DEVELOPMENT OF HURRICANE RESISTANT TRAFFIC SIGNAL SUPPORT SYSTEM

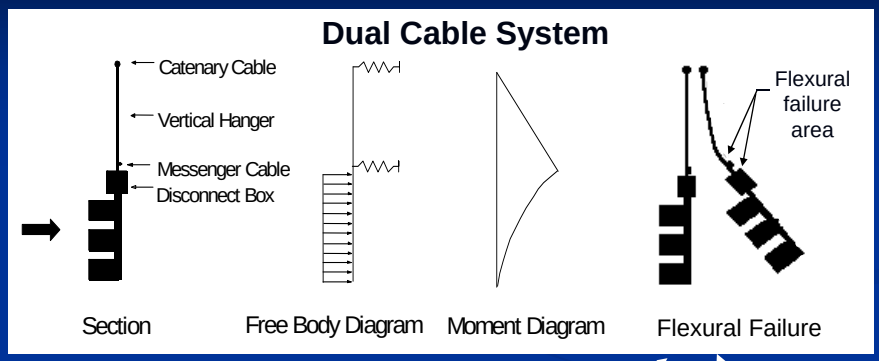
Florida Department of Transportation
University of Florida

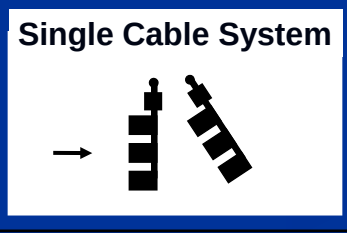
Principle Investigator: Ronald A. Cook, Ph.D., P.E.
Graduate Research Assistant: Eric Johnson
Project Manager: Marcus H. Ansley, P.E.

Background

- Hurricane Andrew caused widespread damage to traffic signals and sparked interest in signal support systems.
- UF/FDOT work in the mid-1990's:
  - a structural analysis/design program for the dual cable system (ATLAS)
  - a test method for hangers and disconnect boxes to be used with the dual cable support system.
- The current project is to compare the structural behavior of the dual-cable support system and the single cable support system

Dual & Single Cable Systems





Testing of Dual and Single-Cable Signal Support Systems

- Full-scale wind tests were conducted using the Wall of Wind, provided by the International Hurricane Research Center at Florida International University.
- The maximum wind speed applied during the tests was 115 mph, this represents a Category 3 hurricane.
- The wind speed was gradually increased to a maximum of 115 mph during a 2 ½ minute period

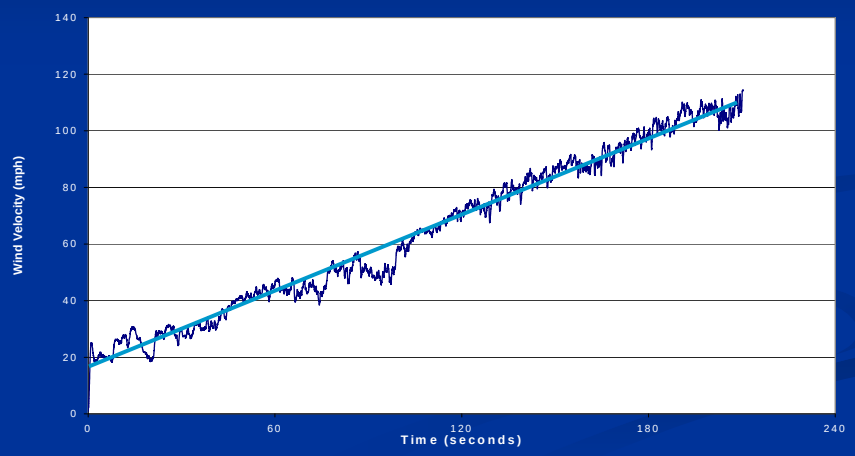
Testing of Signal Support Systems

FIU Wall of Wind

Testing of Signal Support Systems

Testing of Signal Support Systems

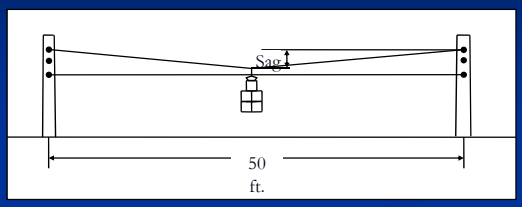
Wind Loading During Tests



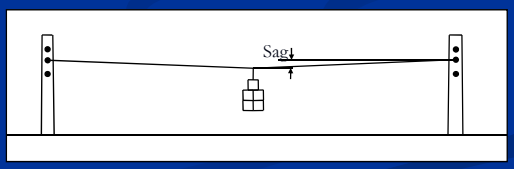
Testing of Signal Support Systems

- The dual cable system in widespread use was tested.
- Single cable systems were tested for comparison.
- The catenary cable sag tested included 5% for the dual-cable system and both 5% and 2% sag for the single cable system

Dual Cable Setup



Single Cable Setup



Testing of Signal Support Systems

Test Setup:

- 3/8” guy wire was used for both the catenary and messenger cable to preclude failure of the messenger cable during the tests.
- Five-section signal heads were determined best for testing because they have a greater surface area and would experience greater wind force.

Testing of Signal Support Systems

Test Setup:

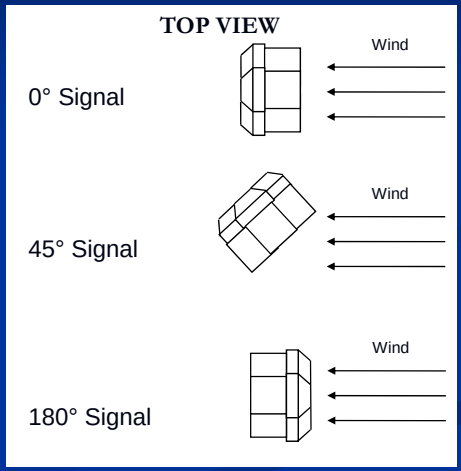
- Adjustable aluminum hangers were used in tests of the dual-cable system
- For single-cable systems, 2 alternatives were tested:
  1) Drop pipe signal hanger of 40” in length
  2) A direct connection to the catenary cable via a gooseneck connector

Testing of Signal Support Systems

Test Setup:

- For single-cable alternatives, further variations were considered:

1) The signal heads were rotated to face the wind directly, at a 45° angle, and backwards
2) Additional weights were added to analyze the effect of signal weight



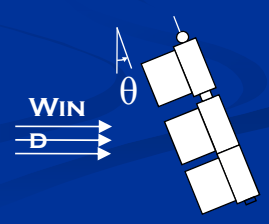
Testing of Signal Support Systems

The most important data that was obtained from these tests:

- Signal rotation
- Cable tension
- Moment at the base of the concrete poles

Test Results – Signal Rotation

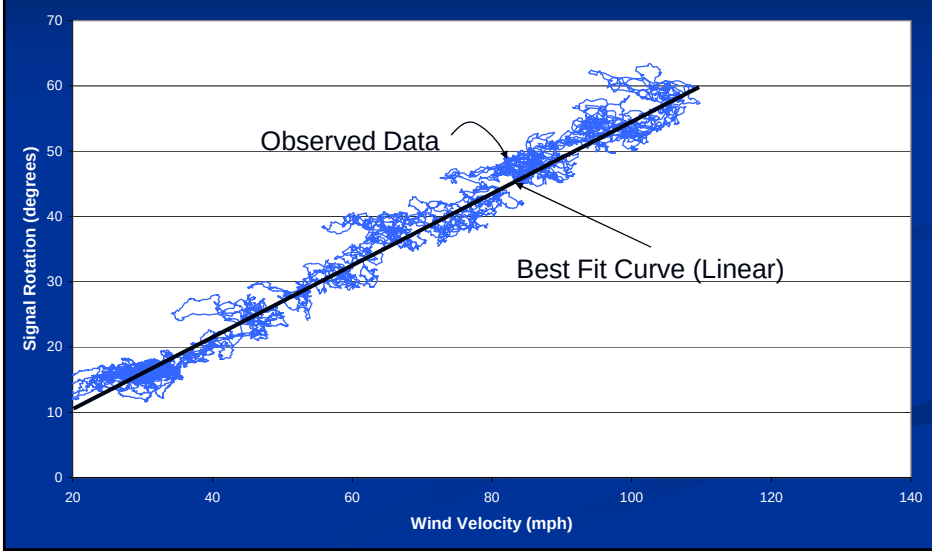
- Signal rotation was the primary concern for signal visibility
- The following graphs depict how the signal rotated during the tests
- Visible signals were defined as ones in which at least half of the bulb is visible to drivers.
- For 12” bulbs, the limiting angle of rotation for visibility was estimated to be 30°

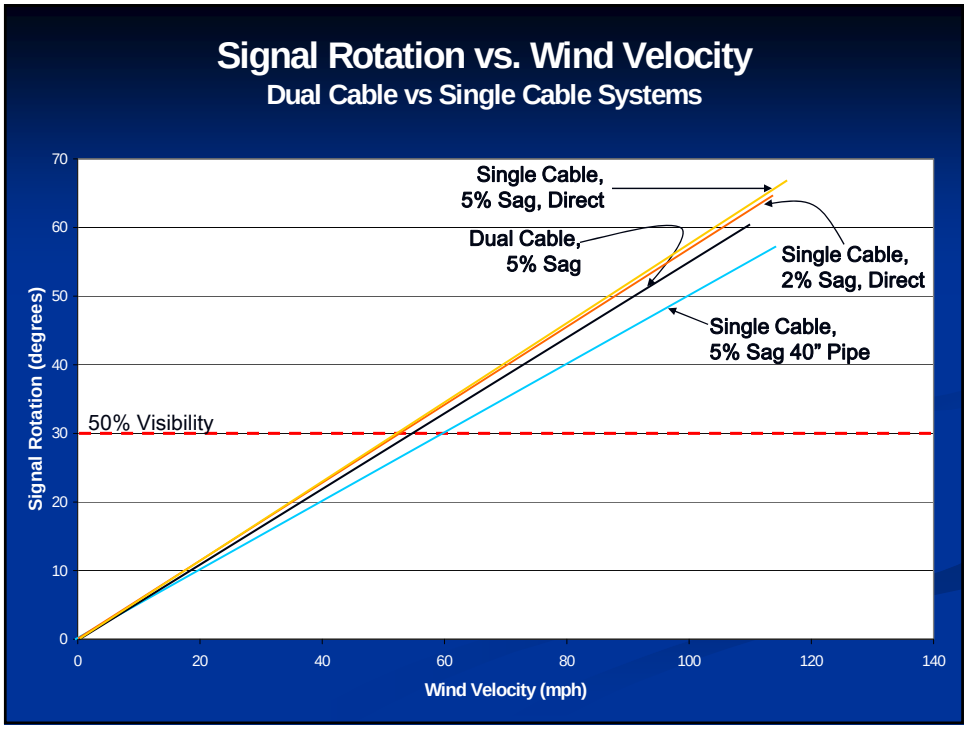


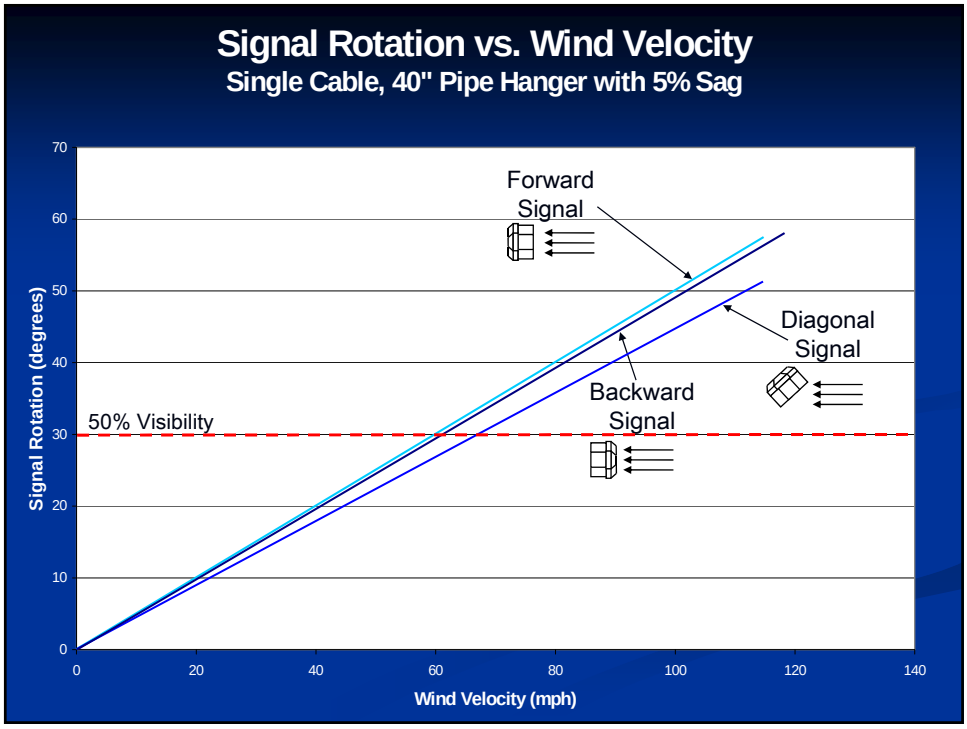
Test Results

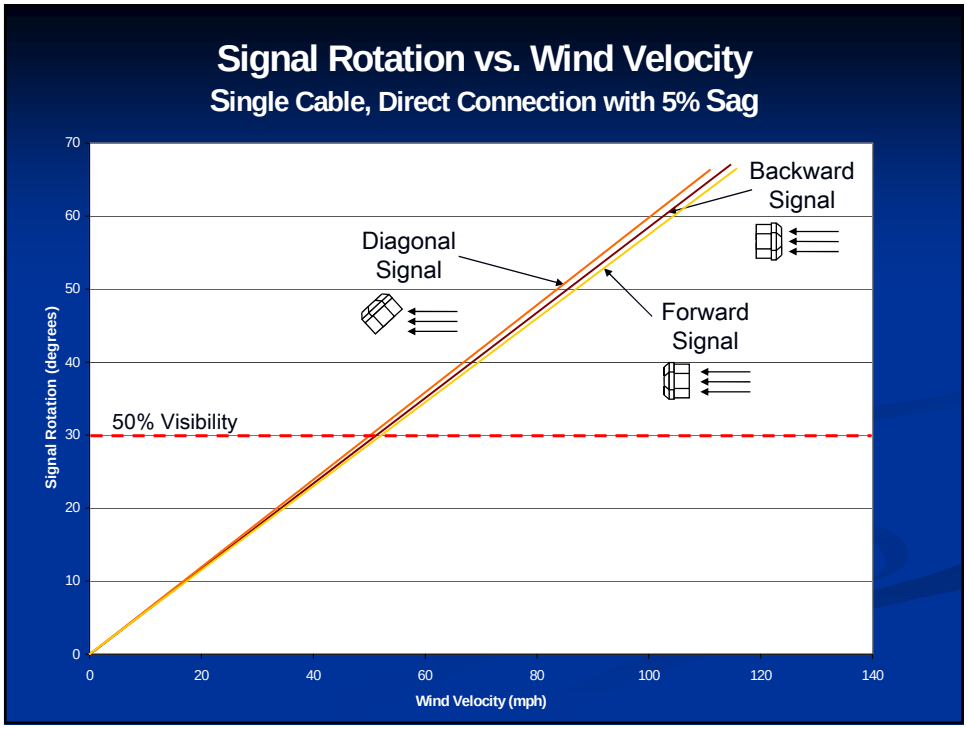
Signal Rotation vs. Wind Velocity

Dual Cable System, 5% Sag




Signal Rotation vs. Wind Velocity
Dual Cable vs Single Cable Systems
Single Cable, 5% Sag, Direct
Dual Cable, 5% Sag
Single Cable, 2% Sag, Direct
Single Cable, 5% Sag 40" Pipe
50% Visibility
Signal Rotation (degrees)
Wind Velocity (mph)
0
10
20
30
40
50
60
70
0
20
40
60
80
100
120
140


Signal Rotation vs. Wind Velocity
Single Cable, 40" Pipe Hanger with 5% Sag
Forward Signal
Diagonal Signal
Backward Signal
50% Visibility
Signal Rotation (degrees)
Wind Velocity (mph)
0
10
20
30
40
50
60
70
0
20
40
60
80
100
120
140

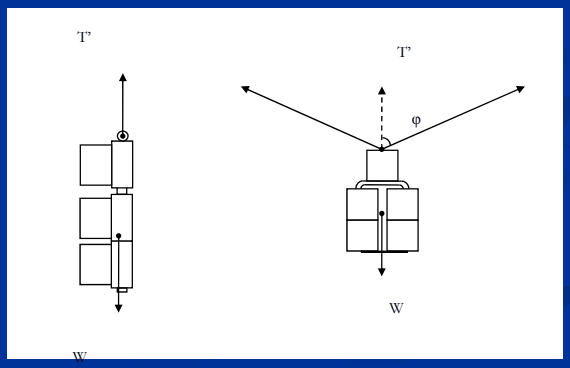


Test Results – Cable Tension

- The initial tension in the catenary cable depends on the sag of the cable, as well as the weights supported by the cable.
- The initial tension in messenger cables is applied during construction.
- Cable tension controls the sizing of cable and poles in design
- Cable tension plays a critical role in the failure of traffic signal structures

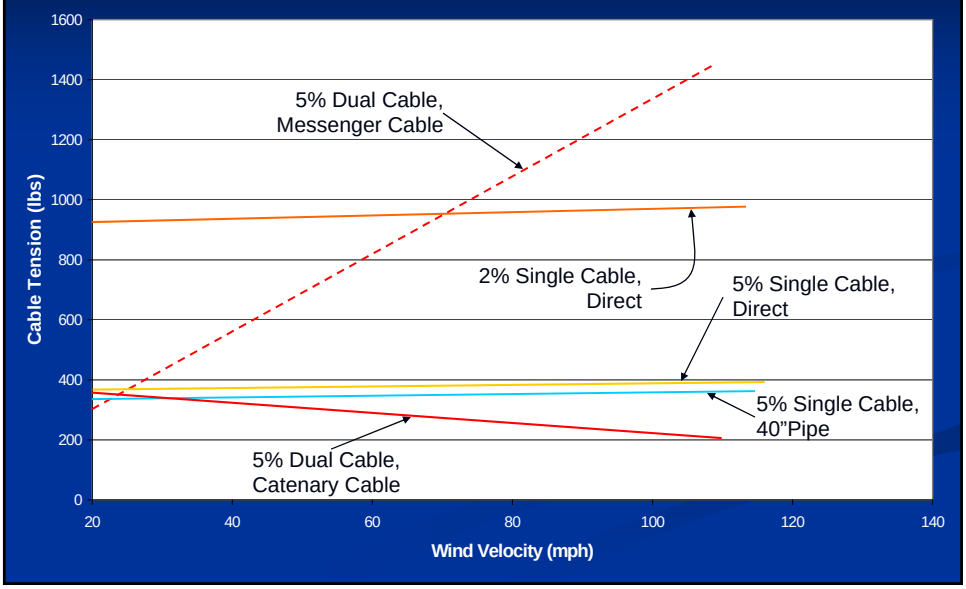
Test Results – Cable Tension

As the sag decreases, the force in the cable increases to support the weight



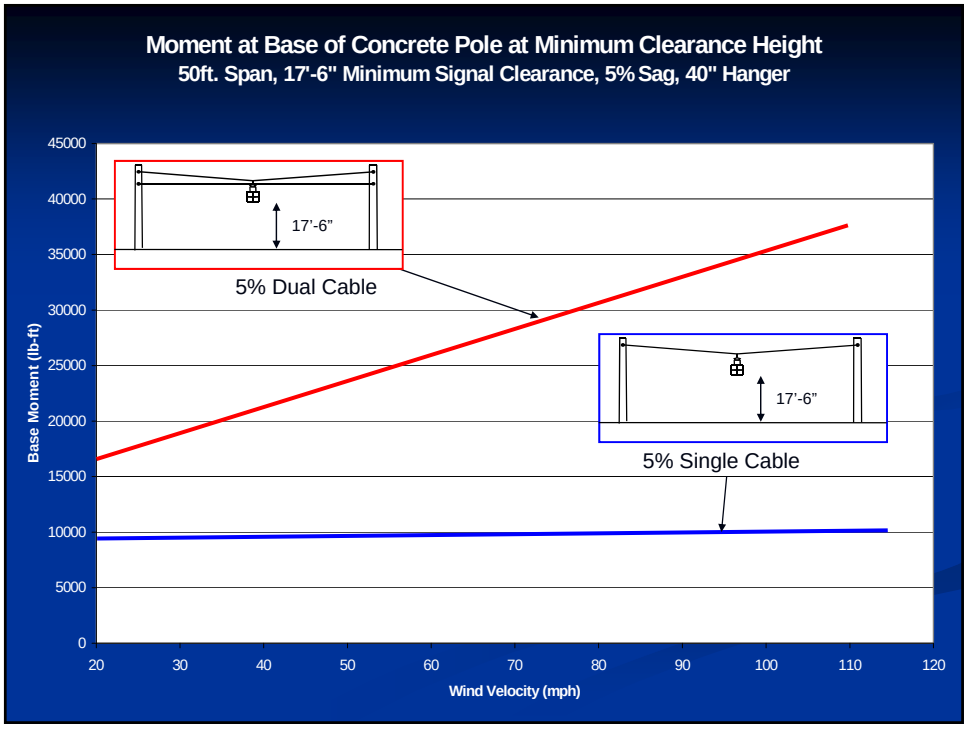
Cable Tension vs. Wind Velocity

Dual Cable vs Single Cable Systems, 5% Sag



Design of the Poles

- The primary factor in pole design is the moment created by the cable forces
- Pole moments were determined from the acquired data and assuming a minimum clearance of 17’-6” to the bottom of the signal.
- The dual cable system with a 40” hanger was compared to the single cable system with 40” hanger (i.e., the same system but with no messenger cable)



Summary

- No appreciable difference in signal rotation between the dual and single cable systems
- In the single cable system, the cable tension remains about the same with increased wind loading
- In the dual cable system, the messenger cable tension increases very significantly with wind loading
- In the dual cable system, the moment in the pole increases significantly with wind loading

Conclusions

- In the dual cable system, the hanger and disconnect are the current weak links
- If these are “beefed up” the next weak links will be the messenger cable and the pole
- From a structural perspective, the single cable support system wins “hands-down” and should very significantly reduce hurricane damages
- How would the single cable system work with operational and maintenance requirements?