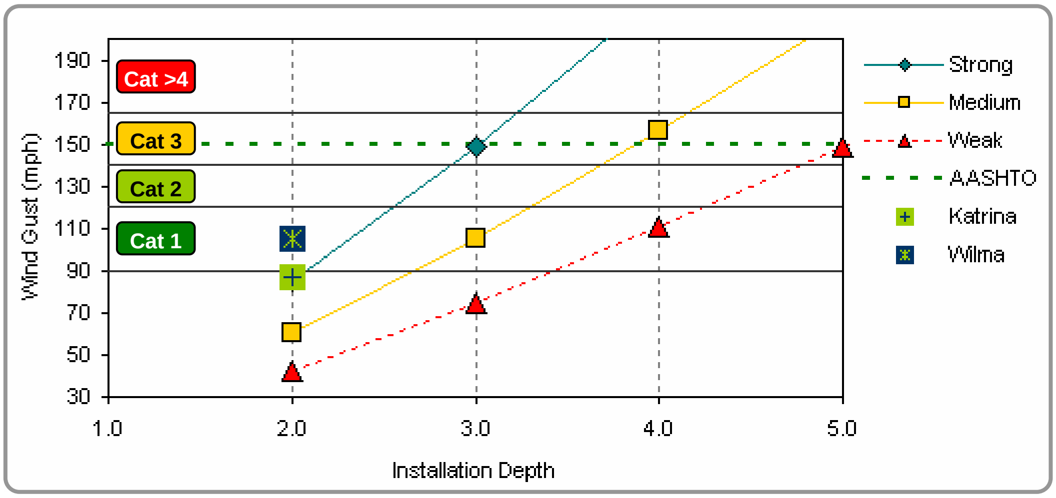


Figure 24: Performance of stop signs in clay using 1 ft. concrete foundation

7.1.4 Third Party Hardware

Hardware such as the drive anchor is difficult to analyze using the regular design standards. In Szary, Wieland and Maher [25], the authors performed physical tests as well as finite element modeling (FEM) of the drive anchor and determined that concrete foundations and drive anchors can be used interchangeably for fence post foundations. Based on the load-displacement curves obtained by the authors it was assumed that for loads under 500 pounds the two types of foundations behave similarly.

7.2 Cost Effectiveness Analysis

From the performance analysis, a set of actions was chosen to be evaluated. The evaluation consisted in laying out the most representative scenarios (soil, hurricane and sign types) that could be experienced in the Miami-Dade County region. The results are shown in Table 5 for sand and clay. The performance of the different actions was evaluated based on the ultimate wind (UW) resistance. The improvement with respect to the current installation method can be observed in Figure 25 for sand and in Figure 26 for clay.

Table 5: Ultimate wind for each scenario

Soil Type	Action	UW (mph) Sands	UW (mph) Clay
Loose	Maintain current depth (2ft)	42	23
Medium	Maintain current depth (2ft)	51	32
Strong	Maintain current depth (2ft)	60	40
Loose	Concrete 2ft	78	42
Medium	Concrete 2ft	93	60
Strong	Concrete 2ft	110	84
Loose	Soil plate 2ft	54	28
Medium	Soil plate 2ft	65	40
Strong	Soil plate 2ft	76	57
Loose	Increase depth 4ft	110	60
Medium	Increase depth 4ft	132	85
Strong	Increase depth 4ft	156	104
Loose	Concrete 3ft	140	74
Medium	Concrete 3ft	160	105
Strong	Concrete 3ft	200	149
Loose	Soil plate 3ft	87	47
Medium	Soil plate 3ft	105	66
Strong	Soil plate 3ft	125	93
Loose	Drive anchor 3ft	140	74
Medium	Drive anchor 3ft	160	105
Strong	Drive anchor 3ft	200	149

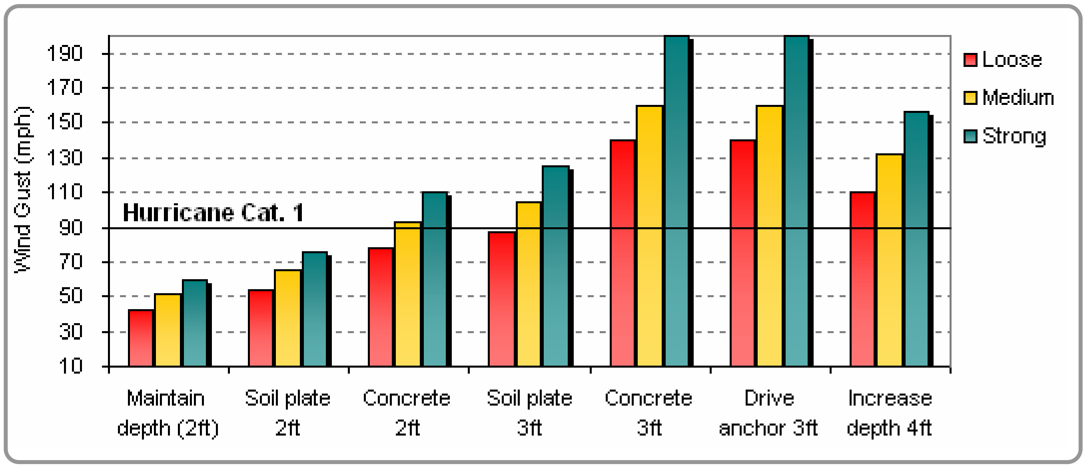


Figure 25: Ultimate wind load resistance for improvement alternatives in sand

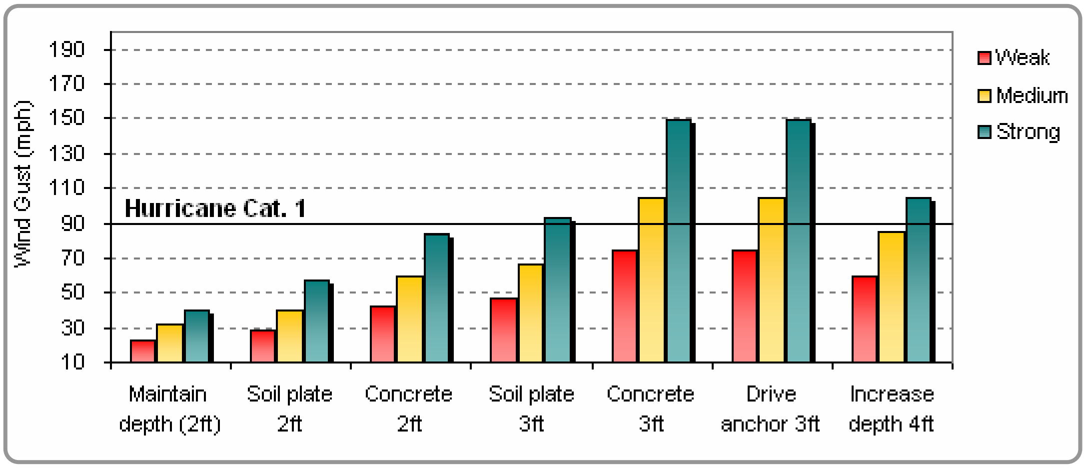


Figure 26: Ultimate wind load resistance for improvement alternatives in clay

In can be observed that, to cover the most likely scenario for Miami-Dade County, the ultimate wind resistance should be close to 120 mph which is the upper limit for wind speeds (3 sec. gusts) for a Category 1 hurricane. This criterion covers almost 90 percent of the possible situations that Miami-Dade County might face (0 or 1 hurricanes reaching Category 1). This criterion is difficult to achieve with the foundation depth at 2 ft. From Figure 26, the resistance improves significantly with only one foot of increment in the installation depth. AASHTO criterion on the other hand is more difficult to meet and may compromise the specifications for minimum yield stress of the signs already in place.

The different alternatives were evaluated using a cost effectiveness ratio. This performance measure is defined as the increase in the wind resistance per dollar of additional cost of the alternative. It was calculated with respect to the baseline action of maintaining the current installation depth. The expression used for calculating the cost effectiveness ratio is shown below:

$$Cost\ \ effectiveness(CE) = \frac{UW\ alternative - UW\ baseline}{\cos t\ \ of\ \ alternative}$$

The ranks based on cost effectiveness are shown in Table 6 for sand and in Table 7 for clay. In general drive anchors offers the best wind resistance per dollar followed by increase the foundation depth to 4 ft.

Table 6: Ranking by cost effectiveness for alternative in sand

Rank	Soil	Action	CE (mph/$)
1	Loose	Drive anchor 3ft	8.6
2		Increase depth 4ft	3.8
3		Concrete 3ft	1.9
4		Soil plate 3ft	1.8
5		Soil plate 2ft	1.2
6		Concrete 2ft	1.0
1	Medium	Drive anchor 3ft	9.6
2		Increase depth 4ft	4.5
3		Soil plate 3ft	2.2
4		Concrete 3ft	2.1
5		Soil plate 2ft	1.4
6		Concrete 2ft	1.1
1	Strong	Drive anchor 3ft	13.9
2		Increase depth 4ft	6.3
3		Soil plate 3ft	3.4
4		Soil plate 2ft	3.3
5		Concrete 3ft	3.0
6		Concrete 2ft	1.8

Table 7: Ranking by cost effectiveness for alternatives in clay

Rank	Soil	Action	CE (mph/$)
1		Drive anchor 3ft	4.5
2		Increase depth 4ft	2.0
3	Weak	Concrete 3ft	1.0
4		Soil plate 3ft	1.0
5		Concrete 2ft	0.5
6		Soil plate 2ft	0.5
1		Drive anchor 3ft	6.4
2		Increase depth 4ft	2.9
3	Medium	Concrete 3ft	1.4
4		Soil plate 3ft	1.4
5		Soil plate 2ft	0.8
6		Concrete 2ft	0.7
1		Drive anchor 3ft	9.6
2		Increase depth 4ft	3.5
3	Strong	Soil plate 3ft	2.2
4		Concrete 3ft	2.1
5		Soil plate 2ft	1.7
6		Concrete 2ft	1.2

8. CONCLUSIONS AND RECOMMENDATIONS

This report covered the evaluation of proposed major actions that can be taken to improve the hurricane-withstanding capabilities of traffic signs for Miami-Dade County. A primary problem is the proximity of buried utilities to the right-of-way. In Florida, buried utilities can be found at 30 in. below the surface which forces the installation of traffic signs at a depth of 2 ft. In general, the soil at that depth is not strong enough to give adequate support to the signposts during a major tropical storm. The following recommendations are proposed to improve the withstanding capabilities of street signs as well as directions for further analysis.

8.1 Recommendations for Improving Withstanding Capabilities of Street Signs

- Currently, the 2001 AASHTO standards contain appropriate wind-loading criteria for designing sign supports ranging from major overhead structures to single post roadside signs. The wind loads considered in the 2001 AASHTO standards include provisions for hurricane winds for the coastal zones. For that reason, it is a safe practice to revise the local standards against the specifications suggested by AASTHO and take the appropriate actions. The wind loading criteria in the AASHTO 2001 standards increase significantly for coastal areas when they are compared to the 1994 version. For the south Florida region, this implies that the adoption of the AASHTO 2001 standards can not only improve the foundations of street signs, but also verify if the post material is capable of withstanding the required wind load. In some cases, replacing the signpost with improved alternatives made with better materials or different cross section may be required.

- The most likely events for Miami-Dade County during any particular year are 0 hurricanes, or at most, 1 hurricane of Category 1. These scenarios account for 90 percent of the possible cases for any year. If an improvement alternative for traffic signs on hurricane-withstanding capabilities is designed based on the above-mentioned scenarios, then it may reasonably reduce the number of failed signs during a hurricane.

- Based on the literature review and practices on traffic sign installation, four major alternatives are proposed to improve traffic sign hurricane-withstanding capabilities: (1) increase installation depth, (2) use soil plates, (3) use concrete foundations, and (4) use third party hardware.

- For the embedment depth of 2 ft., the top two alternatives are concrete foundation and drive anchors. Drive anchors provide withstanding capabilities equivalent to those of concrete foundations. Concrete foundations were consistently at the top of the ranks in terms of ultimate wind resistance for all soil types. Therefore, drive anchors can be used in all types of soils with similar results to those of concrete foundation. The main advantage of drive anchors is that the installation time is significantly shorter than that required to cast a concrete foundation for a street sign. The installation time for a sign with drive anchor is about 25 minutes, whereas it is about 60 minutes for a sign with concrete foundation. It is important to note that, if the foundation depth is greater than 2 ft., then the selected two alternatives can perform even better.

- A notable situation in Miami-Dade County is that rock can be encountered a few inches from the surface. In those cases, a hole can be drilled in the rock at less than 2 ft. and the signpost or post sleeve can be driven into the rock. A concrete backfill can be used to fix the post at its location.

8.2 Directions for Further Analyses and Improvement

- The results obtained might be improved by performing physical testing of the proposed alternatives. Partnering with a manufacturer may be useful to consider variations on the design. In the case of the drive anchor, testing two, three or four anchor blades may be helpful. For testing, the selected improvement alternatives can be installed in sites with appropriate soil characteristics. Once installed, a known load can be applied to the post until the soil or the post fails. The deformation of the sign support will be measured by displacement gauges and saved for analyses. Custom load-displacement profiles can be obtained for different soils and different sign support designs. This will allow a better assessment of the performance of the alternatives for improving the wind resistance capability of traffic signs supports.

- The purchase or rental of ground penetrating radars could be considered as an alternative to safely bypass the process of requesting horizontal clearance.

- By promoting the use of regulations such as those in the Utility Accommodation Manual where utilities cannot be located within 3 ft. of the right-of-way, the problem of installation depth might be overcome for new developments.

- It is recommended that Miami-Dade County implement a GIS-based signage inventory so sign failure can be related to soil and wind information, allowing a better assessment of the sign support reliability.

9. REFERENCES

[1]. National Oceanic and Atmospheric Administration. "Tropical Cyclone Reports 2006." Available: http://www.nhc.noaa.gov/. 25-Sep-2006.

[2]. Miami-Dade Public Works Department. "Departmental Business Plan and Outlook Years 2006-2007." Miami-Dade County, 2006.

[3]. American Association of State Highway and Transportation Officials, "Standard Specifications for Structural Supports for Luminaries and Traffic Signals" (LTS-4)." Washington D.C, 2001.

[4]. Fouad, Fouad, and Elizabeth Calvert. New Wind Design Criteria for Traffic Signal Support Structures. University Transportation Center for Alabama, 2005.

[5]. American Society of Civil Engineers ASCE, "Minimum Design Loads for Buildings and Other Structures." ASCE 7-02, American Society of Civil Engineers, Reston, VA, 2002.

[6]. Florida Department of Transportation. "Standard Index 11000 Series: Signs." Available:http://www.dot.state.fl.us/rddesign/rd/RTDS/06/2006Standards.htm.

[7]. Miami-Dade Public Works. "Dade County Design Standard". Section #168. 1986.

[8]. Florida Department of Transportation, Utility Accommodation Manual. 2004.

[9]. Federal Highway Administration, "Manual on Uniform Traffic Control Devices." 2003.

[10]. Florida Statutes. Chapter 556: "Underground Facility Damage Prevention and Safety". Florida Senate. 2006.

[11]. Cole, Jason, et al. "Risk-Based Post Hurricane Recovery of Highway Signs Signals and Lights". Center for Risk Management of Engineering Systems at University of Virginia, Charlottesville, 1998.

[12]. Fouad, F. and E. Calvert. "Impact of the New Wind Load Provisions on the Design of Structural Supports" in TRB Annual Conference. Washington, 2003.

[13]. White, DongMing. "Adoption of 2001 AASHTO Standard Specifications for Structural Support for Highway Luminairies and Traffic Signals". FICE/FDOT 2006 Design Conference. Orlando, Fl., 2006.

[14]. Ahlborn, T., J. Van de Lindt, and M. Lewis. "Optimization of Cost and Performance of Overhead Sign Support Structures". Michigan Technological University: Houghton, MI., 2003.

[15]. FDOT Structures Manual. "Wind Loads" Jan. 2007. Available from http://www.dot.state.fl.us/structures/StructuresManual/CurrentRelease/StructuresManual.htm

[16]. American Association of State Highway and Transportation Officials (AASHTO), Associated General Contractors of America (AGC), American Road and Transportation Builders Association (ARTBA). "Guide to Small Sign Support Hardware." Washington D.C., 1998.

[17]. Knabb, Richard, Rhome, Jamie and Brown, Daniel. "Tropical Cyclone Report, Hurricane Katrina" 23-30 August 2005. National Hurricane Center, 2006.

[18]. Pasch, Richard, Blake, Eric, Cob III, Hugh, and Roberts, David. "Tropical Cyclone Report, Hurricane Wilma" 15-25 October 2005. National Hurricane Center, 2006.

[19]. National Oceanic and Atmospheric Administration. "National Hurricane Center. Tropical Cyclone Reports". December, 2006. Available: http://www.nhc.noaa.gov/.

[20]. Gray, William, and Klotzbach, Philip. "United States Landfall Probability Webpage". December, 2006. Available: http://www.e-transit.org/hurricane/welcome.html.

[21]. United States Department of Agriculture. "Soil Survey of Dade County Area", Florida. 1996.

[22]. American Society for Testing and Materials, D 2487-83, "Classification of Soils for Engineering Purposes": Annual Book of ASTM Standards. Vol. 04.08, pp 395-408. 1985.

[23]. Gaylord, Edwin, Gaylord, Charles, and Stallmeyer, James. Structural Engineering Handbook. New York: McGraw-Hill, c1997.

[24]. Reese, Lymon, and William Van Impe. "Broms Method for Analysis of Single Piles under Lateral Loading." Single Piles and Pile Groups under Lateral Loading. 1st ed. Rotterdam, Netherlands: A.A. Balkema 369, 2001.

[25]. Szary, Patrick, Wible, Judson, and Maher, Ali. "Evaluation of Standard Right of Way Fence Post Anchors Versus Drive Anchors." Prepared by the New Jersey Department of Transportation for the Federal Highway Administration. February, 2001. Available : http://www.cait.rutgers.edu/finalreports/FHWA-NJ-2000-007.pdf.

APPENDIX A

Wind Loads

AASHTO LTS-4 suggestions are presented in Table A1. The recommended practice is that, since roadside signs have relatively short life expectancies, and in general do not endanger life, in the case of a failure they can be designed with a wind importance factor equivalent to a design life of 10 years.

The design life is the criteria to select the wind importance factor. A wind importance factor of 1.0 indicates that the wind load is applied as calculated. A wind importance factor of less than 1.0 indicates that just a fraction of the wind loading is used to estimate the design parameters, therefore resulting in a shorter design life. The different wind importance factor suggested by AASHTO 2001 are shown in Table A2.

Table A1: Recommended minimum design life AASHTO 2001

Design life	Structure type
50	Luminaries support structures exceeding 15 m.(49.2 ft.) in height Overhead sign structures
25	Luminaries support structures less than 15 m. (49.2 ft.) in height Traffic signal structures
10	Roadside structures

Table A2: Wind importance factors Ir, AASHTO 2001

	Regular wind speed	Hurricane wind speed
Recurrence Interval Years	V=(38-45) m/s V=(85-100) mph	V>45 m/s (100 mph)
100	1.15	1.23
50	1.0	1.00
25	0.87	0.80*
10	0.71	0.54*

The wind exposure factor used in AASHTO LTS-4 corresponds to exposure category C in ASCE 7-02. Exposure category C is defined in ASCE 7-02 as open terrain with scattered obstruction having heights generally less than 30 feet. It can be assumed as flat country or grassland. It is important to note that there are other exposure categories, such as D, which is applicable to flat, unobstructed, areas exposed to wind flowing over large bodies of water. The differences between these two exposure categories can be observed in Figure A1. In the case of Miami-Dade County, the value of the exposure factor is 0.87 because the mounting height is less than 10 ft.

The gust effect factor is assumed to be 1.14. According to AASHTO standard specifications, structural supports designed with this parameter have performed well. Another reason for the adoption of this particular value is to keep the calculations simple.

The drag coefficient is used to represent the wind flow characteristics around a multi-sided or round tube. The wind speeds are transformed to reflect the drag coefficient during the design life of the structure. Although the drag coefficients primarily depend on the shape of the structural component, there are some general suggested specifications shown in Table A3.

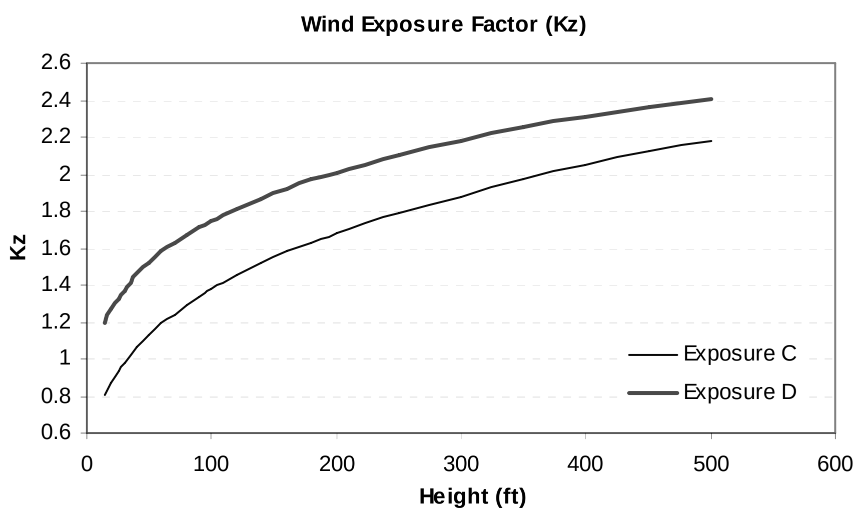


Figure A1: Wind exposure factor Kz Vs height for exposure categories C and D (ASCE 7-02)

AASHTO standard specifications provide alternatives for designing supports taking into consideration hurricane winds on coastal zones. By selecting the appropriate factors (exposure, wind importance, etc.), increased wind load can be obtained and may improve the performance of new highway signs against tropical storms and hurricanes.

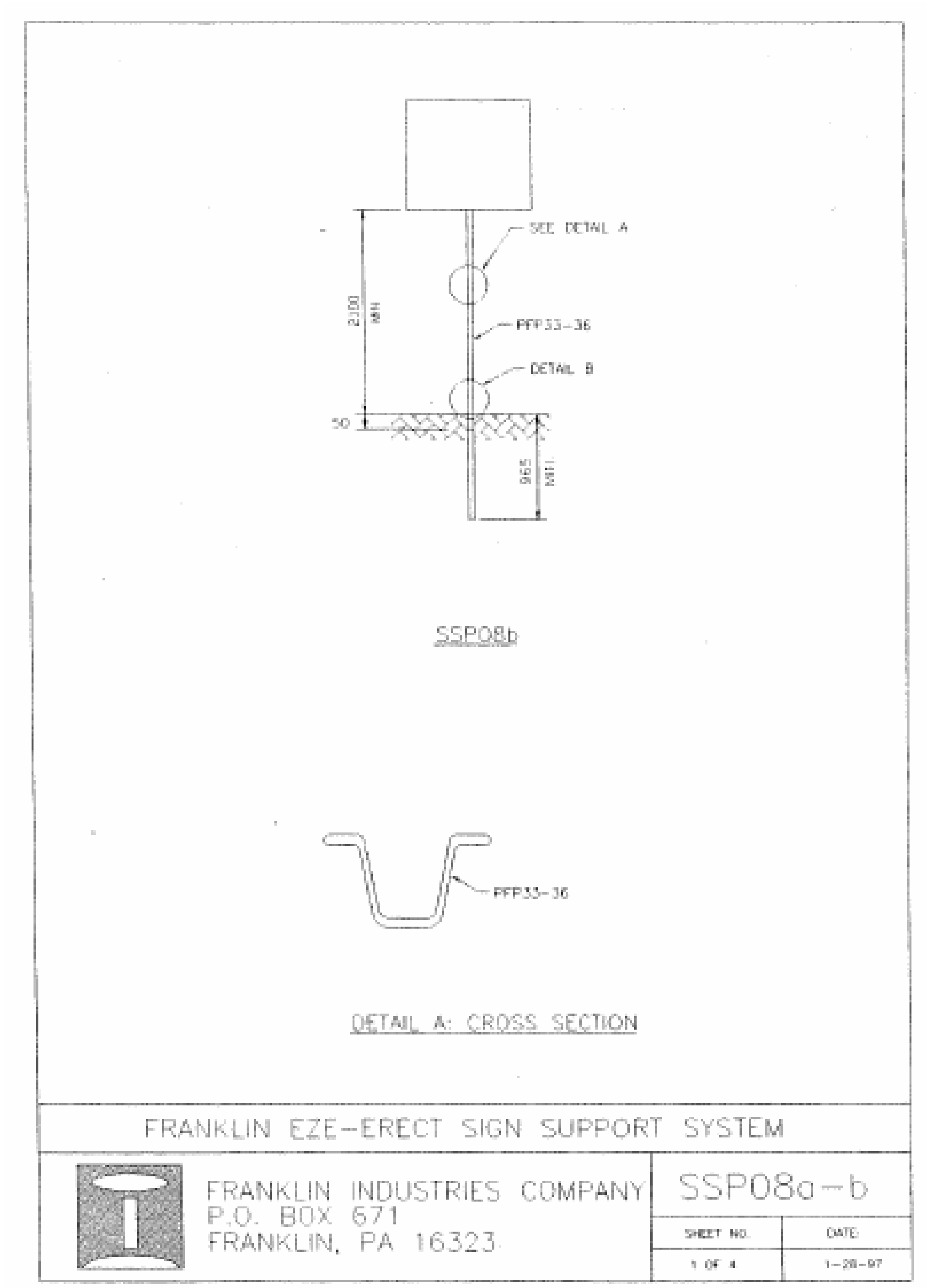
In summary, for street signs in the Miami-Dade case, Kz=0.87, G=1.14, V=150 mph Ir=0.71. The drag coefficient should be established for each sign type; for the regular stop sign with street name, the coefficient is 1.14.

Table A3: Wind drag coefficients Cd, AASHTO 2001

Sign Panel (Ratio of length to width)	Wind drag coefficients
1.0	1.12
2.0	1.19
5.0	1.20
10	1.23
15	1.30
Traffic signals	1.2
Luminaries (with generally rounded surfaces)	0.5
Luminaries (with rectangular flat sides shapes)	1.2
Variable message signs (suggested)	1.7

APPENDIX B

Recommended installation for Franklin Eze-Erect Sign Support System in the AASHTO Guide to Small Sign Support Hardware



INTENDED USE

The Franklin Industries Eze-Erect system can be used as a single- (SSP08a) or dual- (SSP08b) post sign support installation. The system may be driven into strong soil and does not require a concrete foundation. These systems have been successfully crash tested in strong soil soil and have been judged to satisfy the requirements of 1985 AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals* and the National Cooperative Highway Research Program Report 230.

COMPONENTS

The Franklin Industries Eze-Erect system consists of three components: a base post (PFP33-36), a sign post (PFP33-36) and the Eze-Erect splice hardware. The Eze-Erect splice hardware consists of a retainer-spacer strap, bolts (FBX08d), washers and nuts. The splice bolts and nuts are 50-mm long FXB08d M8x1.25 Class 12.9 bolts and nuts. The external toothed lockwashers are 10-mm diameter style, and heavy duty. The bolt, nut, and lockwasher hardware are cadmium plated in accordance with the requirements of ASTM A165-80, Type OS, except using clear chromate. The retainer-spacer strap finish shall be galvanized conforming to ASTM A123.

REFERENCES

L.A. Staron, "Breakaway Sign Supports," Geometric and Roadside Design Acceptance Letter SS-9, Federal Highway Administration, Washington D.C., March 16, 1989.

L.A. Staron, "Breakaway Sign Supports," Geometric and Roadside Design Acceptance Letter, Federal Highway Administration, Washington D.C., April 7, 1989.

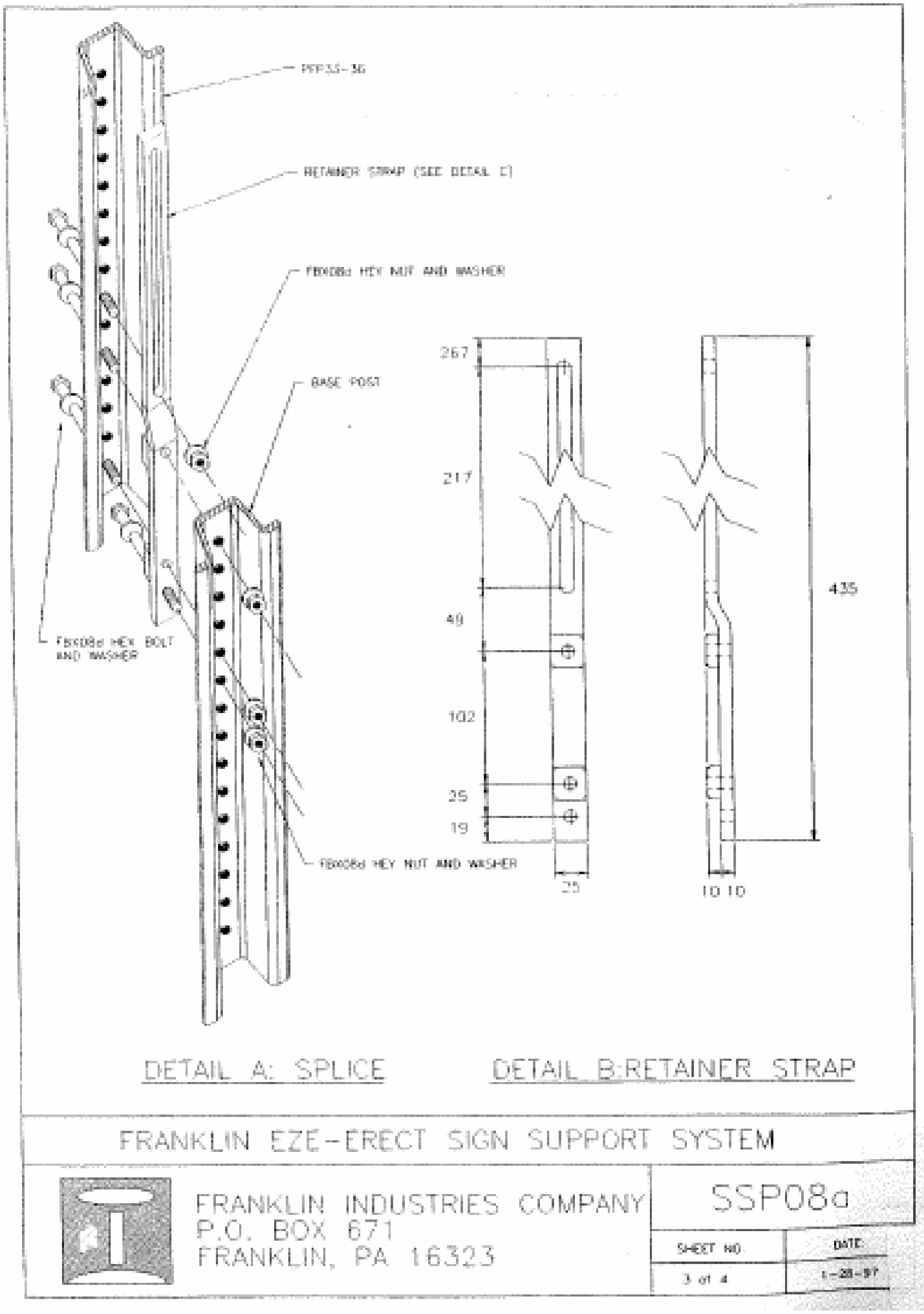
S.I. Sillan, "Breakaway Sign Supports," Geometric and Roadside Design Acceptance Letter SS-67, Federal Highway Administration, Washington D.C., September 9, 1996.

CONTACT INFORMATION

Franklin Industries Company
P.O. Box 671
Franklin, PA 16323
(814) 437-3726
Fax: (814) 432-7556

FRANKLIN EZE-ERECT SIGN SUPPORT SYSTEM

SSP08a-b		FRANKLIN INDUSTRIES COMPANY P.O. BOX 671 FRANKLIN, PA 16323
SHEET NO.	DATE:	
2 OF 4	1-28-97	


PFP35-36
RETAINER STRAP (SEE DETAIL C)
FBX08d HEX NUT AND WASHER
BASE POST
FBX08d HEX BOLT AND WASHER
FBX08d HEX NUT AND WASHER
267
217
49
102
25
19
25
435
10 10
DETAIL A: SPLICE
DETAIL B:RETAINER STRAP
FRANKLIN EZE-ERECT SIGN SUPPORT SYSTEM
FRANKLIN INDUSTRIES COMPANY
P.O. BOX 671
FRANKLIN, PA 16323
SSP08a
SHEET NO.
3 of 4
DATE

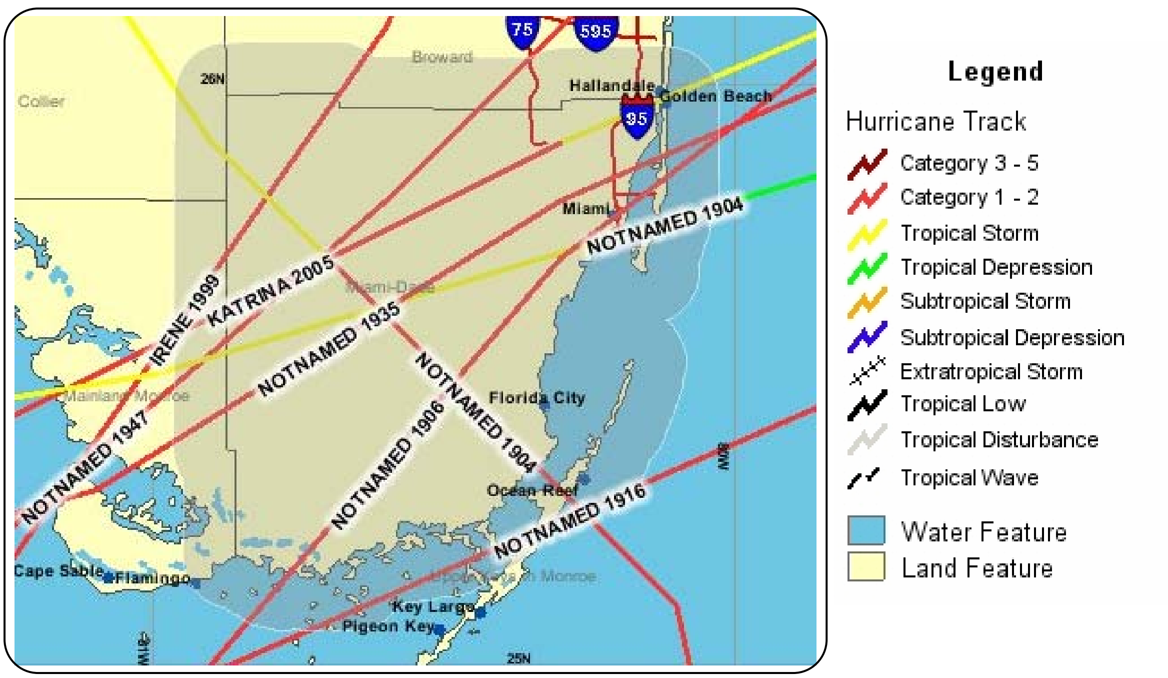
APPENDIX C

Hurricane Landfall Historical Data for Miami-Dade County

Landfall data for Category 1 hurricanes in Miami-Dade County

1900-2005

	Year	Month	Day	Storm name	Wind speed(kts)
1	1904	10	17	Not named	70
2	1906	6	17	Not named	75
3	1916	11	15	Not named	70
4	1935	11	4	Not named	65
5	1947	10	12	Not named	75
6	1999	10	15	Irene	65
7	2005	8	26	Katrina	70

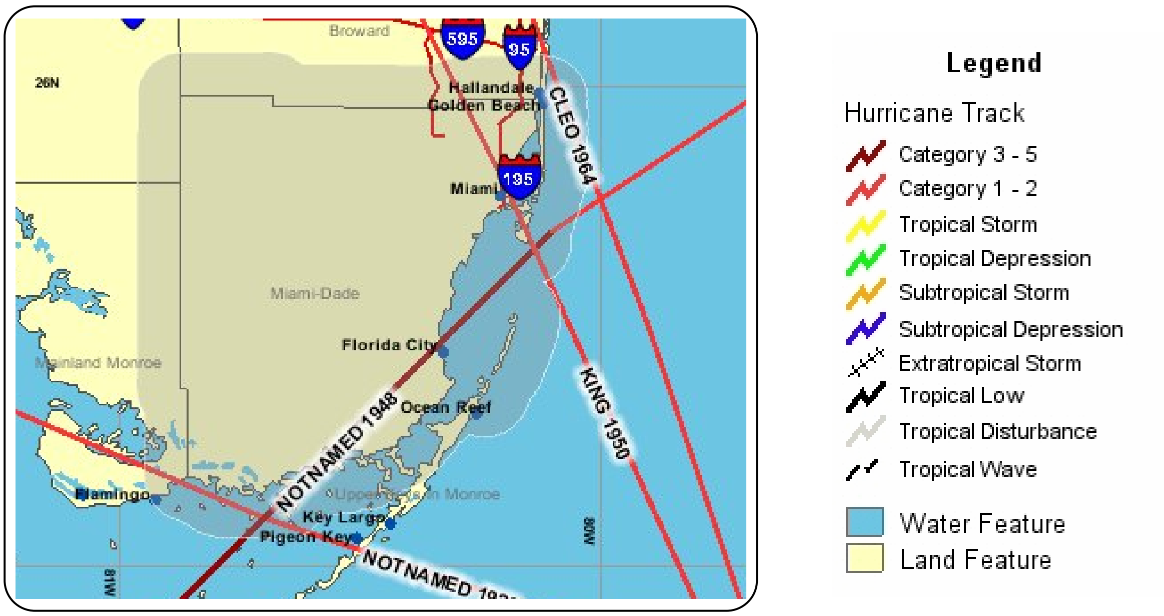


Source: NOAA Hurricane Center, Historical hurricane tracks. http://www.nhc.noaa.gov/

Landfall data for Category 2 hurricanes in Miami-Dade County

1900-2005

	Year	Month	Day	Storm name	Wind speed(kts)
1	1929	9	28	Not named	90
2	1948	10	6	Not named	90
3	1950	10	18	King	95
4	1964	8	27	Cleo	90

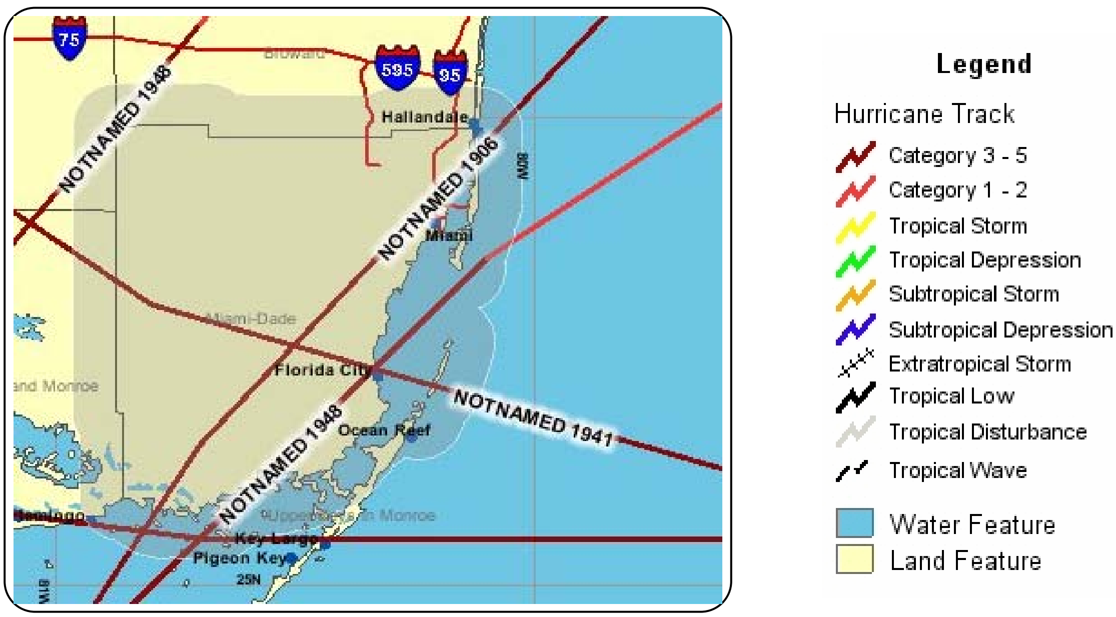


Source: NOAA Hurricane Center, Historical hurricane tracks. http://www.nhc.noaa.gov/

Landfall data for Category 3 hurricanes in Miami-Dade County

1900-2005

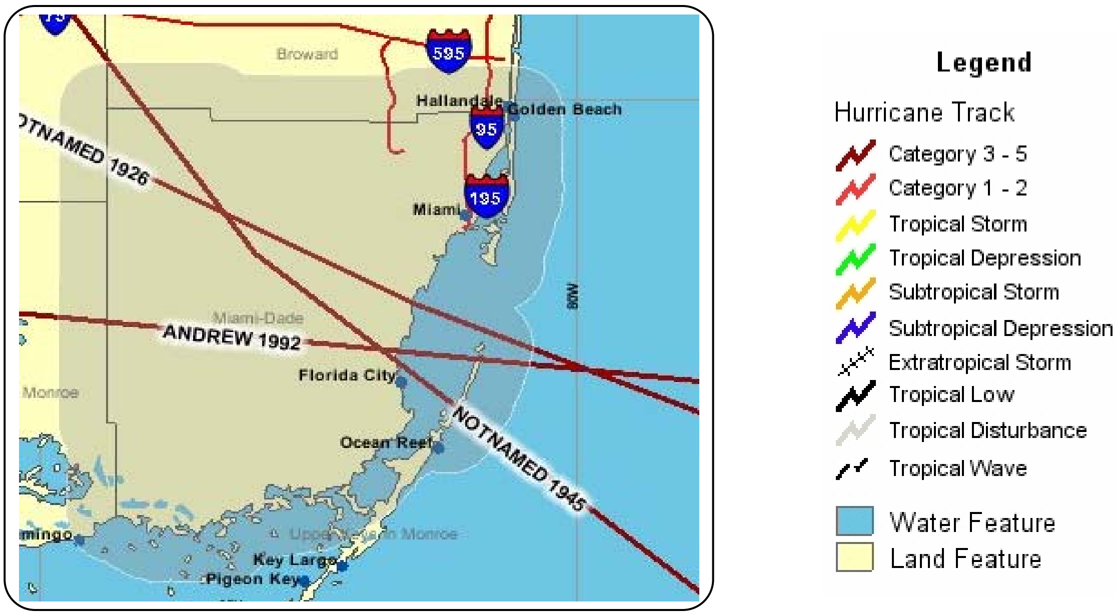
	Year	Month	Day	Storm name	Wind speed(kts)
1	1906	10	18	Not named	105
2	1941	10	6	Not named	105
3	1948	9	22	Not named	100
4	1948	10	5	Not named	110
5	1965	9	8	Betsy	110



Source: NOAA Hurricane Center, Historical hurricane tracks. http://www.nhc.noaa.gov/

Landfall data for Category 4 hurricanes in Miami-Dade County 1900-2005

	Year	Month	Day	Storm name	Wind speed(kts)
1	1926	9	18	Not named	120
2	1945	9	15	Not named	120
3	1992	8	24	Andrew	130



Source: NOAA Hurricane Center, Historical hurricane tracks. http://www.nhc.noaa.gov/

Landfall data for Category 5 hurricanes in Miami-Dade County 1900-2005

Fortunately, there are no Category 5 hurricanes reported in the last 105 years.

Source: NOAA Hurricane Center, Historical hurricane tracks. http://www.nhc.noaa.gov/

APPENDIX D

Hurricane Probabilities for the Southeast Region of Florida

The 2006 hurricane season was favorable to Miami-Dade County since no major hurricanes strikes were reported. In contrast, in 2005, two hurricanes affected Miami-Dade County. Several initiatives predict hurricane landfall that make use of the available information, such as the work of Gray and Klotzbach [20] whose methodology was followed to calculate hurricane strike probabilities in this project. These authors divided the Atlantic coastline into 11 regions. Miami-Dade County is in region 6, which also includes Monroe, Broward, Palm Beach, and Martin counties. A map of the regions is shown in Figure D1.

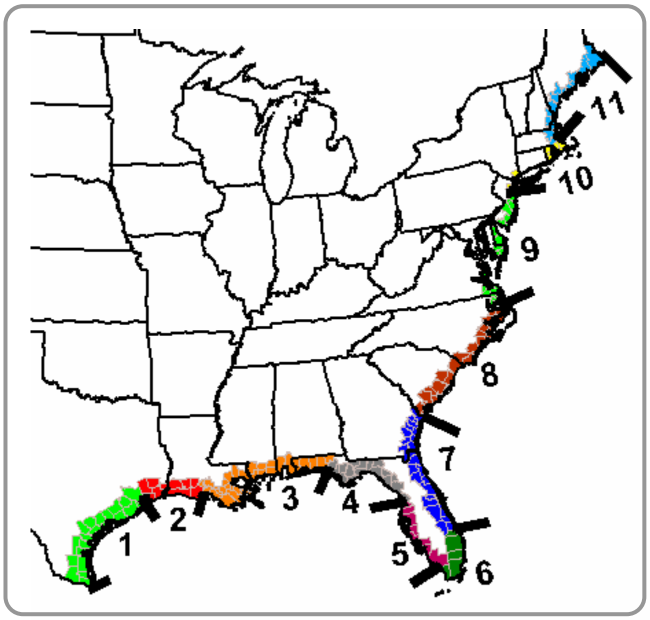


Figure D1: Hurricane probability of occurrence for Atlantic coastline regions (Gray and Klotzbach)

Additional information for region 6 is provided in Table D1 Tropical Storm refers to sustained wind speeds from 40-75 mph. Hurricane refers to sustained wind speeds from 75-115 mph. Intense hurricane refers to sustained wind speeds greater than 115 mph.

As observed in Table D1, hurricanes and intense hurricanes are considered independent events; therefore, the yearly probability of a hurricane can be calculated as the sum of both, which for region 6 is 41 percent. This means that there is an increased chance of a hurricane strike in any of the counties forming region 6.

Table D1: Hurricane probabilities for Region 6 (Gray and Klotzbach)

Storm Type Probability	Value (percent)
Yearly - Tropical Storm Wind Force	28.9
Yearly - Tropical Storm Vicinity	92.6
50-Year - Tropical Storm	100.0
Yearly - Hurricane Wind Force	8.9
Yearly - Hurricane Vicinity	55.1
50-Year - Hurricane	99.1
Yearly - Intense Hurricane Wind Force	2.4
Yearly - Intense Hurricane Vicinity	19.4
50-Year - Intense Hurricane	70.3
1 or more Named Storms	36.1
2 or more Named Storms	7.5
1 or more Hurricanes	27.7
2 or more Hurricanes	4.2
1 or more Intense Hurricanes	14.1
2 or more Intense Hurricanes	1.0

APPENDIX E

Engineering Properties of Soil in Miami-Dade County

Engineering Properties

Miami-Dade County Area, Florida

[Absence of an entry indicates that the data were not estimated]

Map symbol and soil name	Depth	USDA texture	Classification		Fragments		Percent passing sieve number--				Liquid limit	Plasticit y index
			Unified	AASHTO	>10 Inches	3-10 Inches	4	10	40	200		
	In				*Pct*	*Pct*					*Pct*	
2:												
Biscayne, drained	0-7	Gravelly marly silt loam	CL-ML, ML	A-4	---	0-5	60-85	50-75	35-70	35-70	15-25	3-10
	7-11	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Chekika	0-5	Very gravelly loam	GC, GM	A-1-b, A-2, A-4	---	30-50	40-80	35-45	20-45	20-45	20-25	3-10
	5-9	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Pennsuco, drained	0-8	Marly silt loam	CL, CL-ML,	A-4, A-6	0	0	100	100	98-100	85-95	0-40	NP-19
	8-44	Marly silt, marly silt loam	ML	A-4	0	0	100	100	98-100	85-95	0-14	NP
	44-48	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
3:												
Lauderhill, depressional	0-30	Muck	PT	A-8	0	0	100	100	100	100	---	---
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Biscayne	0-5	Marly silt loam	ML	A-4	---	0	100	100	80-100	80-100	0-20	NP-4
	5-17	Marly silt, marly silt loam	ML	A-4	0	0	98-100	95-100	95-100	85-95	0-20	NP-4
	17-21	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Matecumbe	0-3	Muck	PT	A-8	0	0	100	100	100	100	---	---
	3-7	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
Pennsuco	0-4	Marly silt loam	CL, CL-ML,	A-4, A-6	0	0	100	100	98-100	85-95	0-40	NP-19
	4-46	Marly silt, marly silt loam	ML	A-4	0	0	100	100	98-100	85-95	0-14	NP
	46-50	Weathered bedrock	---	---	---	---	---	---	---	---	---	---

Survey Area Version: 1
Survey Area Version Date: 01/22/2007

Engineering Properties

Miami-Dade County Area, Florida

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 Inches	Fragments: 3-10 Inches	Percent passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				*Pct*	*Pct*					*Pct*	
3:												
Perrine	0-4	Marly silt loam	CL, CL-ML,	A-4, A-6	0	0	98-100	95-100	95-100	85-95	20-35	4-12
	4-29	Marly silt, marly silt loam	ML	A-4	0	0	98-100	95-100	95-100	85-95	0-25	NP-7
	29-33	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
4:												
Pennsuco, drained	0-8	Marly silt loam	CL, CL-ML,	A-4, A-6	0	0	100	100	98-100	85-95	0-40	NP-19
	8-44	Marly silt, marly silt loam	ML	A-4	0	0	100	100	98-100	85-95	0-14	NP
	44-48	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
Biscayne, drained	0-5	Marly silt loam	ML	A-4	---	0	100	100	80-100	80-100	0-20	NP-4
	5-15	Marly silt, marly silt loam	ML	A-4	0	0	98-100	95-100	95-100	85-95	0-20	NP-4
	15-19	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Lauderhill, depressional	0-30	Muck	PT	A-8	0	0	100	100	100	100	---	---
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Udorthents	0-30	Gravelly sand	GP, GP-GM, SP,	A-1-b, A-2-4, A-3	0	10-40	50-80	40-70	30-60	2-12	0-14	NP-7
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
5:												
Pennsuco	0-4	Marly silt loam	CL, CL-ML,	A-4, A-6	0	0	100	100	98-100	85-95	0-40	NP-19
	4-46	Marly silt, marly silt loam	ML	A-4	0	0	100	100	98-100	85-95	0-14	NP
	46-50	Weathered bedrock	---	---	---	---	---	---	---	---	---	---

Engineering Properties

Miami-Dade County Area, Florida

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 Inches	Fragments: 3-10 Inches	Percent passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				*Pct*	*Pct*					*Pct*	
5:												
Biscayne	0-5	Marly silt loam	ML	A-4	---	0	100	100	80-100	80-100	0-20	NP-4
	5-17	Marly silt, marly silt loam	ML	A-4	0	0	98-100	95-100	95-100	85-95	0-20	NP-4
	17-21	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Lauderhill, depressional	0-30	Muck	PT	A-8	0	0	100	100	100	100	---	---
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Pahokee	0-46	Muck	PT	A-8	0	0	100	100	100	100	---	---
	46-50	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Tamiami, depressional	0-4	Muck	PT	A-8	0	0	100	100	100	100	---	---
	4-12	Marly silt, marly silt loam	ML	A-4	---	0	100	100	80-100	80-100	0-20	NP-4
	12-31	Muck	PT	A-8	0	0	100	100	100	100	---	---
	31-35	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Udorthents	0-30	Gravelly sand	GP, GP-GM, SP,	A-1-b, A-2-4, A-3	0	10-40	50-80	40-70	30-60	2-12	0-14	NP-7
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
6:												
Perrine, drained	0-10	Marly silt loam	CL, CL-ML,	A-4, A-6	0	0	98-100	95-100	95-100	85-95	0-30	NP-19
	10-26	Marly silt, marly silt loam	ML	A-4	0	0	98-100	95-100	95-100	85-95	0-14	NP
	26-30	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
Lauderhill, depressional	0-30	Muck	PT	A-8	0	0	100	100	100	100	---	---
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---

Engineering Properties

Miami-Dade County Area, Florida

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 Inches	Fragments: 3-10 Inches	Percent passing sieve number--: 4	Percent passing sieve number--: 10	Percent passing sieve number--: 40	Percent passing sieve number--: 200	Liquid limit	Plasticit y index
	In				*Pct*	*Pct*					*Pct*	
6:												
Udorthents	0-30	Gravelly sand	GP, GP-GM, SP,	A-1-b, A-2-4, A-3	0	10-40	50-80	40-70	30-60	2-12	0-14	NP-7
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
7:												
Krome	0-7	Very gravelly loam	GC, GM	A-1-b, A-2-4	---	0-5	40-80	30-45	25-40	5-30	20-25	2-10
	7-11	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Biscayne, drained	0-7	Gravelly marly silt loam	CL-ML, ML	A-4	---	0-5	60-85	50-75	35-70	35-70	15-25	3-10
	7-11	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Cardsound	0-4	Silty clay loam	ML	A-4	---	0-5	100	90-100	70-90	70-90	30-40	10-15
	4-8	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Chekika	0-5	Very gravelly loam	GC, GM	A-1-b, A-2, A-4	---	30-50	40-80	35-45	20-45	20-45	20-25	3-10
	5-9	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Matecumbe	0-3	Muck	PT	A-8	0	0	100	100	100	100	---	---
	3-7	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
Rock outcrop	---	---	---	---	---	---	---	---	---	---	---	---
9:												
Udorthents	0-80	Gravelly loam	CL, ML	A-4	0-5	15-35	50-70	40-60	40-50	35-50	15-30	3-10

Engineering Properties

Miami-Dade County Area, Florida

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 Inches	Fragments: 3-10 Inches	Percent passing sieve number--: 4	10	40	200	Liquid limit	Plasticit y index
	In				*Pct*	*Pct*					*Pct*	
9:												
Water	---	---	---	---	---	---	---	---	---	---	---	---
Urban land	---	---	---	---	---	---	---	---	---	---	---	---
10:												
Udorthents	0-55	Extremely gravelly loam	SC	A-1-b	0-20	60-80	50-80	15-25	10-25	10-20	20-30	5-10
	55-59	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Urban land	---	---	---	---	---	---	---	---	---	---	---	---
Cardsound	0-4	Silty clay loam	ML	A-4	---	0-5	100	90-100	70-90	70-90	30-40	10-15
	4-8	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Krome	0-7	Very gravelly loam	GC, GM	A-1-b, A-2-4	---	0-5	40-80	30-45	25-40	5-30	20-25	2-10
	7-11	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
11:												
Udorthents	0-12	Very gravelly loam	SC	A-4	0-6	35-60	50-80	25-50	15-45	15-45	20-30	5-10
	12-41	Gravelly sandy loam	SC	A-4	---	20-35	60-80	50-70	30-45	10-40	0-30	NP-10
	41-80	Marly silt, marly silt loam	ML	A-4	0	0	100	100	98-100	85-95	0-25	NP-7
Urban land	---	---	---	---	---	---	---	---	---	---	---	---
12:												
Perrine	0-4	Marly silt loam	CL, CL-ML,	A-4, A-6	0	0	98-100	95-100	95-100	85-95	20-35	4-12
	4-29	Marly silt, marly silt loam	ML	A-4	0	0	98-100	95-100	95-100	85-95	0-25	NP-7
	29-33	Weathered bedrock	---	---	---	---	---	---	---	---	---	---

Engineering Properties

Miami-Dade County Area, Florida

Map symbol and soil name	Depth	USDA texture	Classification		Fragments		Percent passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO	>10 Inches	3-10 Inches	4	10	40	200		
	In				*Pct*	*Pct*					*Pct*	
12:												
Dania, depressional	0-15	Muck	PT	A-8	0	0	100	100	100	100	---	---
	15-19	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
Lauderhill, depressional	0-30	Muck	PT	A-8	0	0	100	100	100	100	---	---
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Tamiami, depressional	0-4	Muck	PT	A-8	0	0	100	100	100	100	---	---
	4-12	Marly silt, marly silt loam	ML	A-4	---	0	100	100	80-100	80-100	0-20	NP-4
	12-31	Muck	PT	A-8	0	0	100	100	100	100	---	---
	31-35	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Udorthents	0-30	Gravelly sand	GP, GP-GM, SP,	A-1-b, A-2-4, A-3	0	10-40	50-80	40-70	30-60	2-12	0-14	NP-7
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
13:												
Biscayne	0-5	Marly silt loam	ML	A-4	---	0	100	100	80-100	80-100	0-20	NP-4
	5-17	Marly silt, marly silt loam	ML	A-4	0	0	98-100	95-100	95-100	85-95	0-20	NP-4
	17-21	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Dania, depressional	0-15	Muck	PT	A-8	0	0	100	100	100	100	---	---
	15-19	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
Hallandale	0-4	Fine sand	SP, SP-SM	A-3	0	0	100	100	90-100	2-6	0-14	NP-7
	4-16	Fine sand, sand	SP, SP-SM	A-2-4, A-3	0	0	100	100	90-100	2-12	0-14	NP-7
	16-20	Weathered bedrock	---	---	---	---	---	---	---	---	---	---

Engineering Properties

Miami-Dade County Area, Florida

Map symbol and soil name	Depth	USDA texture	Classification		Fragments		Percent passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO	>10 Inches	3-10 Inches	4	10	40	200		
	In				*Pct*	*Pct*					*Pct*	
13:												
Lauderhill, depressional	0-30	Muck	PT	A-8	0	0	100	100	100	100	---	---
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Pennsuco	0-4	Marly silt loam	CL, CL-ML,	A-4, A-6	0	0	100	100	98-100	85-95	0-40	NP-19
	4-46	Marly silt, marly silt loam	ML	A-4	0	0	100	100	98-100	85-95	0-14	NP
	46-50	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
Tamiami, depressional	0-4	Muck	PT	A-8	0	0	100	100	100	100	---	---
	4-12	Marly silt, marly silt loam	ML	A-4	---	0	100	100	80-100	80-100	0-20	NP-4
	12-31	Muck	PT	A-8	0	0	100	100	100	100	---	---
	31-35	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
14:												
Dania, depressional	0-15	Muck	PT	A-8	0	0	100	100	100	100	---	---
	15-19	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
Biscayne	0-5	Marly silt loam	ML	A-4	---	0	100	100	80-100	80-100	0-20	NP-4
	5-17	Marly silt, marly silt loam	ML	A-4	0	0	98-100	95-100	95-100	85-95	0-20	NP-4
	17-21	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Udorthents	0-30	Gravelly sand	GP, GP-GM, SP,	A-1-b, A-2-4, A-3	0	10-40	50-80	40-70	30-60	2-12	0-14	NP-7
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
15:												
Urban land	---	---	---	---	---	---	---	---	---	---	---	---

Engineering Properties

Miami-Dade County Area, Florida

Map symbol and soil name	Depth	USDA texture	Classification		Fragments		Percent passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO	>10 Inches	3-10 Inches	4	10	40	200		
	In				*Pct*	*Pct*					*Pct*	
15:												
Udorthents	0-30	Gravelly sand	GP, GP-GM, SP,	A-1-b, A-2-4, A-3	0	10-40	50-80	40-70	30-60	2-12	0-14	NP-7
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
16:												
Biscayne, drained	0-5	Marly silt loam	ML	A-4	---	0	100	100	80-100	80-100	0-20	NP-4
	5-15	Marly silt, marly silt loam	ML	A-4	0	0	98-100	95-100	95-100	85-95	0-20	NP-4
	15-19	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Chekika	0-5	Very gravelly loam	GC, GM	A-1-b, A-2, A-4	---	30-50	40-80	35-45	20-45	20-45	20-25	3-10
	5-9	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Dania, depressional	0-15	Muck	PT	A-8	0	0	100	100	100	100	---	---
	15-19	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
Lauderhill, depressional	0-30	Muck	PT	A-8	0	0	100	100	100	100	---	---
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Pennsuco, drained	0-8	Marly silt loam	CL, CL-ML,	A-4, A-6	0	0	100	100	98-100	85-95	0-40	NP-19
	8-44	Marly silt, marly silt loam	ML	A-4	0	0	100	100	98-100	85-95	0-14	NP
	44-48	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
Rock outcrop	---	---	---	---	---	---	---	---	---	---	---	---

Engineering Properties

Miami-Dade County Area, Florida

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 Inches	Fragments: 3-10 Inches	Percent passing sieve number--: 4	10	40	200	Liquid limit	Plasticit y index
	In				*Pct*	*Pct*					*Pct*	
18:												
Tamiami, depressional	0-4	Muck	PT	A-8	0	0	100	100	100	100	---	---
	4-12	Marly silt, marly silt loam	ML	A-4	---	0	100	100	80-100	80-100	0-20	NP-4
	12-31	Muck	PT	A-8	0	0	100	100	100	100	---	---
	31-35	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Biscayne	0-5	Marly silt loam	ML	A-4	---	0	100	100	80-100	80-100	0-20	NP-4
	5-17	Marly silt, marly silt loam	ML	A-4	0	0	98-100	95-100	95-100	85-95	0-20	NP-4
	17-21	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
20:												
Cardsound	0-4	Silty clay loam	ML	A-4	---	0-5	100	90-100	70-90	70-90	30-40	10-15
	4-8	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Rock outcrop	---	---	---	---	---	---	---	---	---	---	---	---
Matecumbe	0-3	Muck	PT	A-8	0	0	100	100	100	100	---	---
	3-7	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
Udorthents	0-30	Gravelly sand	GP, GP-GM, SP,	A-1-b, A-2-4, A-3	0	10-40	50-80	40-70	30-60	2-12	0-14	NP-7
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
22:												
Opalocka	0-6	Sand	SP, SP-SM	A-3	---	0	100	100	90-100	1-6	0-14	NP
	6-10	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Rock outcrop	---	---	---	---	---	---	---	---	---	---	---	---

Engineering Properties

Miami-Dade County Area, Florida

Map symbol and soil name	Depth	USDA texture	Classification		Fragments		Percent passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO	>10 Inches	3-10 Inches	4	10	40	200		
	In				*Pct*	*Pct*					*Pct*	
22:												
Krome	0-7	Very gravelly loam	GC, GM	A-1-b, A-2-4	---	0-5	40-80	30-45	25-40	5-30	20-25	2-10
	7-11	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
23:												
Chekika	0-5	Very gravelly loam	GC, GM	A-1-b, A-2, A-4	---	30-50	40-80	35-45	20-45	20-45	20-25	3-10
	5-9	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Biscayne, drained	0-7	Gravelly marly silt loam	CL-ML, ML	A-4	---	0-5	60-85	50-75	35-70	35-70	15-25	3-10
	7-11	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Krome	0-7	Very gravelly loam	GC, GM	A-1-b, A-2-4	---	0-5	40-80	30-45	25-40	5-30	20-25	2-10
	7-11	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Matecumbe	0-3	Muck	PT	A-8	0	0	100	100	100	100	---	---
	3-7	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
Opalocka	0-6	Sand	SP, SP-SM	A-3	---	0	100	100	90-100	1-6	0-14	NP
	6-10	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Rock outcrop	---	---	---	---	---	---	---	---	---	---	---	---
24:												
Matecumbe	0-3	Muck	PT	A-8	0	0	100	100	100	100	---	---
	3-7	Weathered bedrock	---	---	---	---	---	---	---	---	---	---

Engineering Properties

Miami-Dade County Area, Florida

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 Inches	Fragments: 3-10 Inches	Percent passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				*Pct*	*Pct*					*Pct*	
24:												
Cardsound	0-4	Silty clay loam	ML	A-4	---	0-5	100	90-100	70-90	70-90	30-40	10-15
	4-8	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Lauderhill, depressional	0-30	Muck	PT	A-8	0	0	100	100	100	100	---	---
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
25:												
Biscayne	0-4	Marly silt loam	ML	A-4	---	0	100	100	80-100	80-100	0-20	NP-4
	4-8	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Rock outcrop	---	---	---	---	---	---	---	---	---	---	---	---
Chekika	0-5	Very gravelly loam	GC, GM	A-1-b, A-2, A-4	---	30-50	40-80	35-45	20-45	20-45	20-25	3-10
	5-9	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Dania, depressional	0-15	Muck	PT	A-8	0	0	100	100	100	100	---	---
	15-19	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
Krome	0-7	Very gravelly loam	GC, GM	A-1-b, A-2-4	---	0-5	40-80	30-45	25-40	5-30	20-25	2-10
	7-11	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
26:												
Perrine, tidal	0-12	Marly silt loam	ML	A-4	---	0	100	100	50-100	50-100	20-35	5-12
	12-26	Marly silt, marly silt loam	ML	A-4	---	0	100	100	80-100	80-100	0-25	NP-7
	26-30	Weathered bedrock	---	---	---	---	---	---	---	---	---	---

Engineering Properties

Miami-Dade County Area, Florida

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 Inches	Fragments: 3-10 Inches	Percent passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				*Pct*	*Pct*					*Pct*	
26:												
Lauderhill, depressional	0-30	Muck	PT	A-8	0	0	100	100	100	100	---	---
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Terra Ceia, tidal	0-80	Muck	PT	A-8	0	0	100	100	100	100	---	---
28:												
Demory	0-7	Sandy clay loam	SC, SC-SM,	A-2-4, A-2-6	0-1	0-5	98-100	98-100	95-100	13-35	15-40	5-15
	7-10	Sandy clay loam, sandy loam	SC, SC-SM,	A-2-4, A-2-6, A-4, A-6	0-1	0-5	98-100	98-100	95-100	25-50	15-40	NP-15
	10-14	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Rock outcrop	---	---	---	---	---	---	---	---	---	---	---	---
Biscayne	0-5	Marly silt loam	ML	A-4	---	0	100	100	80-100	80-100	0-20	NP-4
	5-17	Marly silt, marly silt loam	ML	A-4	0	0	98-100	95-100	95-100	85-95	0-20	NP-4
	17-21	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Chekika	0-5	Very gravelly loam	GC, GM	A-1-b, A-2, A-4	---	30-50	40-80	35-45	20-45	20-45	20-25	3-10
	5-9	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Dania, depressional	0-15	Muck	PT	A-8	0	0	100	100	100	100	---	---
	15-19	Weathered bedrock	---	---	---	---	---	---	---	---	---	---

Engineering Properties

Miami-Dade County Area, Florida

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 Inches	Fragments: 3-10 Inches	Percent passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				*Pct*	*Pct*					*Pct*	
30:												
Pahokee	0-46	Muck	PT	A-8	0	0	100	100	100	100	---	---
	46-50	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Dania, depressional	0-15	Muck	PT	A-8	0	0	100	100	100	100	---	---
	15-19	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
31:												
Pennsuco, tidal	0-12	Marly silt loam	CL, CL-ML,	A-4, A-6	0	0	100	100	98-100	85-95	0-40	NP-15
	12-51	Marly silt loam	ML	A-4	0	0	100	100	98-100	85-95	0-40	NP-15
	51-55	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
Lauderhill, depressional	0-30	Muck	PT	A-8	0	0	100	100	100	100	---	---
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Terra Ceia, tidal	0-80	Muck	PT	A-8	0	0	100	100	100	100	---	---
32:												
Terra Ceia, tidal	0-80	Muck	PT	A-8	0	0	100	100	100	100	---	---
Lauderhill, depressional	0-30	Muck	PT	A-8	0	0	100	100	100	100	---	---
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Pennsuco, tidal	0-12	Marly silt loam	CL, CL-ML,	A-4, A-6	0	0	100	100	98-100	85-95	0-40	NP-15
	12-51	Marly silt loam	ML	A-4	0	0	100	100	98-100	85-95	0-40	NP-15
	51-55	Weathered bedrock	---	---	---	---	---	---	---	---	---	---

Engineering Properties

Miami-Dade County Area, Florida

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 Inches	Fragments: 3-10 Inches	Percent passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				*Pct*	*Pct*					*Pct*	
32:												
Perrine, tidal	0-12	Marly silt loam	ML	A-4	---	0	100	100	50-100	50-100	20-35	5-12
	12-26	Marly silt, marly silt loam	ML	A-4	---	0	100	100	80-100	80-100	0-25	NP-7
	26-30	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
33:												
Plantation	0-14	Muck	PT	A-8	0	0	100	100	100	100	---	---
	14-27	Fine sand, sand	SP	A-3	0	0	100	100	90-100	1-4	0-14	NP-7
	27-30	Gravelly sand, very gravelly fine sand	SP	A-3	0	0-5	70-90	60-80	50-70	1-4	0-14	NP-7
	30-34	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
Lauderhill, depressional	0-30	Muck	PT	A-8	0	0	100	100	100	100	---	---
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Udorthents	0-30	Gravelly sand	GP, GP-GM, SP,	A-1-b, A-2-4, A-3	0	10-40	50-80	40-70	30-60	2-12	0-14	NP-7
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
34:												
Hallandale	0-4	Fine sand	SP, SP-SM	A-3	0	0	100	100	90-100	2-6	0-14	NP-7
	4-16	Fine sand, sand	SP, SP-SM	A-2-4, A-3	0	0	100	100	90-100	2-12	0-14	NP-7
	16-20	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
Plantation	0-14	Muck	PT	A-8	0	0	100	100	100	100	---	---
	14-27	Fine sand, sand	SP	A-3	0	0	100	100	90-100	1-4	0-14	NP-7
	27-30	Gravelly sand, very gravelly fine sand	SP	A-3	0	0-5	70-90	60-80	50-70	1-4	0-14	NP-7
	30-34	Weathered bedrock	---	---	---	---	---	---	---	---	---	---

Engineering Properties

Miami-Dade County Area, Florida

Map symbol and soil name	Depth	USDA texture	Classification		Fragments		Percent passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO	>10 Inches	3-10 Inches	4	10	40	200		
	In				*Pct*	*Pct*					*Pct*	
34: Udorthents	0-30	Gravelly sand	GP, GP-GM, SP,	A-1-b, A-2-4, A-3	0	10-40	50-80	40-70	30-60	2-12	0-14	NP-7
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
35: Margate	0-9	Fine sand	SP, SP-SM	A-3	0	0	100	100	95-100	2-8	0-14	NP-7
	9-18	Fine sand, sand	SP, SP-SM	A-3	0	0	100	100	95-100	2-8	0-14	NP-7
	18-36	Fine sand, sand	SP, SP-SM	A-3	0	0	100	100	95-100	2-8	0-14	NP-7
	36-40	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
Udorthents	0-30	Gravelly sand	GP, GP-GM, SP,	A-1-b, A-2-4, A-3	0	10-40	50-80	40-70	30-60	2-12	0-14	NP-7
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
37: Basinger	0-6	Fine sand	SP	A-3	0	0	100	100	85-100	1-4	0-14	NP-7
	6-30	Fine sand, sand	SP, SP-SM	A-2-4, A-3	0	0	100	100	85-100	2-12	0-14	NP-7
	30-50	Fine sand, sand	SP, SP-SM	A-2-4, A-3	0	0	100	100	85-100	2-12	0-14	NP-7
	50-80	Fine sand, sand	SP, SP-SM	A-2-4, A-3	0	0	100	100	85-100	2-12	0-14	NP-7

Engineering Properties

Miami-Dade County Area, Florida

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 Inches	Fragments: 3-10 Inches	Percent passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				*Pct*	*Pct*					*Pct*	
37:												
Dade	0-6	Fine sand	SP, SP-SM	A-3	0	0	100	100	90-100	1-6	0-14	NP-7
	6-24	Fine sand	SP, SP-SM	A-3	0	0	100	100	90-100	1-6	0-14	NP-7
	24-27	Fine sand, sand	SP, SP-SM	A-3	0	0	100	100	90-100	2-8	0-14	NP-7
	27-31	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
Plantation	0-14	Muck	PT	A-8	0	0	100	100	100	100	---	---
	14-27	Fine sand, sand	SP	A-3	0	0	100	100	90-100	1-4	0-14	NP-7
	27-30	Gravelly sand, very gravelly fine sand	SP	A-3	0	0-5	70-90	60-80	50-70	1-4	0-14	NP-7
	30-34	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
Pomello	0-5	Sand	SP, SP-SM	A-3	0	0	100	100	60-100	1-8	0-14	NP-7
	5-35	Sand	SP, SP-SM	A-3	0	0	100	100	60-100	1-8	0-14	NP-7
	35-76	Coarse sand, fine sand, sand	SM, SP-SM	A-2-4, A-3	0	0	100	100	60-100	6-15	0-14	NP-7
	76-80	Coarse sand, fine sand, sand	SP, SP-SM	A-3	0	0	100	100	60-100	4-10	0-14	NP-7
Udorthents	0-12	Very gravelly loam	SC	A-4	0-6	35-60	50-80	25-50	15-45	15-45	20-30	5-10
	12-41	Gravelly sandy loam	SC	A-4	---	20-35	60-80	50-70	30-45	10-40	0-30	NP-10
	41-80	Marly silt, marly silt loam	ML	A-4	0	0	100	100	98-100	85-95	0-25	NP-7
38:												
Rock outcrop	---	---	---	---	---	---	---	---	---	---	---	---

Engineering Properties

Miami-Dade County Area, Florida

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 Inches	Fragments: 3-10 Inches	Percent passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				*Pct*	*Pct*					*Pct*	
38:												
Vizcaya	0-6	Mucky silt loam	ML, OL	A-4	---	0	100	100	90-100	85-99	20-30	3-10
	6-15	Clay, sandy clay	CL	A-4	---	0	100	100	85-100	65-95	35-50	10-20
	15-19	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Biscayne	0-4	Marly silt loam	ML	A-4	---	0	100	100	80-100	80-100	15-25	3-10
	4-8	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Lauderhill, depressional	0-30	Muck	PT	A-8	0	0	100	100	100	100	---	---
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Pahokee	0-46	Muck	PT	A-8	0	0	100	100	100	100	---	---
	46-50	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Terra Ceia, tidal	0-80	Muck	PT	A-8	0	0	100	100	100	100	---	---
39:												
Beaches	---	---	---	---	---	---	---	---	---	---	---	---
Canaveral	0-4	Sand	SP	A-3	0	0	100	100	90-100	1-4	0-14	NP-7
	4-80	Coarse sand, fine sand, gravelly sand	SP	A-3	0	0	70-100	70-95	65-90	1-3	0-14	NP-7

Engineering Properties

Miami-Dade County Area, Florida

Map symbol and soil name	Depth	USDA texture	Classification		Fragments		Percent passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO	>10 Inches	3-10 Inches	4	10	40	200		
	In				*Pct*	*Pct*					*Pct*	
40:												
Pomello	0-5	Sand	SP, SP-SM	A-3	0	0	100	100	60-100	1-8	0-14	NP-7
	5-35	Sand	SP, SP-SM	A-3	0	0	100	100	60-100	1-8	0-14	NP-7
	35-76	Coarse sand, fine sand, sand	SM, SP-SM	A-2-4, A-3	0	0	100	100	60-100	6-15	0-14	NP-7
	76-80	Coarse sand, fine sand, sand	SP, SP-SM	A-3	0	0	100	100	60-100	4-10	0-14	NP-7
Basinger	0-6	Fine sand	SP	A-3	0	0	100	100	85-100	1-4	0-14	NP-7
	6-30	Fine sand, sand	SP, SP-SM	A-2-4, A-3	0	0	100	100	85-100	2-12	0-14	NP-7
	30-50	Fine sand, sand	SP, SP-SM	A-2-4, A-3	0	0	100	100	85-100	2-12	0-14	NP-7
	50-80	Fine sand, sand	SP, SP-SM	A-2-4, A-3	0	0	100	100	85-100	2-12	0-14	NP-7
41:												
Dade	0-6	Fine sand	SP, SP-SM	A-3	0	0	100	100	90-100	1-6	0-14	NP-7
	6-24	Fine sand	SP, SP-SM	A-3	0	0	100	100	90-100	1-6	0-14	NP-7
	24-27	Fine sand, sand	SP, SP-SM	A-3	0	0	100	100	90-100	2-8	0-14	NP-7
	27-31	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
Pomello	0-5	Sand	SP, SP-SM	A-3	0	0	100	100	60-100	1-8	0-14	NP-7
	5-35	Sand	SP, SP-SM	A-3	0	0	100	100	60-100	1-8	0-14	NP-7
	35-76	Coarse sand, fine sand, sand	SM, SP-SM	A-2-4, A-3	0	0	100	100	60-100	6-15	0-14	NP-7
	76-80	Coarse sand, fine sand, sand	SP, SP-SM	A-3	0	0	100	100	60-100	4-10	0-14	NP-7

Engineering Properties

Miami-Dade County Area, Florida

Map symbol and soil name	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments: >10 Inches	Fragments: 3-10 Inches	Percent passing sieve number--: 4	Percent passing sieve number--: 10	Percent passing sieve number--: 40	Percent passing sieve number--: 200	Liquid limit	Plasticity index
	In				*Pct*	*Pct*					*Pct*	
42:												
Udorthents	0-30	Gravelly sand	GP, GP-GM, SP,	A-1-b, A-2-4, A-3	0	10-40	50-80	40-70	30-60	2-12	0-14	NP-7
	30-34	Unweathered bedrock	---	---	---	---	---	---	---	---	---	---
Urban land	---	---	---	---	---	---	---	---	---	---	---	---
45:												
Canaveral	0-4	Sand	SP	A-3	0	0	100	100	90-100	1-4	0-14	NP-7
	4-80	Coarse sand, fine sand, gravelly sand	SP	A-3	0	0	70-100	70-95	65-90	1-3	0-14	NP-7
Basinger	0-6	Fine sand	SP	A-3	0	0	100	100	85-100	1-4	0-14	NP-7
	6-30	Fine sand, sand	SP, SP-SM	A-2-4, A-3	0	0	100	100	85-100	2-12	0-14	NP-7
	30-50	Fine sand, sand	SP, SP-SM	A-2-4, A-3	0	0	100	100	85-100	2-12	0-14	NP-7
	50-80	Fine sand, sand	SP, SP-SM	A-2-4, A-3	0	0	100	100	85-100	2-12	0-14	NP-7
47:												
St. Augustine	0-3	Sand	SP, SP-SM	A-3	0	0	85-95	80-95	80-90	2-5	0-14	NP-7
	3-51	Fine sand, loamy fine sand, sand	SM, SP-SM	A-2-4, A-3	0	0	85-95	80-95	80-90	5-15	0-14	NP-7
	51-80	Fine sand, loamy fine sand, sand	SM, SP-SM	A-2-4, A-3	0	0	85-95	80-95	80-90	5-15	0-14	NP-7

Engineering Properties

Miami-Dade County Area, Florida

Map symbol and soil name	Depth	USDA texture	Classification		Fragments		Percent passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO	>10 Inches	3-10 Inches	4	10	40	200		
	In				*Pct*	*Pct*					*Pct*	
47:												
Basinger	0-6	Fine sand	SP	A-3	0	0	100	100	85-100	1-4	0-14	NP-7
	6-30	Fine sand, sand	SP, SP-SM	A-2-4, A-3	0	0	100	100	85-100	2-12	0-14	NP-7
	30-50	Fine sand, sand	SP, SP-SM	A-2-4, A-3	0	0	100	100	85-100	2-12	0-14	NP-7
	50-80	Fine sand, sand	SP, SP-SM	A-2-4, A-3	0	0	100	100	85-100	2-12	0-14	NP-7
48:												
Kesson, tidal	0-6	Muck	PT	A-8	0	0	100	100	100	100	---	---
	6-12	Fine sand, sand	SP, SP-SM	A-3	0	0	90-100	90-100	90-100	2-10	0-14	NP-7
	12-33	Fine sand, sand	SP, SP-SM	A-3	0	0	90-100	90-100	90-100	2-10	0-14	NP-7
	33-80	Fine sand, sand	SP, SP-SM	A-3	0	0	70-100	65-95	60-95	2-10	0-14	NP-7
Pennsuco, tidal	0-12	Marly silt loam	CL, CL-ML,	A-4, A-6	0	0	100	100	98-100	85-95	0-40	NP-15
	12-51	Marly silt loam	ML	A-4	0	0	100	100	98-100	85-95	0-40	NP-15
	51-55	Weathered bedrock	---	---	---	---	---	---	---	---	---	---
Udorthents	0-12	Very gravelly loam	SC	A-4	0-6	35-60	50-80	25-50	15-45	15-45	20-30	5-10
	12-41	Gravelly sandy loam	SC	A-4	---	20-35	60-80	50-70	30-45	10-40	0-30	NP-10
	41-80	Marly silt, marly silt loam	ML	A-4	0	0	100	100	98-100	85-95	0-25	NP-7
99:												
Water	---	---	---	---	---	---	---	---	---	---	---	---
100:												
Waters of the Atlantic Ocean	---	---	---	---	---	---	---	---	---	---	---	---