Thermal Integrity Testing of Foundations

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Cross Sonic Logging (CSL) testing
CSL testing

- Information inside tubes perimeter only.
- Debonding and bleeding issues.
- Steel tubes preferred
Gamma- Gamma Logging

- Needs **PVC access tubes (100 mm range)**
- Local cover information
- Uses radioactive materials (Cesium 137)
- Probe **must** be retrieved
- Long probe vs. bent PVC tubes
Coverage by GGL and CSL

![Graph showing coverage by GGL and CSL](image)
What does Thermal Integrity Testing show:

- Tests the entire volume of concrete (100%)
- Cage alignment
- Radius vs. Depth-Estimated shaft shape
- Necks, bulges, or inclusions
- Concrete cover
- Quality of concrete
Thermal Integrity Testing

Thermal Probe

Depth Encoder Assembly

Data Acquisition System
Thermal Integrity Testing
Method A - Uses Probes through Access Tubes
Method B - Uses Embedded wires attached to reinforcement cage
Thermal Integrity Testing

- It may be used on both Drilled Shafts and Auger Cast Piles
- Does not have debonding or bleeding issues (as CSL)
  - No false alarms
- It could work in PVC and steel tubes and in embedded wires in concrete
  - Access tubes not necessary

*Limitation: Test window limited to few days.*
Concepts used by Thermal Testing
Temperature radial distribution for several sizes
Thermal Integrity Testing

Reinforcement Cage

Drilled Shaft

Logging Tubes

Normal Heat Signature
Field Observations

- Little to no cage eccentricity (*all tubes same temp throughout*)
- Clean top and toe signature (*approximate 1 diameter temperature roll-off top and bottom*)
- Good Shaft
Thermal Integrity Testing

- Drilled Shaft
- Reinforcement Cage
- Logging Tubes
Shaft Heat Signature

Temperature

Temperature vs Depth

- 70-80
- 60-70
- 50-60
- 40-50
- 30-40
- 20-30

Avango
Anomaly

Interrupted Heat Signature

Thermal Integrity Testing
Optimum testing time for different size shafts
3-D image of a shaft with loss of concrete cover
Analysis

There are 4 levels of analysis:

• Level 1: Direct Observation of Temperature Profiles
• Level 2: Superimposed construction logs and concrete yield data. Radius determination.
• Level 3: Three dimensional thermal modeling
• Level 4: Signal matching numerical models to field data.
Example 2 - Level 2
FDOT EXPERIENCE AND PROSPECTIVE

• EXPERIENCE:
  
  • As of February 2016, TIP used successfully on 386 drilled shafts statewide (299 in Tampa).
  • TIP Test has been accepted by consultants and the industry.
  • Currently 4 Consultants in Florida have the capability of performing the test.
  • Two FDOT offices own the equipment: State Materials Office and the D4-6 Materials Office.

• FDOT PROSPECTIVE
  
  • Specifications still uses CSL as the primary integrity testing
  • Thermal Integrity Testing is included in the specs as an option for verification
  • Looking forward to use it as the primary Integrity Testing for drilled shafts
  • Future inclusion on acceptance for Auger Cast Piles (Bridge applications)
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QUESTIONS ?
If you want to do it yourself:

- **Machine costs $34 K** (Includes depth encoder, TAPP, data acquisition system. It does not include TAP for wires)
- **Wires with thermometers @ 12”: $5/ft**
- **TAP: $350 each**
- **Consultant typically charge us $2500 per test (including field collection and report. Same cost as they charge us for CSL testing).**
• **FDOT REPORT REQUIREMENTS:**
  
  • *T vs Depth graphs* (measured and theoretical):
    - Indication of unusual temperatures, including cooler local deviations from the average at any depth from the overall average over the entire length.
    - Overall T average temperature and theoretical temperature.
    - Variations in temperature between access tubes which may indicate variations in cage alignment.
  
  • **Radius** of the shaft throughout the entire depth.
  • **Alignment** of the reinforcing cage along the shaft
  • **Calculated concrete cover** throughout the entire depth.
  • **Conclusion** stating whether the tested shaft is free from integrity defects and meets the minimum concrete cover and diameter requirements by the specifications.
    - When anomalies are detected, include in the report a three dimensional rendering of the shape of the shaft.