One test is worth a thousand expert opinions...

By Brian Liebich, P.E.
Need for Non-Destructive Evaluation

- Visual Observation Difficult / Impossible (Slurry / Casing)
- Critical Structural Element (High Load)
- Constructed Under Field Conditions
Danger of Not Performing NDT

- Significant Risk of Defects
- Anomaly Rate: 18%
- No subsequent Verification
Testing of Drilled Shafts

- Quality Assurance (Performance Specification)
- Caltrans Tests every “wet” pile
- In-house testing routine since early 1990’s
Drilled Shafts

Gamma-Gamma Logging (GGL)

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Gamma-Gamma Logging

- Downhole Method (PVC Inspection Tubes)
- Evaluates Radius Around Tubes
- Selected for Design Concerns
Principles of Gamma-Gamma Logging

- Gamma - Density Correlation
- Homogeneity of Material
- Nuclear Considerations
Gamma-Gamma Logging

- Objective
- Highly Repeatable
- Proven
- Recognized
- Primary Method
GGL Data Processing

- Data Collected for all tubes of a pile
- Converted to Density
- Tests plotted for each pile
• Bulk Concrete is Homogeneous
• Density Essentially Uniform
• Statistical Analysis
Detected Anomaly from GGL

Anomaly Detected By Gamma-Gamma Logging

Anomaly Confirmed By Excavation
Interpretation and Anomalies

• Three Standard Deviation Criteria
• Anomalous = not Homogeneous concrete
• California Test Method (CTM) 233
Sizing the Anomaly

- Representative Sample
- Proportional Apportionment Method
- If 1/14 Tubes Anomalous, 6%
Drilled Shafts

Crosshole Sonic Logging (CSL)

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CSL Capabilities

- Determines Arrival Time Between Tubes
- Arrival Time Determines Homogeneity of Velocity
- Anomalies are Reductions in Velocity
**CSL/GGL Comparison**

- Nuclear vs. Sonic
- GGL is more repeatable and less prone to environment
- CSL is able to analyze between tubes in greater detail
CSL/GGL: Complementary

- Tests Analyze different portions of the pile
- Strengths often correlate to the other method’s weaknesses
Lack of Cover Concrete
Slight Intrusion into Shaft Core
Slight Intrusion Into Core

Assists to Define Nature and Extent
Anomaly Mitigation

Drilled Shafts

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Mitigation Process

- Anomaly Identification
- Design Review
- Contractor Plan
- Review / Approval
- Perform Repair
- Evaluation
Successful Repair

- Timely Resolution
- Meets Design Requirements
- Assurance of Repair
- No “One Size Fits All”
Mitigation Methodologies

- Replacement / Supplement
- Unearth and Recast
- Structural Bridging
- Pressure Grouting
Replace / Supplement

- Based on Design Concerns
- May not be Possible
- Typically Most Expensive
Unearth and Recast

- Physical Replacement
- Visual Inspection
- Access and Restoration
Structural Bridging

- Core Drill Hole
- Insert Steel Supplement
- Grout into Place
Pressure Grouting

- Access to Anomaly
- High-Pressure Water Jetting (Hydroblasting)
- High-flow Water Scour
- Material Dependent
- Communication
Inject Grout

- Permeation Grouting
- Replacement Grouting
- Water Test Done Prior to Select
Downhole Camera

- QA of Contractor Procedure
- Verify Anomaly Type / Extent
- Useful for Confirming Anomaly
How Mitigation Methods are Selected

- Contractor Selects
- Mitigation Committee Approves
- Competing Concerns: Cost vs. Effectiveness
Drilled Shafts

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