Dynamic Testing Methods for Evaluation of Integrity and Capacity for Drilled Shafts
Deep Foundation Solutions:

- **Driven Piles**
  - Steel, Concrete, Timber
- **Drilled Shafts**
  - Wet or Dry, Cased or Uncased
- **Augercast Piles**

*Each pile type has different inspection needs*
Planned inspection (Preferred)

- Included in project specifications
- Planned costs - normal pay item

Unplanned inspection

- in response to something gone wrong
- Unplanned costs - who pays?
- Delays project, extra claims
Low Strain Integrity Methods

- **PILE INTEGRITY TESTING (PIT)**
  - Measure Pile Top Motion, Reflections from Defects
  - For concrete piles, concrete filled pipes, drilled shafts, augercast piles, and sometimes timber piles.

- **CROSS-HOLE SONIC LOGGING (CSL)**
  - Determines Concrete Quality Between Tubes in Shaft
  - For drilled shafts and larger augercast piles
Pile Integrity Testing looks for *major* defects

- Small hammer impact device
- Accelerometer measures response

ASTM D5882
PIT - Basic Interpretations

Local Defect: small | medium | large

Local Bulge: small | medium | large
Normal test (pile top “free”)
14 inch augercast pile with 15 foot rebars.

Failed static load test often prompts testing.

Defect in this test pile shaft caused failed test (rather than soil failure)
PIT detected bored pile defect at 4.1 m depth; confirmed by core
Good pile with local bulge at about 25 ft and clear toe

Bulge -/+ cycle

Bad pile with major defect at about 3.5 ft and no clear toe

Neck +/− cycle

Bad pile excavated to reveal neck

Bad pile with major defect at about 3.5 ft and no clear toe
Classifications
(4 categories proposed by GRL)

- **A - Good Pile**
  Clear toe response, no obvious defect; sound shaft

- **B - Bad Pile**
  Clear identification of serious defect; no toe signal
  - needs contingency tests or corrective measures

- **C - Possible Defect**
  - re-test, other tests, reduce capacity or replace

- **D - Inconclusive data**
  (poor pile top quality, or no reflections due to strong soil)
  - fix pile top & re-test; might give info for upper pile shaft which is reason to accept pile.
What to do if find a “problem”?

- Compare with other observations
- Re-test with PIT (trim pile top to solid concrete)
- Excavate if near top
- Request pile core
- Request a PDA test or a static test
- Replace pile (or repair)
- Other?

- **Have a plan** what to do if find a defect
Some studies suggest a 30 L/D limit. Actually this is only a “rule of thumb” and useable length depends on:
- soil strength,
- pile uniformity,
- actual diameter and length,
- and equipment noise and resolution.
- We often see much farther

Highly non-uniform piles difficult to interpret

Cracks or mechanical joints block waves

Small defects (or of short length) hard to find

Gradual changes hard to find
PIT Conclusions

- **PIT finds major defects**, low cost so can test every pile
- Inclusion of inspection requirements in job specifications is suggested
- PIT can sometimes test piles in structure
- Guideline of use till 30 L/D is not a limit.
- Cracks or gaps limit transmission of wave
- No information about capacity
Stress Waves, emitted in one tube are received in another one if concrete quality is satisfactory.
Cross Hole Sonic Logging
Cross Hole Sonic Logging

\[
\text{wave speed} = \frac{\text{tube distance}}{\text{arrival time}}
\]
Cross Hole Sonic Logging

How do we spot defects?
Low energy
Late arrivals

Defect
Defect
Defect
48” shaft with soft toe condition
Shaft with tremie defect
CSL Testing Advantages

- insensitive to surrounding soil or pile length
- finds multiple defects, depth and quadrant
- finds “soft bottoms” if tubes go to bottom
- inspires careful construction by contractor
CSL Testing Limitations

- must plan and install access tubes
- tubes preferably less than 2 meters apart
- evaluates concrete only between tube pairs
- defects undetected when outside cage
CSL Conclusions

• Can find multiple defects and their quadrant; not sensitive to pile length or soil

• CSL finds defects between (steel) access tubes; consider defect remedy in advance

• CSL access tubes in every shaft inspires high quality installation for every shaft (even if do not test every shaft)

• Allows low cost testing access if problems occur during installation

• Waterfall, FAT and energy compliment interpretation of results
The End