FLORIDA DEPARTMENT OF TRANSPORTATION

FDOT MODIFICATIONS TO LRFD SPECIFICATIONS FOR STRUCTURAL SUPPORTS FOR HIGHWAY SIGNS, LUMINAIRES AND TRAFFIC SIGNALS (LRFDLTS-1)

FDOT STRUCTURES MANUAL
VOLUME 3
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<td>R3-1</td>
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1 INTRODUCTION (Rev. 01/17)

1.1 Scope
Add the following:

Conform to the date specific AASHTO Publications listed in Structures Manual Introduction I.6 References.

For evaluation of existing support structures, including the addition of attachments, the Standard Specification for Structural Supports for Highway Signs, Luminaires and Traffic Signals, 6th Edition, including Appendix C may be used. See FDOT Plans Preparation Manual (PPM), Volume 1 and Section 18 of this Manual for requirements.

2.1 Scope
Add the following:

See Chapters 2, 7 and 29 of the FDOT PPM, Volume 1 regarding the use of FDOT Design Standards and other plans preparation requirements.

C 1.1
Add the following:

Structures Manual Introduction I.6 is updated annually to reflect the specific specifications editions and interims adopted by the FDOT.

For existing supports, FDOT PPM, Volume 1, Section 25.4.26 defines when structural evaluation is necessary and lists FDOT Design Exception and Variation requirements.

C 2.1
Add the following:

The FDOT PPM contains additional FDOT requirements for sign, signal and lighting structures. The FDOT Design Standards contains drawings for all typical sign, signal and lighting structures.

Structures Manual Home
2.4 Functional Requirements

2.4.2 Structural Supports for Signs and Traffic Signals

2.4.2.2 Size, Height and Location of Signs

Add the following:

Span type overhead sign structures in urban locations shall be designed for the actual signs shown on the signing plans and a minimum sign area of 120 sq. ft. (12 ft. W x 10 ft. H) per lane. The minimum sign area applies to lanes without signs and lanes with sign sizes smaller than the minimum. A lane is considered to be without signs when 8 feet or more of the lane is not under a sign. Adjust the sign width when necessary while maintaining a minimum sign area of 120 sq. ft. (e.g. 8 ft. W x 15 ft. H). If the signing plans require signs for only one traffic direction, the minimum sign area per lane requirement applies to the traffic lanes in this direction only.

C 2.4.2.2

Add the following:

Minimum sign areas provide additional capacity for future sign panel installations.

See the FDOT PPM, Volume 1, Introduction for a link to the Urban Area Boundary Maps. See PPM, Volume 1 for cantilever and span overhead sign support location criteria.

Cantilever type overhead sign structures in urban locations shall be designed either for the actual signs shown on the signing plans or for a minimum sign area of 80 sq. ft. (8 ft. W x 10 ft. H) located at the end of the cantilever, whichever provides the larger load or stress at the location under consideration.

Figures 1 and 2 show how to apply the above minimum sign areas for span type overhead sign structures in urban locations.

Overhead signs in rural locations should be designed for the actual sign shown on the signing plans.
2.4.2.4 Changeable (Variable) Message Signs

Add the following:

For all overhead Variable Message Sign (VMS) structures, the horizontal member shall consist of a truss with a minimum of two chords with a minimum center-to-center distance between the chords of 3'-0". See FDOT section 11.8 for VMS maximum span-to-depth ratios.

FDOT vertical clearance requirements for walk-in VMS structures are found in PPM, Volume 1, Chapter 2.

2.4.2.5 Horizontal Span and Cantilever Limits

New Section, add the following:

See PPM, Volume 1, Section 29.1 for sign and signal support structure limits.

C 2.4.2.4

Add the following:

The minimum requirements given provide additional measures to limit the possibility of galloping.

Since cantilever walk-in overhead Variable Message Sign (VMS) structures are more susceptible to fatigue than span overhead VMS structures, span structures should be used whenever possible.

In Florida, changeable or variable message sign structures are typically referred to as Dynamic Message Sign (DMS) structures.
3 LOADS

3.8 Wind Load

Delete Table 3.8.1 and replace it with the following:

<table>
<thead>
<tr>
<th>Structure Type</th>
<th>Interval (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Overhead sign structures</td>
<td></td>
</tr>
<tr>
<td>• Luminaire support structures &gt;50' in height.</td>
<td></td>
</tr>
<tr>
<td>• Mast Arm Signal Structures</td>
<td></td>
</tr>
<tr>
<td>• Monotubes</td>
<td></td>
</tr>
<tr>
<td>• Steel Strain Poles</td>
<td>700</td>
</tr>
<tr>
<td>• ITS Camera Poles &gt;50' in height</td>
<td></td>
</tr>
<tr>
<td>• Luminaire supports and other structures ≤ 50' in height</td>
<td>300</td>
</tr>
<tr>
<td>• Concrete Strain Poles</td>
<td></td>
</tr>
<tr>
<td>• Roadside sign structures</td>
<td>10</td>
</tr>
</tbody>
</table>

3.8.2 Basic Wind Speed

Delete the entire paragraph including Figures 3.8.-1, 3.8-2, 3.8-3 and 3.8-4 and add the following:

For the 700 year Extreme Event Limit State, use the wind speeds (mph) shown in FDOT SDG Table 2.4.1-1

For the 300 year Extreme Event Limit State, use the wind speeds (mph) shown in FDOT SDG Table 2.4.1-1 minus 10 mph.

For the 10 year Extreme Event Limit State, use a design wind speed of 110 mph for the entire state.

For the Service Limit State, use a design wind speed of 90 mph for the entire state.

For temporary signs, luminaires and traffic signals, for both the Extreme Event and Service Limit States, use a design wind speed of 80 mph for the entire state.

C 3.8

FDOT continues the past practice of determining wind speeds based on structure type.

C 3.8.2

Add the following:

FDOT SDG Table 2.4.1-1 was derived from the ASCE 7-10 wind speed map.

To simplify the design process, FDOT has designated one wind speed per county for the 700 year and 300 year Extreme Event Limit States. To maintain consistency with past practice, a 110 mph design wind speed was chosen for the 10 year Extreme Event Limit State, and an 80 mph design wind speed was chosen for temporary sign supports.
### 3.8.7 Drag Coefficients $C_d$

Add the following to Table 3.8.7-1:

<table>
<thead>
<tr>
<th>Item</th>
<th>Projected Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>12&quot; Signal Section</td>
<td>1.36 sf</td>
</tr>
<tr>
<td>3 Section 6&quot; wide Backplate</td>
<td>5.67 sf</td>
</tr>
<tr>
<td>4 Section 6&quot; wide Backplate</td>
<td>6.83 sf</td>
</tr>
<tr>
<td>5 Section 6&quot; wide Backplate</td>
<td>8.00 sf</td>
</tr>
</tbody>
</table>

A drag coefficient for traffic signal installed with the ability to swing has been established through research (Cook 2007).

The coefficients given for solar panels are approximately the same as the ones given in ASCE 7-10, Figure 27.4-4 for inclined monosloped roofs. See simplified illustration in FDOT Figure 3.8.6.

### FDOT Figure 3.8.7-1 Drag Coefficients for Solar Panels

### 3.9 Design Wind Loads On Structures

#### 3.9.1 Load Application

Add the following:

Use the following areas for traffic signals:

Areas given are for standard signals in Florida. For example, the total area for a 3 head signal with backplate is equal to:

$$(3 	imes 1.36 	ext{ sf}) + 5.67 	ext{ sf} = 9.75 	ext{ sf}$$
3.10 References

Add the following:

5 STEEL DESIGN

5.4 Material

Replace 5.4 with the following:
Use the materials specified in the following documents:
• FDOT Structures Manual
• FDOT Construction Specifications
• FDOT Design Standards

Do not specify ASTM A588 (rustic, Corten, "self-oxidizing", or "self-weathering") steel in sign, signal, or lighting structures.

5.6 General Dimensions and Details

5.6.3 Transverse Plate Thickness

Add the following:
The minimum base plate thickness shall be 2½ inches for mast arm signal structures, steel ITS poles, and steel strain poles, and 3 inches for high mast light poles.

For base plate connections without stiffeners on 700 year recurrence interval structures, only use full-penetration groove welds.

5.13 Cables And Connections

Add the following:
Use the cable breaking strength values specified in FDOT Specifications Section 634.

Use \( \phi_{rt} = 0.6 \)

C 5.4

Add the following:
In some environmental conditions in Florida, A588 steel has deteriorated significantly.

C 5.6.3

Add the following:
Research has proven full-penetration groove welds combined with thicker base plates increases the pole-to-base-plate connection fatigue strength.

C 5.13

Add the following:
Cables used in the construction of spanwire pole structures are listed in FDOT Specifications Section 634.
5.14 Welded Connections

Add the following:

On steel sign, lighting, and signal support structures, no circumferential welds are permitted on the uprights, arms or chords with the following exceptions:

- The upright to base plate weld
- The flange plate connection weld on tubular truss chords
- Mitered arm-to-upright angle welds on monotubes
- Uprights with lengths greater than available mill lengths.

5.15 Bolted Connections

Add the following:

Design all pole to arm connections on Mast Arm structures as "through bolted" using a minimum of six bolts.

5.16 Anchor Bolt Connections

Add the following:

All sign, signal, and lighting structures designed for a 700 year mean recurrence interval wind speed shall use a minimum of eight ASTM F1554 Grade 55 anchor bolts at the pole to foundation connection, with the exception of Mast Arm signal structures, where the minimum is six anchor bolts.

5.16.1 Anchor Bolt Types

Delete anchor bolts types listed in the second and third bullet and add the following:

Both Adhesive anchors and threaded post-tensioning bars are not permitted.

C 5.14

Add the following:

The Department’s intent is to avoid any unnecessary welds on sign, signal or lighting structures.

Typical mill lengths for pipes and tubes are 35 feet and greater.

C 5.15

Add the following:

Tapped connections are not permitted. Through bolted connections allow for fully tensioned F3125 bolts.

C 5.16

Add the following:

A minimum of eight anchor bolts provides redundancy and better distribution of forces through the base plate.

C 5.16.1

Add the following:

FDOT only allows straight headed anchor bolts.

Adhesive anchor and threaded post-tensioning bars have undesirable creep and non-ductile behavior respectively.
5.16.2 Anchor Bolt Materials

Add the following:

Only use ASTM F 1554 anchor bolts with 55 ksi yield strength.

5.16.3 Design Basis

Add the following:

Use double-nut moment joints in all mast arm signal structures, steel strain poles, high mast light poles and overhead sign structures.

If the clear distance between the bottom of the bottom leveling nut and the top of concrete is equal to or less than the nominal anchor bolt diameter, bending of the anchor bolt from shear and torsion may be ignored. If the clear distance exceeds one bolt diameter, bending in the anchor bolt shall be considered.

On mast arm signal structures and cantilever overhead sign structures, a structural grout pad is required under the base plates in double-nut moment joints.

Grout pads are not required under the base plates in double-nut moment joints of span overhead sign structures, high mast light poles, and steel strain poles.

5.19 References

Add the following:

6 ALUMINUM DESIGN

6.1 Scope
Add the following:

Do not specify aluminum overhead sign structure supports with the exception of the vertical sign panel hangers, which may be aluminum or steel.

6.4 Material and Material Properties
Add the following:

Use the materials specified in the following documents:
- FDOT Structures Manual
- FDOT Construction Specifications
- FDOT Design Standards

7 PRESTRESSED CONCRETE DESIGN

7.4 Materials

7.4.2 Normal and Lightweight Concrete

7.4.2.1 General
Replace 7.4.2.1 with the following:

Use the materials specified in the following documents:
- FDOT Structures Manual
- FDOT Construction Specifications
- FDOT Design Standards

For Standard Prestressed Concrete Pole Design, the minimum compressive concrete strength shall be 6 ksi.
7.4.3 Reinforcing Steel

7.4.3.1 General

Replace 7.4.3.1 with the following:
Use the materials specified in the following documents:
• FDOT Structures Manual
• FDOT Construction Specifications
• FDOT Design Standards

7.4.4 Prestressing Steel

7.4.4.1 General

Replace 7.4.4.1 with the following:
Use the materials specified in the following documents:
• FDOT Structures Manual
• FDOT Construction Specifications
• FDOT Design Standards

7.6 Design

Add the following:
The minimum clear concrete cover for all prestressed and non-prestressed poles is 1 inch.

7.6.1 General

Add the following:
For Standard Prestressed Concrete Pole Design, see Instructions for Design Standards Index 17725, for the Moment Capacities for the Extreme Event and Service Limit States.

C 7.6

Add the following:
FDOT requires a minimum 1 inch cover on all concrete poles in all environments.

C 7.6.1

Add the following:
FDOT uses Standard Prestressed Concrete Poles in accordance with Index 17725 and Specifications Section 641. After analysis of the proposed span-wire pole structure, the Designer selects the appropriate pole using the design moment values given in the Instructions for Design Standards for Index 17725.
10 SERVICEABILITY REQUIREMENTS

10.5 Camber

Replace this section with the following:

Provide a design camber equal to 2.5 times the dead load deflection for overhead sign structures. For span overhead sign structures, arch the horizontal member upwards and for cantilever overhead sign structures rake the vertical support backwards. For mast arm signal structures, provide a two degree upward angle at the arm/upright connection.

11 FATIGUE DESIGN

11.6 Fatigue Importance Factors

Add the following:

When evaluating galloping, use Fatigue Category II for all flat panel sign, traffic signal, and lighting support structures meeting the limits in FDOT 2.4.2.5 and designed in accordance with the current LTS specifications. Use Fatigue Category I for all other sign, traffic signal, and lighting support structure designs including all VMS support structures.

C 10.5

Add the following:

Design camber = Permanent camber + dead load deflection. Permanent camber equal to 1.5 times the dead load deflection provides for a better appearance than the relatively small L/1000 given in AASHTO. For mast arms, a two degree upward angle at the arm/upright connection is standard industry practice.

C 11.6

Add the following:

Sign, signal and lighting structures built using FDOT Design Standards have performed well over time.
11.7 Fatigue Design Loads

11.7.1 Sign and Traffic Signal Structures

11.7.1.1 Galloping

Replace the 2nd, 3rd and 4th paragraphs with the following:

Vibration Mitigation devices are not allowed in lieu of designing for galloping.

Mast arms designed for flat panel signs only, require the installation of FDOT Developmental Design Standard D17749, Damping Device for Miscellaneous Structures.

Exclude galloping loads for the fatigue design of overhead cantilevered sign and VMS support structures with three or four chord horizontal trusses with bolted web to chord connections.

11.8 Deflection

Add the following:

In addition, VMS structures shall also meet the following maximum span-to-depth ratios:

<table>
<thead>
<tr>
<th>VMS Structure Type</th>
<th>Max. Span-to-Depth Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overhead Span Structure</td>
<td>25</td>
</tr>
<tr>
<td>Overhead Cantilever Structure</td>
<td>9</td>
</tr>
</tbody>
</table>

13 FOUNDATION DESIGN

13.6 Drilled Shafts

Add the following:

Drilled shafts are the standard foundation type on high mast light poles, overhead signs, mast arms and steel strain poles.
13.6.1 Geotechnical Design

13.6.1.1 Embedment

Add the following:

For overturning resistance, use the following $\phi$ factors:

<table>
<thead>
<tr>
<th>MRI Winds (yrs)</th>
<th>$\phi$</th>
</tr>
</thead>
<tbody>
<tr>
<td>700</td>
<td>0.6</td>
</tr>
<tr>
<td>300</td>
<td>0.6</td>
</tr>
<tr>
<td>10</td>
<td>0.8</td>
</tr>
</tbody>
</table>

For torsion resistance in drilled shafts supporting Mast Arm signal and cantilever overhead sign structures, use the following equations:

$$ T_u \leq \phi_{tor} \cdot T_n $$

Where

- $T_n = \pi D L F_s \left(\frac{D}{2}\right)$
- $F_s = \sigma_v \Omega_{f\dot{}}$
- $\sigma_v = \gamma_{soil} \left(\frac{L}{2}\right)$
- $T_u =$ Torsion force on the drilled shaft
- $T_n =$ Nominal torsion resistance of the drilled shaft
- $\phi_{tor} =$ $\phi$ Factor against torsion
  - $= 1.0$ for Mast Arm signal structures
  - $= 0.90$ for overhead cantilever sign structures
- $D =$ diameter of the drilled shaft
- $L =$ length of the drilled shaft
- $F_s =$ unit skin friction
- $\sigma_v =$ effective vertical stress at mid-layer
- $\Omega_{f\dot{}} =$ load transfer ratio where the allowable shaft rotation may exceed 10 degrees
  - $= 1.5$ for granular soils where uncorrected SPT N-values are 15 or greater
  - $= 1.5 \left(\frac{N-value}{15}\right)$ for uncorrected N-values greater than or equal to 5 and less than 15.
- $\gamma_{soil} =$ unit weight of soil

C 13.6.1.1

Add the following:

Since sign, lighting and signal foundations have performed well in Florida, *LRFD* $\phi$ factors have been calibrated to allowable stress design.

The torsion resistance equation is based on the theory for the Beta Method (O'Neill and Reese, 1999). The torsional resistance from the bottom face of the shaft is omitted to increase the conservatism in this approximate calculation. A single $\Omega_{f\dot{}}$ factor of 1.5 is used to adjust for the concurrent overturning and torsional forces and to compare with past FDOT practice. Since the consequence of a torsion soil-structure failure is usually small, some rotation may occur from the design wind.

Since cantilever overhead sign structures can have significantly more torsion than a Mast Arm, a higher safety factor of 1.3 is appropriate. In *LRFD*, with higher loading, this equates to a $\phi$ factor $= 0.90$.

For soils with SPT N-values less than 5, consult the Geotechnical Engineer for additional recommendations.
13.6.2 Structural Design
Add the following:
Longitudinally reinforce drilled shaft foundations with a minimum of 1% steel. At a minimum, place #5 stirrups at 4 inch spacing in the top two feet of shaft. In cantilever structures, design for shear resulting from the torsion loading on the anchor bolt group.

C 13.6.2
Add the following:
Using 1% steel is conservative for flexural design in most cases. Additional stirrups in the top of the shaft provides resistance against shear failure in the top of the shaft. Due to torsion, additional stirrups may be required in cantilever structures.

13.6.2.1 Details
Replace the second sentence with the following:
A minimum concrete cover of six inches over steel reinforcement is required.

Add the following:
The minimum design diameter for drilled shafts is 3 feet and the maximum design diameter is 6 feet. A minimum reinforcement clear spacing of six inches is required for proper concrete consolidation. The top five feet of stirrups in drilled shafts for sign, signal and lighting structures are exempt from this spacing requirement.

C 13.6.2.1
Add the following:
FDOT requires six inches of cover to ensure durability in drilled shafts.

The concrete in drilled shafts with design diameters greater than 6 feet is considered mass concrete, therefore shafts of this size should be avoided.

Concrete consolidation below the anchor bolts becomes more difficult with reinforcement clear spacing less than six inches. Larger shaft diameters should be considered to increase reinforcement spacing.

Modification for Non-Conventional Projects:
Delete FDOT 13.6.2.1 and insert the following:
Replace the second sentence with the following:
A minimum concrete cover of six inches over steel reinforcement is required.

Add the following:
A mass concrete placement plan is required for drilled shafts with design diameters greater than 6 feet. A minimum reinforcement clear spacing of six inches is required for proper concrete consolidation. The top five feet of stirrups in drilled shafts for sign, signal and lighting structures are exempt from this spacing requirement.

13.7 Spread Footings
13.7.1 Geotechnical Design
Add the following:
For overturning resistance, use $\phi = 0.6$. 
13.10 References

Add the following:


14 FABRICATION, MATERIALS, AND DETAILING

*Replace this section with the following:*

See the FDOT Construction Specifications and FDOT Materials Manual.

15 CONSTRUCTION

*Replace this section with the following:*

See the FDOT Construction Specifications and FDOT Materials Manual.

18 EVALUATION OF EXISTING STRUCTURAL SUPPORTS FOR HIGHWAY SIGNS, LUMINAIRES AND TRAFFIC SIGNALS

*Add new Section 18 as titled above and include the following:*

18.1 General

See *PPM* Section 25.4.26 for requirements for evaluating existing highway signs, luminaires and traffic signals.

A Design Variation/Exception is not required for any of the following existing details:

- mast arm to upright connections with 4 bolts (FDOT 5.15)
- tapped mast arm connections (FDOT 5.15)
- fillet welded tube-to-transverse plate connections (FDOT 5.14)
• mast arm upright anchorages with 4 bolts (FDOT 5.16)
• transverse plate thickness (FDOT 5.6.3)
  ◦ mast arm horizontal and upright 1.5 inches and greater
  ◦ high mast light pole and steel strain pole 2.0 inches and greater

All items listed above should be checked in situations where there is evidence of distress or instability, or where the Engineer has reason to believe the structural capacity is in doubt.

18.2 Analytical Evaluation Without Proposed Additional Loading

When using PPM Section 25.4.26.1, Analytical Evaluation Without Proposed Additional Loading, the evaluation is allowed using any of the following design specifications:

• LTS LRFD as modified in this Volume.
• LTS 6th edition without Appendix C and the wind speeds defined in FDOT Table 18.3-1.
• LTS 6th edition with Appendix C as modified in this section, and the wind speeds defined in FDOT Table 18.2-1

When using LTS 6th edition with Appendix C, the following assumptions are allowed:

• an allowable overstress factor (LTS 3.4) of 1.4 for Group II loading is allowed.
• FDOT minimum sign areas (FDOT 2.4.2.2) are not required.
• fatigue evaluation (LTS Section 11) is not required.
• foundation evaluation (LTS Section 13), structural and geotechnical, is not required.

C 18.2

By allowing an overstress factor of 1.4, consistent with previous editions of LTS, properly designed existing structures will be allowed to remain in place in accordance with the PPM.

To simplify the design process, FDOT has designated one wind speed per county.
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18.3 Analytical Evaluation With Proposed Additional Loading

When using PPM Section 25.4.26.2, Analytical Evaluation With Proposed Additional Loading, the evaluation is allowed using either of the following design specifications:

- LTS LRFD as modified in this Volume.
- LTS 6th edition without Appendix C and the wind speeds defined in FDOT Table 18.3-1.

FDOT Table 18.3-1 Basic Wind Speed, V

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C 18.3
To simplify the design process, FDOT has designated one wind speed per county.
VOLUME 3 - REVISION HISTORY

1...............Revised Volume 3 extensively throughout to coordinate with the new LRFDLTS-1.