LRFD and Deep Foundation Integrity

- Problem statement
- Examples of treatment of integrity
- Methods
- Summary and recommendations

Problem Statement

- We consider
  - the structural limit state
  - the geotechnical limit state
  - serviceability.
- We have dealt with the geotechnical limit at length
- We do not consider adequately, the installed condition of the foundation element.
- We can only inspect pile at the time of construction or shortly thereafter.

Current situation (Example 1)

HP 12x53, 50 ksi driven to rock

(assume combined load factor of 1.4)

- **Capacity = structural capacity, i.e. load test "fails" at 775 kips**
- **structural (AASHTO 6.5.4.2):**
  - **φ_C = 0.7 undamaged pile (540 kips /1.4=400 kips)**
  - **φ_C = 0.5 pile when tip protection needed: (390 kips /1.4=275 kips)**
- **bearing:**
  - **φ = 0.4 to 0.90**

    (310 to 700 kips /1.4 = 220 to 500 kips)
- **settlement: OK**

Current Situation (Example 2)

For pipes, 12-3/4” x 0.375”; fy=35 ksi; in rock or plugged in v.d. material:

- **Capacity, i.e. load test “fails” at 510 kips**
- **structural (AASHTO 6.5.4.2):**
  - **φ_C = 0.6 (310 kips /1.4=220 kips)**
- **bearing:**
  - **φ = 0.40 to 0.90**

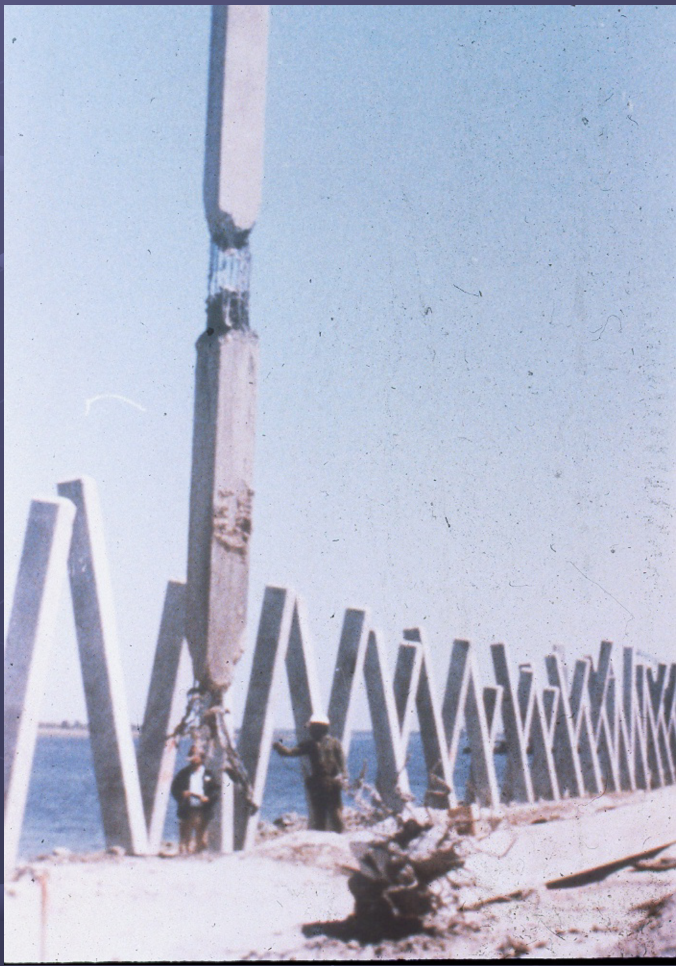
    (330 to 460 kips /1.4= 150/330 kips)
- **settlement: OK**

Problem Statement (Example 3)

14x14" concrete (4 ksi net) pile driven to rock

- bearing capacity 780 kips
- structural limit (AASHTO 5.5.4.2.1):
- φ_C = 0.7 (550 kips /1.4 = 390 kips)
- bearing capacity: φ = 0.40 to 0.90

  (310 to 710 kips / 1.4 = 220 to 500 kips)
- settlement: OK (rock)



Problem Statement, Example 4

Example – drilled shaft bearing in IGM

- structural material:
  - $\varphi_C = 0.7$
- tip resistance on IGM:
  - **φ = 0.55 (**for high quality control and using O'Neill and Reese Method)
- settlement: OK (IGM)

CSL Testing: Anomalies reported by S&ME

- Number of Projects 37
- Number of Shafts 421
- Shafts with Anomalies 141(33%)

Experiences in Europe

- UK:
  - primarily on CFA piles, one firm reports doing 100,000 Pulse Echo tests/year and typically finds 2% of piles with anomalies
- Germany:
  - primarily on drilled shafts, one firm reports 2% of piles tested with anomalies

Quality Control for Integrity

- for Driven Piles
  - Blow Counting (with stroke measurements)
  - Dynamic Monitoring
- for Drilled Shafts
  - High?
  - Low?
- for ACIP
  - Installation Recording

Quality Assurance Methods

- Driven Piles
  - Pulse Echo Method for Relatively Short Concrete Piles or Timber Piles
  - Load Testing (HSDT, RLT, SLT)
- Drilled Piles
  - Cross Hole Sonic Logging
  - Sonic Pulse Echo/Transient Response
  - (Core) Drilling
  - Load Testing (HSDT, RLT, SLT)

Concern

- For H-piles, AASHTO provides an unusual mix of structural limits based on integrity concerns
- For drilled shafts AASHTO mixes geotechnical and structural concerns
- There is no clear incentive/reward of Quality Control (if possible) though it is implied that driven piles have, automatically, a better QC than other foundation types
- There is no clear incentive/reward for Quality Assurance
- QA methods are available and some owners require their use without clear benefit
- We need a protocol for QA

Summary

- There are inconsistencies as far as how materials are treated by AASHTO
- High Quality Control is demanded for Drilled Shafts, but hard to accomplish
- Quality Assurance would be a reasonable alternative, but is not clearly rewarded

Recommendation

- In code improve of treatment of driven/drilled pile structural limit states.
- Obtain information from national and international sources on
  - present experiences with relationship between QA/QC methods and safety concepts
  - demonstrate what effect QA/QC had on quality of foundations
  - present specs/codes/norms from other countries
  - develop and propose “rewards” for QA/QC testing