Thermal Integrity Profiling
( TIP )

ASTM D7949
It is obvious why we test
Typical Inspection

Dry Cast
• Generally visual inspection only

Wet Cast
• Since visual inspection is impossible some NDT is needed. Options include:
  1. CSL
  2. PIT (pulse echo)
  3. Gamma Gamma Logging
  4. Thermal Profiling
Percentage of Shafts with “Anomalies”

Billy Camp, S&ME Inc.
Southeast USA
“Crosshole Sonic Logging of South Carolina Drilled Shafts: A Ten Year Summary” - Presentation to ADSC Expo 2012, San Antonio March 2012

Jones & Wu, Geotechnology, Inc.
Missouri and Kansas
Thermal Integrity Profiling

Advantages

• 100% Cross-section of the shaft
• Use temperature vs. depth vs. quadrant
• Test early after casting, speeds const.
  • 12 to 48 hours (dependent on diameter)
• Evaluates concrete quality, cover & alignment
• Only reports significant defects
Thermal Integrity Profiling

- Use temperature vs. depth vs. quadrant

- Concrete Temperature versus depth during curing at cage

- Strength
  - Shaft
  - Serviceability

- Cement Quantity

- Cover

- Durability
Shaft Heat Signature
Shaft Heat Signature

Temperature

Temperature Signature
For uniform shaft, temperature is constant, except 1 diameter at top and bottom roll-off.
Two TIP Methods
Probe or Wire
Test Procedure using probes

- Remove water from tube, if applicable
- Insert IR probe into tube
- Collect data (top to bottom)
- Repeat IR scan in all tubes
THERMAL WIRE® Cables

TAP Data Logger

Thermal Wire
Data Output

Bridge 100718
Pier 6-6 -- Shaft 3

Temperature (deg F)

Depth (ft)

T1
T2
T3
T4
Avg
TOS
BOS
BOC
Level 1: Direct Observation (Field)

- Verify shaft length - Identify top and bottom
- Confirm cage alignment
- Locate changes in shaft diameter

Locate immediate areas of concern
view data instantly in field
ODOT – I71 over Little Miami River
Shaft # 17 Thermal Wire @18 hours
Level 2: Added Field Records

- Relate concrete volume to meas’ed temperature
- Predict as-built shaft radius, shape, and cover
Theoretical Diam. vs. Effective Diam.

No Correction for Over-pour Concrete

No Correction for Tremie filling / volume

Method Shaft

Depth (ft)

Shaft Diam (ft)

Average

Grd Surf

TOS

WT

BOC

TOLime

TOR

BOS

Effective Diam.

Theoretical Diam.

Truck volume and depth after each truck can establish the effective diameter for each shaft segment.
Average temperature is related to average radius

No Correction for
Over-pour Concrete

No Correction for
Tremie filling / volume
TIP Projects
RW Harris Test Site

- Probe Method, 3 tubes
- 48 Inch Diameter
- 25 Feet Depth
- Concrete Placement – Tremie
- Purpose built defects, sandbags installed
Tampa, FL

- Instrumented with 4 Thermal Wires
- 36 Inch Diameter
- 75 Feet Depth
- Concrete Placement - Tremie
- Temporary Casing Installed to 40ft
Bridge 100722 Pier 3-1L Shaft 1
Sequoia, CA

- Instrumented with 4 Thermal Wires
- 37 Inch Diameter
- 60 Feet Depth
37 inch diameter shaft
18.5 in. radius, 15 in. cage radius
Gradient = 2 inch Per 5.1°F

Sequoia Project – soft bottom
15 cu.y installed (13.8 theoretical)
Sequoia Project – soft bottom
15 cu.y installed (13.8 theoretical)

37 inch shaft

Depth(ft)
20 40 60 80 100 120

Casing
Granular
Rock

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Reporting: Sequoia Results
Cleveland Innerbelt Bridge - OH

- Instrumented with 6 Thermal Wires
- 66 Inch Diameter
- 180 Feet Depth
- Concrete Placement - Tremie
- Temporary Casing Installed to 28ft
- Cage Spliced
Let’s watch temperature change during 6 day curing …

20 trucks
5 hrs to fill

4 hours – after end casting

2 hr break

0.8 hr

2.5 hrs

Temperature vs Depth

Depth (ft)

Temp (F)
Can assess shaft over a wide range of time

Extra pumping 2 hr delay

2 days  4 days  6 days

03/27/2012 01:09:00  03/29/2012 01:36:00  03/31/2012 01:25:30

66 inch diameter shaft - Cleveland
CSL looks only inside the cage

TIP can look outside cage also and estimate the shaft profile
TIP can look outside cage also and estimate the shaft profile.
Retaining Wall Drilled Shaft - OH

- Instrumented with 4 Thermal Wires
- 21 Inch Diameter
- 36 Feet Depth
- Concrete Placement - Free Fall
- Temporary Casing Installed to 24ft
- Casing extracted using vibro hammer

Observed or Measured:
- Exterior to cage, materials caved in during casing extraction
- Interior to cage, 18 inches of water & loose material at toe (retaining wall – not an issue to contractor)
TIP Results at Peak Temp – 11 Hours

Temporary casing removed with vibratory hammer

Debris fell between cage and inner-wall of shaft – resulting in necking indicated by reduced temperature readings

Early Rolloff Indicating Soft-Toe

Weighted tape showed 1.5 ft of water and soft soil at shaft bottom
CSL vs. TIP

TIP – At Peak Temp.

- Anomaly visible outside of cage

CSL – Results after 2 days

- Anomaly not visible
- Anomaly not visible
- Anomaly not visible

Soft Toe visible in both methods
Thermal Integrity Profiling

• Temperature during curing at cage is related to concrete quality, volume, and cover

• Thermal Integrity Profiler evaluates concrete both inside and outside the cage, assessing both cover and alignment

• Evaluates shaft during curing (as early as 12 hrs) allows construction to progress much earlier
Thanks for your attention

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