Overview

• Introduction

• Specifications

• Pile Problems and Solutions
Hammers Types

• Internal Combustion
  • open end diesels
  • closed end diesels

• External Combustion
  • steam hammers
  • air hammers

• Vibratory hydraulic hammers
• Gravity Hammers
• New Hammers – The Resonant Driver
Pile Types

- Steel H-Piles
- Prestressed Concrete Piles
- Precast Concrete Piles
- Cast-In-Place Pipe Piles
- Timber Piles
- Shell & Fluted Piles
WVDOH Specifications

Steel Piles: Steam /Air Hammer ~ 12,000 ft-lb
Concrete Piles :Steam /Air Hammer ~15,000 ft-lb

“Gravity hammer for driving steel [and concrete] piles shall weight not less than 2,000 and 3,000 lb respectively ....”

“Refusal is defined as the equivalent of 20 BPI with a power hammer developing the minimum designated foot pounds per blow”
LRFD Specifications

• **10.7.3.2.2 Piles Driven to Soft Rock**
  Soft rock that can be penetrated by pile driving shall be treated in the same manner as soil for the purpose design for axial resistance.

• **10.7.3.2.3 Piles Driven to Hard Rock**
  The nominal resistance of piles driven to point bearing on hard rock where pile penetration into the rock formation is minimal is controlled by the structural limit state. (This is the normal case in WV)

• The resistance factors for the compression limit state are specified in Article 6.5.4.2. - 0.6 for easy driving and 0.5 for hard driving
WVDOH Specifications

- Plumbness ~ 2% from vertical or batter
- Alignment ~ 6-inches for group
- 3-inches for a single line of piles

Why?
LRFD Specifications

• Resistance Factor for Wave equation analysis, without pile dynamic measurements or load test, at end of drive conditions only is 0.40 (Table 10.5.5.2.3-1)

• We used 0.5 for point bearing piles on rock when using the end of driving analysis

• We include a skin friction estimate for our analysis purposes only
WVDOH Specifications

- Predrilling
  - Through fill or into rock when on the Plans
  - No Rock ~ approx. 85% of depth of H-pile
  - HP 10x42 ~7.5 inches
  - HP 12x63 ~ 9.25 inches
  - HP 14x73 ~ 10.75 inches

- Rock ~ min. of 100% of the diagonal
- Backfill after driving with dry sand or pea gravel (When should we backfill?)
  - Predrilling through boulder on a batter?
LRFD Specifications

10.7.3.8.4—Wave Equation Analysis
A wave equation analysis may be used to establish the driving criteria.

• 10.7.8—Drivability Analysis
The establishment of the installation criteria for driven piles should include a drivability analysis.
Problems
Problems
Problems
Solutions
## Solutions

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<th>Test Description</th>
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<th>Hammer Stroke</th>
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<th>CAPWAP Mobilized Capacity</th>
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Solutions
Solutions

Good Plan Notes

All steel piles shall be HP-___ Steel Bearing Piles, Predrilled and Driven, and shall meet AASHTO M270, Grade 50, requirements. **Hardened steel pile points** shall be used. The target capacity is ___kips per pile [Insert 2x maximum factored load per pile here] at refusal in bedrock. The Contractor shall predrill all the pile boreholes into [soft, medium hard, or hard rock___ft. If vary hard or extremely hard, provide additional warning to contractor]

- All predrilled boreholes shall have a minimum diameter of ___ inches [Insert diameter 6-inches larger than the pile diagonal dimension rounded up to the nearest size in 6-inch increment]. As a minimum, all predrilled boreholes shall be drilled to the tip elevations shown on the plans. The holes shall be backfilled with dry sand prior to driving.
Solutions

• **Refusal** is defined as 20 blows for 1 inch of penetration, or the equivalent, using a power hammer with a minimum rated capacity of approximately 25,000 ft-lbs.

• If a **larger hammer** is used, the Contractor shall submit new driving criteria using a wave equation analysis, such as **GRLWEAP**.

  Or

• A power hammer shall be **sized by the Contractor** to achieve the target capacity without exceeding 45 ksi maximum driving stress. The Contractor shall determine the hammer(s) rated energy, and pile driving criteria using a wave equation analysis such as **GRLWEAP**.
Solutions

- The driving criteria should include the STROKE HEIGTH, the required blows per 1 inch of penetration to achieve the target capacity, and the fuel setting.
- Use a Saximeter to determine the STROKE HEIGTH.
QUESTIONS