Florida’s 2004 Hurricane Season

Structural Impacts on the FDOT System
Hurricane Wind Speed versus Design Wind Speed
Wind Speeds

- **Sustained Wind Speed**
  - 60 second measurement duration
  - National Weather Service

- **Fastest Mile**
  - measurement duration varies
  - 1994 AASHTO

- **Gust Wind Speed**
  - 3 second measurement duration
  - National Weather Service and 2001 AASHTO
Maps from NOAA

www.aoml.noaa.gov/hrd/data_sub/wind.html
Charley

- Sustained Winds - 110/120 mph (map)
Frances

- Sustained Winds – 80 (map)
Ivan

- Sustained Winds - 90 mph (map)
Jeanne

- Sustained Winds - 85 mph (map)
Andrew

- Sustained Winds - 150 mph (map)
Sustained Wind Speeds

Charley  120 mph  
Frances  80 mph  
Ivan  90 mph  
Jeanne  85 mph

\[
\begin{bmatrix}
120 \\
80 \\
90 \\
85 \\
\end{bmatrix}
\rightarrow
\begin{bmatrix}
128.5 \\
82.1 \\
93.5 \\
87.8 \\
\end{bmatrix}
\text{mph}
\]

\[
\begin{bmatrix}
120 \\
80 \\
90 \\
85 \\
\end{bmatrix}
\rightarrow
\begin{bmatrix}
145.9 \\
97.3 \\
109.4 \\
103.4 \\
\end{bmatrix}
\text{mph}
\]
## Actual Winds vs. Design Winds

<table>
<thead>
<tr>
<th>Hurricane</th>
<th>Wind</th>
<th>County</th>
<th>10 year</th>
<th>25 year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charley</td>
<td>128 mph</td>
<td>Charlotte</td>
<td>80 mph</td>
<td>90 mph</td>
</tr>
<tr>
<td>Frances</td>
<td>84 mph</td>
<td>Brevard</td>
<td>80 mph</td>
<td>90 mph</td>
</tr>
<tr>
<td>Ivan</td>
<td>94 mph</td>
<td>Escambia</td>
<td>60 mph</td>
<td>90 mph</td>
</tr>
<tr>
<td>Jeanne</td>
<td>88 mph</td>
<td>Martin</td>
<td>80 mph</td>
<td>90 mph</td>
</tr>
</tbody>
</table>
1994 AASHTO – Fastest Mile
2001 AASHTO – 3 Sec Gust

67(150) 63(140)

150°
District 1 Traffic Signals & Supports

Considerable Damage to Traffic Signal Hangers, Disconnect Boxes, Clamps.

Some Damage to Strain Wires (connections).
## Mast Arm & Span Wire Inventory

<table>
<thead>
<tr>
<th>District No.</th>
<th>No. Signals</th>
<th>No. Masts</th>
<th>Masts Damage</th>
<th>No. Wires</th>
<th>Other Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,778</td>
<td>802</td>
<td>2</td>
<td>976</td>
<td>496</td>
</tr>
<tr>
<td>2</td>
<td>1,585</td>
<td>537</td>
<td>0</td>
<td>1,048</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>987</td>
<td>300</td>
<td>2</td>
<td>687</td>
<td>265</td>
</tr>
<tr>
<td>4</td>
<td>3,329</td>
<td>1,180</td>
<td>14</td>
<td>2,149</td>
<td>735</td>
</tr>
<tr>
<td>5</td>
<td>2,972</td>
<td>458</td>
<td>2</td>
<td>2,514</td>
<td>1,885</td>
</tr>
<tr>
<td>6</td>
<td>2,640</td>
<td>1,848</td>
<td>0</td>
<td>660*</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>2,151</td>
<td>518</td>
<td>0</td>
<td>1,633</td>
<td>102</td>
</tr>
<tr>
<td>Sum</td>
<td>15,442</td>
<td>5,643</td>
<td>20</td>
<td>9,667</td>
<td>3,523</td>
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</tbody>
</table>
Component Failures: Hangers
Component Failures: Disconnect Boxes
District 4 Mast Arm Failures

14 Failures

• All pre-standard structures.
• 3 base failures
• 4 anchor bolt failures
• 7 pole @ flange failures
Structural Successes

New Mast Arm - Punta Gorda

Strain Poles – Punta Gorda
I-10 over Escambia Bay

Escambia Bay on 9/16/2004
I-10 over Escambia Bay

Bridge Looking from West Bank
I-10 over Escambia Bay

Bridge Looking from East Bank
I-10 over Escambia Bay

60’ Trestle Spans Missing: 46 EB & 12 WB
I-10 over Escambia Bay

One Known Fatality
I-10 over Escambia Bay

Misaligned Spans: 50 EB & 16 WB
I-10 over Escambia Bay

Hold-Down Bolts Sheared
I-10 over Escambia Bay

Hold-Down Bolts & Embedded Studs Sheared
I-10 over Escambia Bay

I-10 OVER ESCAMBIA BAY
HURRICANE IVAN 9/16/04

16 11:57 AM

56

I-10 OVER ESCAMBIA BAY
HURRICANE IVAN 9/16/04

17 12:34 PM

I-10 over Escambia Bay
Hurricane Ivan 9/15/04

17 12:34 PM

I-10 OVER ESCAMBIA BAY
HURRICANE IVAN 9/16/04

18 11:35 AM

63

I-10 OVER ESCAMBIA BAY
HURRICANE IVAN 9/16/04

18 11:37 AM

54

I-10 OVER ESCAMBIA BAY
HURRICANE IVAN 9/16/04

18 11:47 PM

54

DTOE, January 27, 2005
I-10 over Escambia Bay

East Abutment of EB Bridge
I-10 over Escambia Bay

East Abutment of WB Bridge
Regional Peak Surge Elevations

Gulf of Mexico

Hurricane Ivan Peak Elevations
- Mobile Tide Gage
- USGS Gage
- Inside HWM
- Outside HWM
1. The Lifting

Storm surge rose to 14 to 16 feet above sea level beneath the bridge decks, where beams captured air beneath them, increasing the upward force to 900,000 pounds.
2. The Pounding

At the same time, waves of 13 feet atop the surge hit the sides of the bridge decks with 700,000 pounds of force every 6.5 seconds at the height of the storm.
3. The Breaking

The water's lifting and pounding broke the connections between 150-foot-deep pilings and piers supporting the bridge decks, allowing the decks to slide sideways or fall into the water.
Other Bridges

Jensen Beach Causeway – Under Construction
East Relief Bridge

Hurricane Francis
Hurricane Jeanne
Other Bridges

Jensen Beach Causeway – Under Construction
Fishing Pier (under Main Bridge)

Hurricane Francis

Hurricane Jeanne

Two spans lost – 14” piles shattered
Other Bridges

Jensen Beach Causeway – Under Construction
Existing Bascule Bridge

Hurricane Jeanne

Existing fishing pier – lost X spans

Hurricane Jeanne

Existing bridge closed for good – New bridge to open in 3 weeks

DTOE, January 27, 2005
Other Bridges

Typical Slope failures around end bents at three bridges

E. Lyons Bridge
Lake Worth Bridge
Roosevelt Bascule Bridge
EAST RELIEF BRIDGE

PILE DATA TABLE

<table>
<thead>
<tr>
<th>INSTALLATION CRITERIA</th>
<th>DESIGN CRITERIA</th>
<th>PILE CUT-OFF ELEVATIONS</th>
<th>** STATE PLANE COORDINATE &amp; STATIONS</th>
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</thead>
<tbody>
<tr>
<td>BENT</td>
<td>PILE SIZE</td>
<td>ULTIMATE DEGRADING LOAD</td>
<td>TENSION CAPACITY</td>
</tr>
<tr>
<td></td>
<td>(kN)</td>
<td>(kN)</td>
<td>(kN)</td>
</tr>
<tr>
<td>Ext Bent No.1</td>
<td>60</td>
<td>2000</td>
<td>M/A -0.2</td>
</tr>
<tr>
<td>Ext Bent No.2</td>
<td>60</td>
<td>2000</td>
<td>M/A -0.2</td>
</tr>
<tr>
<td>Ext Bent No.3</td>
<td>60</td>
<td>2000</td>
<td>M/A -0.2</td>
</tr>
<tr>
<td>Ext Bent No.4</td>
<td>60</td>
<td>2000</td>
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</tr>
<tr>
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<td>2000</td>
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<tr>
<td>Ext Bent No.6</td>
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<td>2000</td>
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<tr>
<td>Ext Bent No.7</td>
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</tr>
<tr>
<td>Ext Bent No.8</td>
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<td>2000</td>
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<td>Ext Bent No.9</td>
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<td>2000</td>
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</tr>
<tr>
<td>Ext Bent No.10</td>
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<td>2000</td>
<td>M/A -0.2</td>
</tr>
<tr>
<td>Ext Bent No.11</td>
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<td>2000</td>
<td>M/A -0.2</td>
</tr>
<tr>
<td>Ext Bent No.12</td>
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<td>2000</td>
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</tr>
<tr>
<td>Ext Bent No.13</td>
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<td>2000</td>
<td>M/A -0.2</td>
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<tr>
<td>Ext Bent No.14</td>
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<td>Ext Bent No.15</td>
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<tr>
<td>Ext Bent No.16</td>
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<td>2000</td>
<td>M/A -0.2</td>
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<tr>
<td>Ext Bent No.17</td>
<td>60</td>
<td>3000</td>
<td>M/A -0.2</td>
</tr>
</tbody>
</table>

DTOE, January 27, 2005
Main Bridge Scour

DTOE, January 27, 2005
Multi-Post Ground Signs
Multi-Post Ground Sign
I-75 Cantilever Signs Structure
I-4 Cantilever Sign Structure

- Hurricane Jeanne
- Location I-4 near John Young Parkway
- Rush Hour 3:00 pm
- Damage to foundation identified by inspector and structure removed
I-95 Cantilever Sign Structure

DTOE, January 27, 2005
19 High Mast Lights Failed in District 1
2 High Mast Lights Failed in District 4

Following Charley, Policy Issued to Lower Lights when Category 2 or Higher Threaten.
164 of 1,559 (10%) Poles Damaged on 4 District 4 Projects.

Damage: Frangible aluminum bases, support arms, light fixtures (connections).
Lighting Structures

PGA – West Palm Beach

55 failures out of 186 lights

DTOE, January 27, 2005
Other Bridges - Erosion