

## THERMAL INTEGRITY PROFILING (TIP) Drilled Shafts in South Carolina



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- **Non-Destructive Test (NDT) Methods**
  - Crosshole Sonic Logging (CSL) and TIP
- **Carolina Bays Parkway Phase III**
  - TIP; Probe, Embedded Wires, Suspended Wires
- **US-15 O-Cell Test Shaft**
  - Manufactured Anomalies
- **Project YEEO (for Your Eyes and Ears Only)**
  - Aggressive Schedule

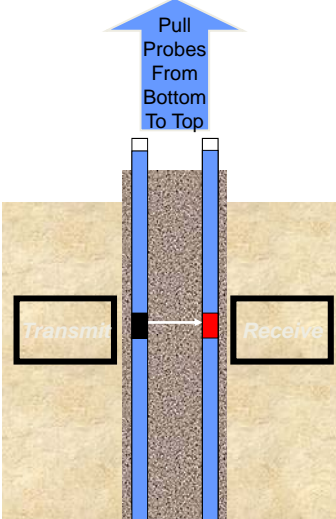
David Schoen, EIT  
S&ME, Inc.  
Charleston, SC

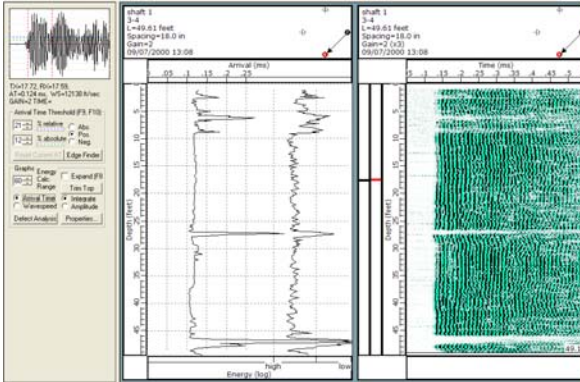
[dschoen@smeinc.com](mailto:dschoen@smeinc.com)  
843-884-0005




## CSL TESTING

### Non-Destructive Tests Background





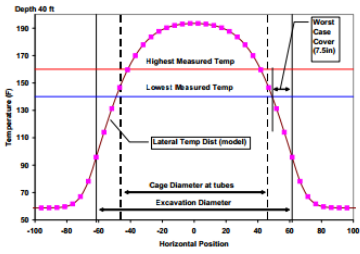


Graphics courtesy of PDI


## TIP TESTING

### Non-Destructive Tests Background

- **Heat Generation**
  - Cement content, mix design, shaft volume
  - Necks and Bulges
- **Temperature Distribution**
  - Cage Eccentricity/Cover
  - Top and Bottom Roll-Off
- **Time Dependent**
  - Concrete Placement
  - Pre-Peak
  - Peak
  - Shaft Cooling



*Temperature distribution for 10 ft diameter shaft (WSDOT). Lowest temperature measured corresponded to a 7.5 in cover*



## PROJECT OVERVIEW

### Carolina Bays Parkway

#### ■ CSL Testing – Scope

- 116 drilled shafts
  - 92 @ 7-ft diameter
  - 12 @ 8½-ft diameter

#### ■ TIP Testing – To Date

- Probe (22 Shafts)
- Embedded Wires (1 Shaft)
- Suspended Wire (1 Tube)

#### ■ Exploratory Coring

- 5 shafts to date



## CSL – CURRENT PRACTICE

### Carolina Bays Parkway

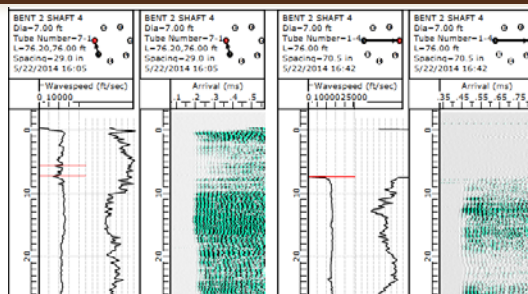
#### ■ “No Signal” in CSL data

- Long permanent casing
- Two cages in upper portion of shaft
- Common in coastal plain drilled shafts
- CSL on column cage

#### ■ “Anomalies” attributed to bleedwater



- Observed “welling” of water on top of shaft
- Coring indicated bleedwater path cavities and small air bubbles


#### ■ Are defects being masked?



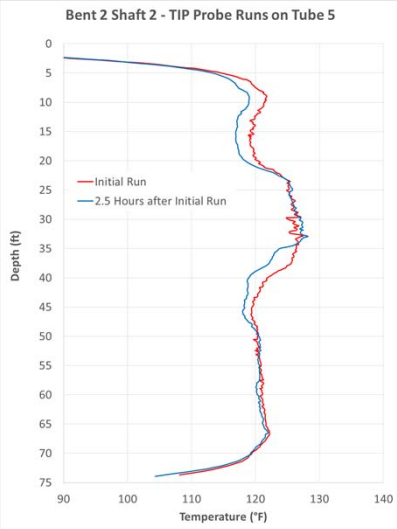
### TIP PROBE Carolina Bays Parkway

- Must dewater CSL tubes
- Lower potential for failure of equipment
- Reusable investment
- Allows for subsequent CSL readings







### TIP PROBE Carolina Bays Parkway



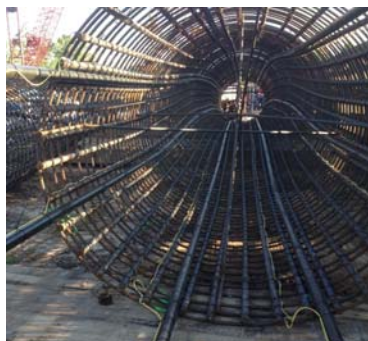
- Difficulty in scheduling
  - Not typically performed at Peak-Temp (When is Peak?)
- Curing and environmental effects during readings
- Snapshot temperature



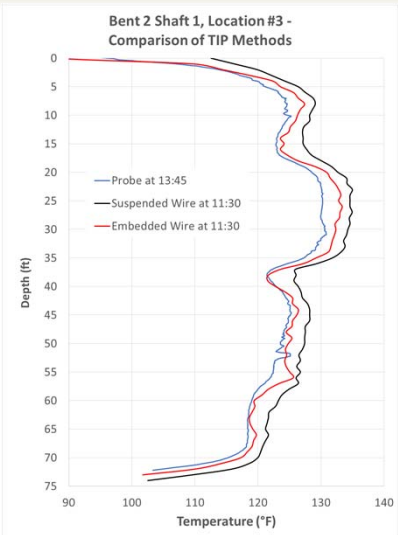
## TIP WIRES – EMBEDDED AND SUSPENDED Carolina Bays Parkway

### ■ Minimally used on project

- Budget constraints
- Wires donated by PDI
- 7 embedded (1 damaged)
- 1 suspended in water filled CSL tube



## TIP WIRES – EMBEDDED AND SUSPENDED Carolina Bays Parkway



- **Embedded Wires**
  - Labor intensive to install
  - Potential for damage to wire
- **Suspended Wires**
  - Somewhat reusable
  - Good correlation with other TIP methods?
  - Still allows for subsequent CSL if needed



## TIP WIRES – CONCRETE PLACEMENT Carolina Bays Parkway

Beginning of Concrete Placement

Near End of Concrete Placement

- Wave of concrete as being placed
- Concrete not always level
- Only recording every 15 min., but could reduce increment

## PROJECT OVERVIEW US-15 O-Cell Test Shaft

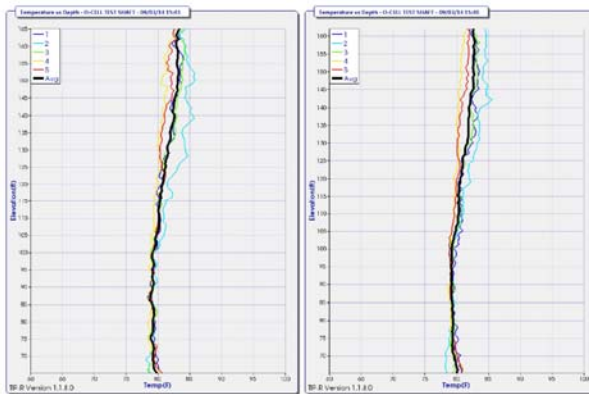
- Two-levels of O-Cells
- Manufactured defects
  - Gravel filled canvas bags
    - Sand filled bags not used
  - Two discreet levels (>3D apart)
    - Roll-off area (upper 1D)
    - 2D above strain gage
  - 15% of cross-sectional area

## EMBEDDED WIRES – ISSUES ENCOUNTERED US-15 O-Cell Test Shaft

- Installation of Thermal Wires
- Damage to Wire
  - Wire Install
  - Cage Modification
  - Cage Installation
  - Concrete Placement
- Security and data retrieval



## TIP WIRES – CONCRETE PLACEMENT US-15 O-Cell Test Shaft



Embedded Wires

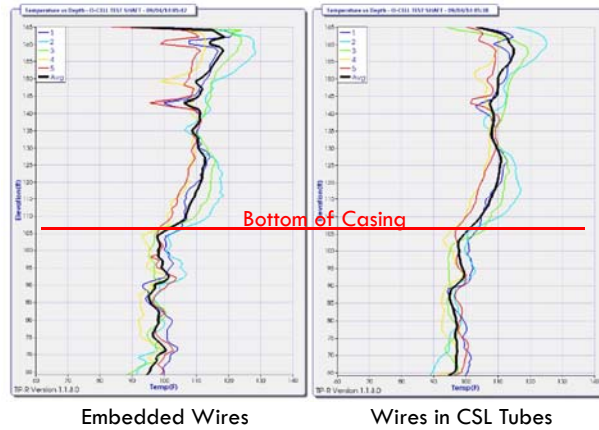
Wires in CSL Tubes

- Defects not apparent after concrete placement
- Concrete and slurry at similar temps?



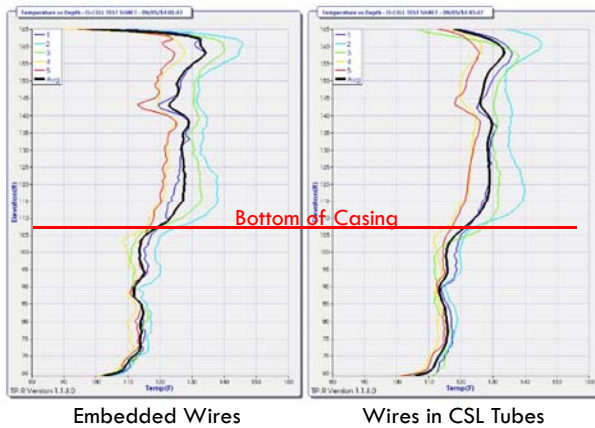
## TIP WIRES – 14 HOURS AFTER PLACEMENT US-15 O-Cell Test Shaft

- **Embedded Wires**
  - Top defect – 9 to 11% temp reduction
  - Lower defect – 10 to 13% temp reduction
- **Wires in CSL tubes**
  - Top defect – 3 to 5% temp reduction
  - Lower defect – 4 to 7% temp reduction
- **What is too big of a reduction?**
- **Tube 4 at depth of 15 ft?**



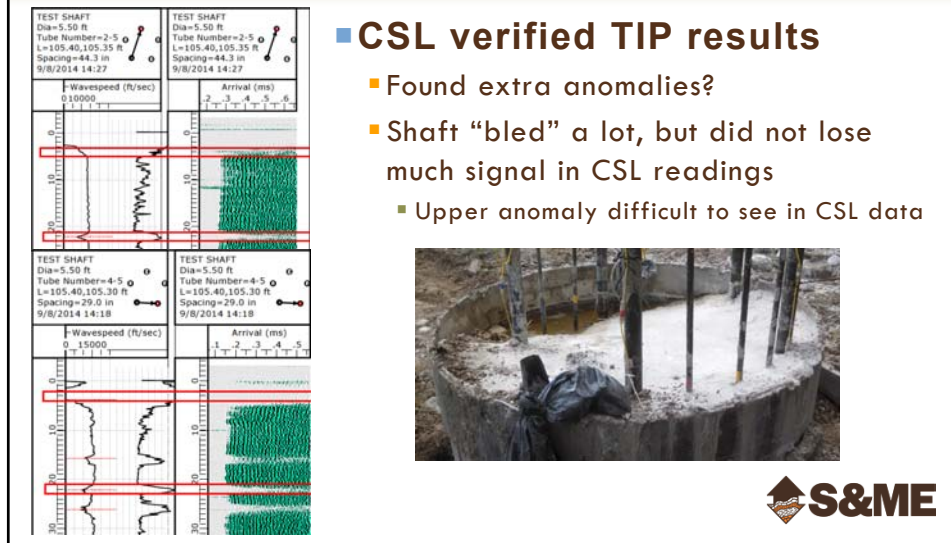
## TIP WIRES – 34 HOURS (PEAK-TEMP) US-15 O-Cell Test Shaft

- **Embedded wires**
  - Still show some indication of defects
- **Wires in CSL tubes**
  - Barely indicate defects
- **What if this was when the probe was performed?**
  - Wires allow for multiple time points to be analyzed





## CSL ANALYSIS US-15 O-Cell Test Shaft



## PROJECT OVERVIEW YEEO (for Your Eyes and Ears Only)

- **Private Sector Job**
  - 303 total drilled shafts
    - 4-ft, 6-ft, 8-ft diameters
    - Shaft tops up to 13 ft below ground
  - 6 total rigs, 5 working at a time
  - Install all shafts in 6 weeks
- **Embedded TIP Wires**
  - Installed on every shaft
  - Specs: up to 35% evaluated by TIP
  - 93 shafts (31%) evaluated by TIP
- **Exploratory Coring**
  - 4 shafts (1 @ 8ft, 3 @ 4-ft)



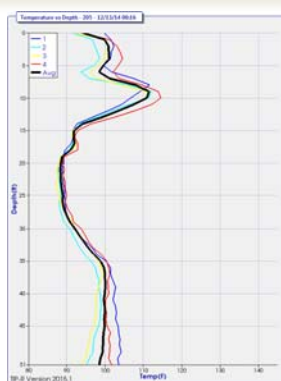
## DAMAGE TO TIP WIRES YEE0

- 1,680 Total TIP Wires Installed (≈70,000 LF)
- At top of cage, wires tied to single sister bar
- Cages moved multiple times
- Concrete placed by freefall
- Uncased excavation backfilled
- 93 shafts (516 wires) evaluated by TIP
  - 45 wires (8.7%) did not work at all
  - 67 wires (13.0%) did not work entire time/depth
- 86 shafts (464 wires) checked to determine if wires working
  - 156 wires (33.8%) giving error light

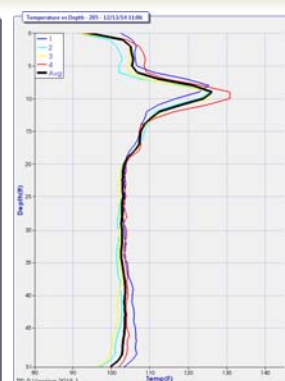


## TIP ANALYSIS – THE GOOD YEE0

- Temp. casing pulled after concreting
- Numerous bulges in “cased section”
- Some minor necking (or insufficient quality concrete)
- Very little information on concrete placement
- Damaged wires

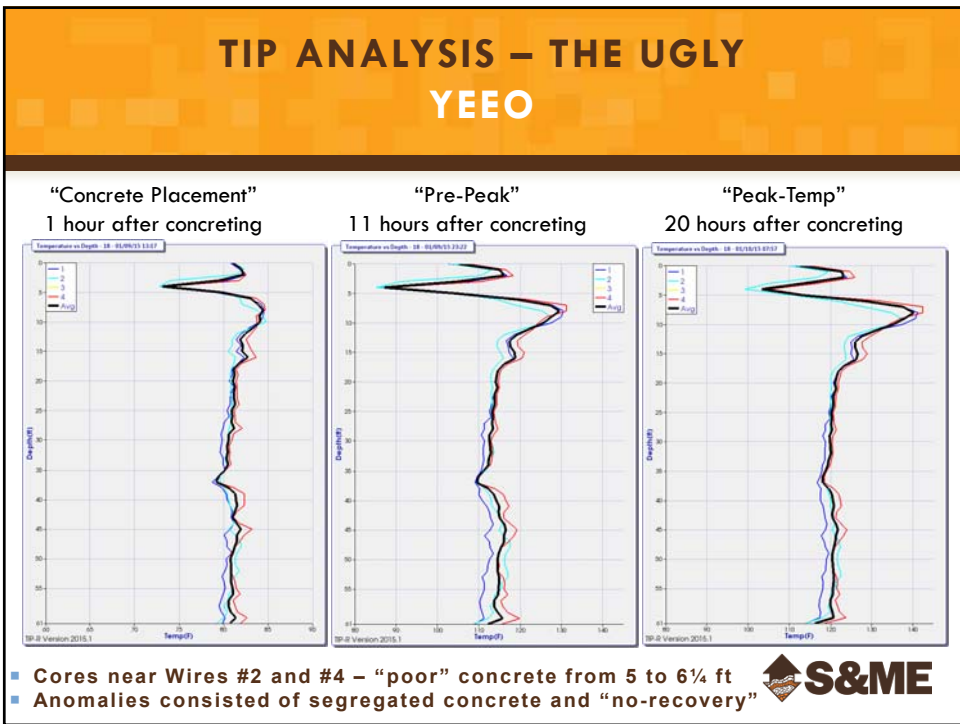
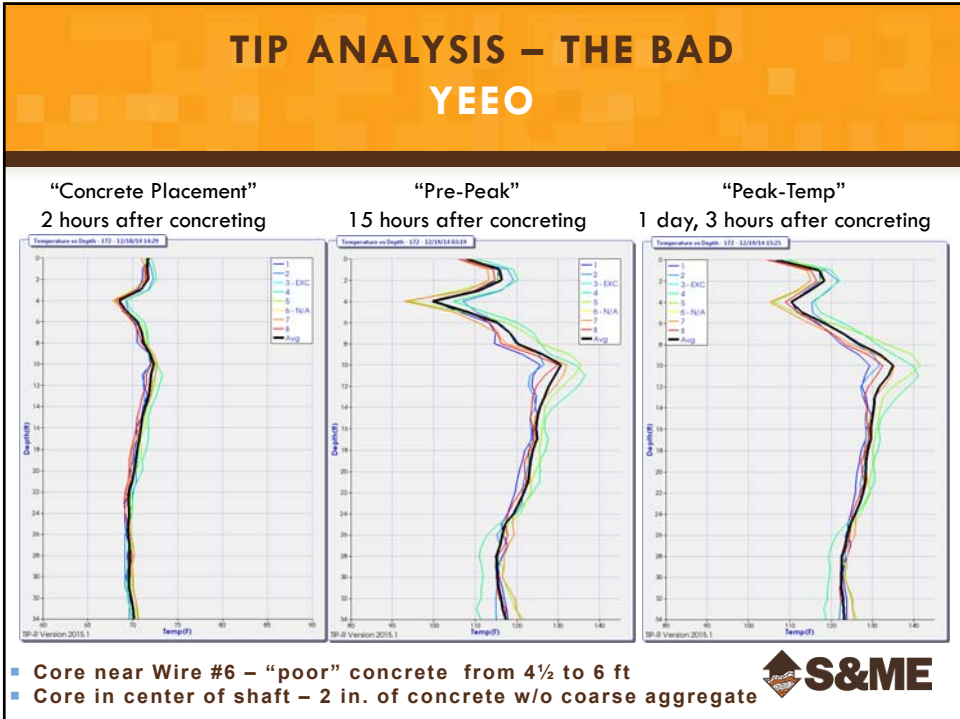


Middle truck not heating  
9 hours after concreting



“Peak-Temp”  
21 hours after concreting





## EXPLORATORY CORING AND REMEDIATION YEEO



### ■ Pressure Grouting

- Packers or plugs
- Flush with water (connect holes)
- Pump with grout

- Cored one 8-ft shaft and three 4-ft shafts, in two locations each



## ANY QUESTIONS? Did I Leave Enough Time?



Where can I  
get some  
dam beer?

